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# To Know the Land with Hands and Minds: Negotiating Agricultural Knowledge in Late-Nineteenth-Century New England and Westphalia

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An Abstract of the Dissertation Presented
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Ever since the eighteenth century, experts have tried to tell farmers how to farm. The agricultural enlightenment in Europe marked the beginning of a long arc of new experts aiming to change agricultural knowledge and practice. This dissertation analyzes the pivotal period in the late nineteenth and early twentieth century in Germany and the United States when scientists, improvers, and market agents began to develop comprehensive ways to communicate agricultural innovation to farmers. In a functional approach to analyzing the negotiation of agricultural knowledge through its communication in things, words, and practices, this dissertation argues that the process of change in German and American farming in response to globalizing markets for agricultural commodities included a multi-tiered process of conflict and knowledge negotiation between a variety of actors. Scientists, improvers, market agents, farmers, and others all shaped the future of farming as part of an agrarian-industrial knowledge society. While the path of each innovation to each farm was historically and geographically contingent, actors shared perspectives, strategies, and evidence to establish their own expertise, form expert communities, and reach their own goals. The agrarian-industrial knowledge society brought their patchwork of expertise into agreement, but also excluded those farmers as “backward” who were unwilling or unable to use capital-intensive innovation and extracted nutrients and labor from soils and nonwhite people of the American South and European and American colonies around the world.

This dissertation advances this argument through an entangled and comparative history of livestock feeding in the United States and Germany. To integrate the perspectives of actor groups and to bring their negotiations into sharper relief, this study analyses interconnections and comparisons between two case study areas in challenging agricultural conditions where innovation for ideal farming conditions required more significant adaptation: western Maine in New England and the Sauerland in Westphalia. The analysis combines print and manuscript sources by all actor groups with Geographic Information Systems (GIS) mapping and spatial and statistical analysis of cadastral and census data in microhistorical case studies situated in Serkenrode, Westphalia, and South Paris, Maine. This approach argues for an integrated, global history of agricultural knowledge.

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Despite studying history, I have bad memory. The list of the many people and institutions I want to thank for their support and encouragement will be incomplete, but I will try anyway.

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Rural History Organisation in 2017, and the Triennial Conference of the Rural Women's Studies Association in 2021. I also got to present my work at colloquia of the a.r.t.e.s. Graduate School, Historical Institute, and the Department of American History at the University of Cologne and the Department of History at the University of Heidelberg. I also received feedback at the Early Career Researchers Conference "Transatlantic Histories of Schooling and Education – Traveling Knowledge, Concepts, and Materials" at Münster University in 2018 and got to publish part of this work in the resulting edited volume.

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**CHAPTER 1**

# INTRODUCTION: TELLING FARMERS HOW TO FARM

> The weather was unprecedented—weeks of damp and rain and fog. Everybody talked about it. One day during that spell I was holding forth to a practical farmer on the subject of hay. Full of book learning, I was explaining (rather too glibly) the advantages of cutting hay in June. I described in detail the vitamin loss incurred by letting hay stand in the field after it has matured, and how much greater the feed value was per unit weight in early-cut hay, even though the quantity might be slightly less. The farmer was a quiet man, with big hands for curling round a scythe handle. He listened attentively. My words swirled around his head like summer flies. Finally, when I had exhausted my little store of learning and paused for a moment, he ventured a reply.
> "The time to cut hay," he said firmly, "is in hayin' time."[1]
>
> E. B. White, Book Learning, July 1942

Ever since the eighteenth century, experts have tried to tell farmers how to farm. The agricultural enlightenment in Europe marked the beginning of a long arc of new experts aiming to change agricultural knowledge and practice.[2] This enterprise reached into the twentieth century, sprawled out from its European origins around the globe, and might not have concluded to this day. The first agricultural enlightenment thinkers developed new ways of producing agricultural knowledge and historians have used it to explain the period of agricultural intensification between 1750 and 1850.[3] Still, these enlightenment thinkers failed to communicate their insights to farmers at scale. In Europe and North America, agricultural knowledge communication became a problem for the nineteenth century. Only by its conclusion did the various heirs of the agricultural enlightenment begin to develop comprehensive

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[1] E. B. White, *One Man's Meat*, (Gardiner, Maine: Tilbury House, 1997), 246.
[2] Marcus Popplow identifies this period as the economic enlightenment in which he places an agricultural perspective, see Marcus Popplow, *Landschaften agrarisch-ökonomischen Wissens: Strategien innovativer Ressourcennutzung in Zeitschriften und Sozietäten des 18. Jahrhunderts* (Waxmann Verlag, 2010); Marcus Popplow, "Economizing Agricultural Resources in the German Economic Enlightenment," in: Ursula Klein und E. C. Spary (eds.), *Materials and Expertise in Early Modern Europe. Between Market and Laboratory*, (Chicago and London: University of Chicago Press, 2010), 261-287. Peter Jones identifies this period as the agricultural enlightenment, Peter M. Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature, 1750-1840* (Oxford: Oxford University Press, 2016).
[3] For an insightful summary of what they term the first agricultural revolution, 1750-1850, see Peter Moser and Tony Varley, "The state and agricultural modernization in the nineteenth and twentieth centuries in Europe," in Peter Moser and Tony Varley (eds.), *Integration through Subordination the Politics of Agricultural Modernisation in Industrial Europe* (Turnhout, Belgium: Brepols, 2013) 13-40.

ways to communicate agricultural innovation to farmers. Their co-developed configuration of how to convince farmers of new ways to farm would then shape the twentieth century and beyond. This study analyzes the pivotal period in the late nineteenth and early twentieth century and asks: How did the negotiation of agricultural knowledge work? How did the process change? How did disparate groups of actors reach agreement over each of their roles and the novelty and usefulness of the agricultural knowledge each produced?

For decades now, historians of science have expanded their object of study to a history of knowledge more broadly understood. With the fundamental insight that scientific practice was situated in space and time, scientific knowledge production and communication was no longer self-evident as universal, as scientists claimed, but required analysis like all manners of knowledge making. Indigenous knowledge, the know-how of craftspeople, and farmers' knowledge have taken their place next to science in historical analysis. The significant moment of knowledge production was no longer the moment of "discovery" but rather the movement, translation, and negotiation of knowledge. Rather than assuming "diffusion" of knowledge into the vague mass of the public, the negotiation of knowledge takes center stage. Just as knowledge production was historically contingent, so was its communication and negotiation. People adapted knowledge "in the shape of matter, words, and practices"[4] to new local contexts around the globe. Knowledge was malleable and mutable to be understood and useful to different people in different places. This was also true for agricultural knowledge.[5]

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[4] Stefanie Gänger, *A Singular Remedy: Cinchona across the Atlantic World, 1751-1820* (Cambridge: Cambridge University Press, 2021), 3.

[5] This state of the field has been well summarized in James A. Secord, "Knowledge in Transit," *Isis* 95, no. 4 (2004): 654–72. The mutability of knowledge to enable its movement addresses the earlier conceptualization of "immutable mobiles" by Bruno Latour as the foundation of knowledge movement. See David Kaiser, *Drawing Theories Apart: The Dispersion of Feynman Diagrams in Postwar Physics* (Chicago: The University of Chicago press, 2005). Latour's idea of immutable mobiles was first developed in Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge: Harvard University Press, 1987). This direction in the history of science reconfigures what sociologists have defined as "diffusion of innovation," most prominently developed by Everett M. Rogers. Much of Rogers' model finds evidence in this study although especially his quantitative data on how many farmers accepted new practices is largely impossible to prove in the historical sources of the nineteenth century. Even though Rogers' framework has been developed to address some of its biases, I foreground the co-production and negotiation of innovation to highlight the agency of all actors involved as constituent of innovation rather than as obstacles for promoters of innovation to overcome. Rogers' model

In recent years, historians of agricultural knowledge in Europe and North America have used insights from the history of science to push for analysis of larger patterns. Studies of local, situated knowledge production by non-scientists have proven the multiplicity of knowledge and its producers. Recent studies have gone beyond formal institutions concerned with agricultural knowledge towards the new history of capitalism. So rather than focusing on the dichotomy scientists, farmers, and advisors or extension agents produced between "theory" and "practice," historians of agricultural knowledge have begun to look at the knowledge production of market agents, such as seedsmen or livestock breeders. Still, the key analytical concept has been the negotiation of knowledge: the idea that agricultural knowledge was always part of a negotiation process between disparate groups of experts with their own goals, practices, kinds of evidence, and communication strategies. These actor groups depended on one another, leading some studies to describe them as a knowledge society.[6]

The concept of an agrarian-industrial knowledge society is the most promising starting point for framing larger patterns in the history of agricultural knowledge in the late nineteenth and early twentieth century. Developed by Peter Moser, Juri Auderset, and other historians of the Archives of Rural History in Bern, Switzerland, the concept of the agrarian-industrial knowledge society provides two fundamental

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developed from agricultural extension research and activism to tell farmers how to farm. It thus appears as a long-term product of the historical processes I analyze in this study. Everett M. Rogers, *Diffusion of Innovations*, 5th edition., Free Press trade pbk. edition (New York: Free Press, 2003).

[6] For an overview of recent developments in the history of agricultural knowledge, see Albert G. Way and William Thomas Okie, "Roundtable: Agricultural History and the History of Science," *Agricultural History* 92, no. 4 (Fall 2018): 569–604; Denise Phillips and Sharon E Kingsland, *New Perspectives on the History of Life Sciences and Agriculture* (Cham: Springer, 2015). As instructive and transformative examples for these shifts, see Emily Pawley, *The Nature of the Future. Agriculture, Science, and Capitalism in the Antebellum North.* (Chicago: The University of Chicago Press, 2020); Juri Auderset and Peter Moser, *Die Agrarfrage in der Industriegesellschaft: Wissenskulturen, Machverhältnisse und natürliche Ressourcen in der agrarisch-industriellen Wissensgesellschaft (1850-1950).* (Köln: Böhlau, 2018); Frank Uekötter, *Die Wahrheit ist auf dem Feld: eine Wissensgeschichte der deutschen Landwirtschaft* (Göttingen: Vandenhoeck & Ruprecht, 2010); Jonathan Harwood, *Technology's Dilemma: Agricultural Colleges between Science and Practice in Germany, 1860-1934* (Oxford: P. Lang, 2005). For the concept of knowledge negotiation in the history of science, see especially the work of Lorraine Daston, e.g. Lorraine Daston, "On Scientific Observation," *Isis* 99, no. 1 (2008): 97–110; Lorraine Daston, "Why Are Facts Short?," *A History of Facts.*, 2001, 5–21; Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2014). I distinctly refer to the movement and negotiation of knowledge rather than its circulation as the latter term evokes an image of free flow that does not address the obstacles, detours, and one-way streets that were part of these processes. See, Stefanie Gänger, "Circulation: Reflections on Circularity, Entity, and Liquidity in the Language of Global History," *Journal of Global History* 12, no. 3 (November 2017): 303–18.

insights to this study. First, it bounds the group of actors relevant to the study of agricultural knowledge in Europe and North America between 1850 and 1950. The agrarian-industrial knowledge society was an "ensemble of actors, institutions, discourses, and practices."[7] The people who came to understand themselves as a community concerned with changing agriculture were "male and female farmers as well as farmhands, scientists, agronomists, teachers, students, newspaper editors, and civil servants and politicians."[8] Second, it defines the fundamental epistemological dynamic of their interactions. The drive of innovation in this period pushed for bringing concepts and practices from industry to agriculture, the former deemed progressive, the latter in need of progress. This push was quickly found to require repeated adaptation. Industry was powered by mineral resources from the lithosphere. This allowed continuous, linear production. A factory powered on coal, for example, could operate at will without stopping, almost anywhere at any time, as long as there was coal. Agriculture was powered by organic resources from the biosphere. This required cyclical, seasonal reproduction. The plants, animals, and soils on a farm reproduced themselves with the seasons. Most innovations in this time frame attempted to treat living organisms as dead, controllable resources. Animals, plants, and soils were to be standardized machines but refused to comply. The fundamental negotiation of knowledge was whether and how to apply industrial concepts and practices to the organisms of agriculture.[9]

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[7] Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*, 11. Original: "Ensemble von Akteuren, Institutionen, Diskursen und Praktiken."

[8] Juri Auderset, Beat Bächi, and Peter Moser, "Die Agrarisch-Industrielle Wissensgesellschaft Im 19./20. Jahrhundert: Akteure, Diskurse, Praktiken," in *Geschichte Im Virtuellen Archiv. Das Archiv Für Agrargeschichte Als Zentrum Der Geschichtsschreibung Zur Ländlichen Gesellschaft*, ed. Beat Brodbeck, Martina Ineichen, and Thomas Schibli, vol. 3, Studien Und Quellen Zur Agrargeschichte/Etudes et Sources de l'histoire Rurale (Baden: hier + jetzt, 2012), 24. Original: "Bäuerinnen und Bauern als auch Dienstboten, Wissenschafter, Agronomen, Lehrer, Schüler, Zeitungsredaktoren sowie Beamte und Politiker."

[9] Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*; Auderset, Bächi, Moser, "Die agrarisch-industrielle Wissensgesellschaft im 19./20. Jahrhundert: Akteure, Diskurse, Praktiken," 21-38; Moser and Varley, "The state and agricultural modernization in the nineteenth and twentieth centuries in Europe." See also Jonathan Harwood, "Die Agrarfrage in Der Industriegesellschaft: Wissenskulturen, Machtverhaeltnisse Und Natuerliche Ressourcen in Der Agrarisch-Industriellen Wissensgesellschaft (1850-1950)," *Agricultural History* 93, no. 1 (Winter 2019): 191–93. Their concept of the agrarian-industrial knowledge society expands on the concept of the agricultural knowledge society by Frank Uekötter to point out that between 1850 and 1950, there was such amalgamation between agriculture and industry that it became impossible to tell where one ended and the other began, see Uekötter, *Die Wahrheit ist auf dem Feld.*

Several histories of agricultural knowledge have begun this analysis to explain how agriculture became damaging to its own environmental foundation. The ways human societies today produce the bulk of their own food and other agricultural commodities do not acknowledge ecological limits to growth. What happened to the farming knowledge of these limits? I argue that analyzing how the constellations and functions of actors in the agrarian-industrial knowledge society were negotiated can provide insights into how agriculture became unsustainable and how we might start to change that.[10]

**Functional knowledge history: Defining knowledge systems and actor groups**

I propose in this study a functional approach to analyzing the negotiation of agricultural knowledge through its communication in things, words, and practices. To find out how agricultural knowledge negotiation worked, I look at how those negotiating imagined it should work. The actors of the agrarian-industrial knowledge society pulled in different directions and formed groups to produce their own expertise, expert communities, and thus power. I use the idea of knowledge systems to describe actor groups' shared envisioning of how transmission of innovation into use was supposed to function. Actor groups were guided in their behavior and communication by their imagination of ideal constellations of actors, their expertise, and their functions. In these knowledge systems, each actor group also defined its own expertise – the practices, evidence, and knowledge only they had intellectual authority over – as counters to the expertise of other actor groups.[11] While their idealized constellations of knowledge makers differed, all actor groups knew they depended on each other. As a result, the process of knowledge negotiation was not a hierarchical process. It bound power and innovation to context. Each group only held power to define what was new and useful agricultural knowledge in specific contexts, for specific audiences, in specific places. Expertise was relative. Innovation was relative. A patchwork of expertise enabled the negotiation and thus change of agricultural knowledge and practice all the way into

[10] Compare Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*; Uekötter, *Die Wahrheit ist auf dem Feld*.
[11] See John Hardwig, "Epistemic Dependence," *The Journal of Philosophy* 82, no. 7 (1985): 335–49.

use. As much as historians might want to privilege scientists, improvers, market agents, or farmers, one type of expertise was not better than the other. They were only good together.[12]

A functional approach in knowledge history requires the definition of analytical categories rather than the use of contemporary self-identifications. This is of particular relevance in agricultural history. The formative studies in the field tend to use the terms contemporaries used to describe what they perceived as their expert community on agriculture, generally summarized as the camps of "theory" as opposed to "practice." Historians of science, however, contend that this dichotomy should not be accepted uncritically as it is a product of historically contingent knowledge production. Early modern enlightenment thinkers began to establish the difference between the knowledge of the hand as opposed to the knowledge of the mind to build their own expertise. Greats of the so-called scientific revolution like Francis Bacon, Descartes, and Galileo began to work with and observe artisans and their practice to produce their own knowledge expressed as "laws of nature." So, accepting the dichotomy of theory and practice obscures rather than illuminates processes of knowledge making. Contemplation and manipulation were always intertwined. All actors in the agrarian-industrial knowledge society used their hands and minds to know the land. Some just strategically hid this fact to produce their own expertise. My analytical categories emerged empirically from my research and allow me to look behind historical actors' strategic self-identifications to how they produced knowledge and organized knowledge producers.[13]

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[12] This functional approach and concept of knowledge systems builds on ideas in Uekötter, *Die Wahrheit ist auf dem Feld*; Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*; Harwood, *Technology's Dilemma*.
[13] See Lissa Roberts and Simon Schaffer, "Preface," in *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation*, ed. Lissa Roberts, Simon Schaffer, and Peter Dear, vol. 9, History of Science and Scholarship in the Netherlands (Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2007), XIII–XXVII. In a similar vein, I refrain from using the concept of "modernity" or "progress" as other means by contemporaries and historians to classify specific knowledge as superior and turned to the future over other knowledge which was inferior and belonging to the past. Improvers called themselves "intelligent farmers" to present themselves as rational, progressive and modern, in stark contrast to "dumb farmers," irrational, backward, and traditional. All uses of these and related terms I use to echo the arguments of contemporaries, not my own. Compare e.g. Dipesh Chakrabarty, *Provincializing Europe: Postcolonial Thought and Historical Difference*, Reissue, with a new preface by the author, Princeton Studies in Culture, Power, History (Princeton: Princeton University Press, 2008).

In the following chapters, I define four actor groups by their knowledge systems: scientists, improvers, market agents, and farmers. Individual historical actors could move between these groups and their knowledge systems. In fact, much of knowledge negotiation depended on such border crossers. Depending on the specific context and acquisition of expertise, an educated estate manager could choose to become a scientist, an improver, a market agent, or even a farmer. Not all historical actors had the privilege of such opportunity and the shifting between expert groups was certainly not fluid and without obstacle. Still, historical actors were not bound to one expert group and its knowledge system.

In the description of each knowledge system, I identify functional roles as descriptive concepts distinct from historical actors and their actions. This facilitates disambiguation between people within the historical record and functional positions within a knowledge system. Actors assigned roles to other actors in specific constellations. I represent these idealized constellations and the communication between them in diagrams in each chapter.

Each chapter provides a more comprehensive definition of the actor group it covers, which can be summarized as follows. *Scientists* produced agricultural knowledge by experiment, chemical analysis, and mathematical calculation removed from economic pressures. In agricultural colleges and experiment stations, they did not have to produce financial profit but the knowledge for others to do so. Their innovation was in principles: new knowledge deemed universal, but useless without adaptation to place. *Improvers* farmed themselves, whether only in management or working the land with their own hands. They had the means to invest time, learning, and money into trials of new methods for a net profit. Whether learning scientists' principles or other improvers' trials elsewhere, improvers had the ability to adapt knowledge from other places to their place. Their successful trials served as evidence for improvers vocally promoting their innovation in place to those farming in the same place. *Farmers* stood at the opposite end of a spectrum to improvers. They also farmed, but they did not have the means to learn, adapt, or even trust knowledge from far away. Farm families looked to their neighbors and tried the new ideas, methods, and materials they saw and talked about on their own farm. Many outsourced the adaptation costs of innovation in place to nearby improvers. Once improvers and neighbors were making a secure profit from a given innovation, farm families could begin integrating it into their home – all the people, animals, plants, and materials that made life familiar, projectable, and homely. *Market agents* collaborated with all three of these groups in developing and then selling new material farm inputs for a profit. Their innovation in things packaged new knowledge into objects and materials designed to fit customer expectations. They had to be easy to use yet effective. Consumers invested money into products rather than time into learning. This was the key to surviving market competition.

Other key actors of the agrarian-industrial knowledge society were extension agents and state agents. Extension agents were college-educated teachers or advisors of farmers. They were the result of negotiation between scientists and improvers and then also engaged with market agents to reach farmers. The emergence of extension and its influence runs through all four chapters. Educated by scientists, extension agents for the most part embraced the scientific knowledge system. Their role was to translate innovation in principles to improvers and farmers. State agents were recruited from the ranks of scientists, improvers, farmers, and market agents. Putting themselves into the service of the state, politicians and civil servants essentially played the role of deciders between actor groups and their knowledge systems. They controlled much of the funding that enabled agricultural innovation, so winning their trust of the expertise of one's own actor group was paramount. By means of laws, state agents also influenced the interactions and negotiations between the other actor groups. On a fundamental level, state agents enacted national policy to intensify domestic agricultural production, create a reliable food supply, and grow the national economy. While state agents and their knowledge system might be deserving of their own analysis, this study treats them as powerful allies and financiers of other actor groups throughout all chapters.[14]

## **Contrasts to ideal conditions: Western Maine and the Sauerland as case studies**

[14] For extension agents, compare Abbe L. Karmen, "Putting the House in Order: Women's Cooperative Extension Work in the Early Twentieth Century," *Maine Historical Society Quarterly* 32, no. 1 (March 1992): 30–50. For bureaucrats, compare Peter Becker and William Clark, "Introduction," in Peter Becker and William Clark, eds., *Little Tools of Knowledge: Historical Essays on Academic and Bureaucratic Practices* (Ann Arbor: University of Michigan Press, 2004) 1-34.

To tell an inclusive and representative story of agricultural knowledge negotiation, all key actor groups have to be represented. This influenced the choice of study area. The United States and Germany in the late nineteenth century fulfill this requirement particularly well. Agricultural science found its most influential professionalization in mid-nineteenth-century German lands. German scientists became world leaders in agricultural research before American scientists joined them in the early twentieth century. In both countries, improvers developed strong and long-lasting movements beginning in the 1830s and 1840s. Industrialization took off in both countries in the second half of the nineteenth century, and both became countries among the most industrialized in the world. Early on, market agents were able to develop new farm inputs by industrial means and industrial mindsets. Still, the majority of the population in both countries was still involved with producing at least part of their own food through farming. Scientists, improvers, market agents, and farmers all developed strong positions in the United States and in Germany, turning them into forerunners of agricultural knowledge negotiation.[15]

Most previous studies have neglected the agency of farmers in agricultural knowledge negotiation.[16] This is not surprising, especially for periods before the twentieth century. Farmers were by far the largest group of actors in the agrarian-industrial knowledge society but they have left the fewest written sources. Accessing their decision processes, communication, and innovation remains difficult. This study addresses these difficulties with hard-to-find well-documented case studies, mixed methods including data visualization and mapping, and the particular choice of study regions. Scientists, improvers, and market agents usually developed innovation for ideal farming conditions. Negotiations with farmers in less than ideal agricultural regions puts the processes of knowledge communication into sharper relief.

[15] Frank Uekötter justified this comparison for the late nineteenth and twentieth century well, see Frank Uekötter, “Why care about dirt? Transatlantic perspectives on the history of agriculture,” in *GHI Bulletin* 39 (Fall 2006), 65-77.

[16] Even Auderset and Moser’s groundbreaking study has been accused of this shortcoming, see e.g. Clemens Zimmermann: Review of *Auderset, Juri; Moser, Peter: Die Agrarfrage in der Industriegesellschaft. Wissenskulturen, Machtverhältnisse und natürliche Ressourcen in der agrarisch-industriellen Wissensgesellschaft (1850–1950)*, In: H-Soz-Kult, 05.12.2018, www.hsozkult.de/publicationreview/id/reb-27666.

Western Maine and the Sauerland were challenging agricultural regions within their contexts in New England and Westphalia. Mountainous terrain, thinner soils, colder climate, less infrastructure, remote location, worse market connections, and poorer farmers: in all these ways western Maine and the Sauerland resembled other challenging farming regions within the United States and Germany. In the late nineteenth century, mixed composite farms dominated both landscapes. Farmers mixed their land use between varied field and livestock farming as well as private forest use, which spread risk between multiple types of crops and livestock. This also structured daily labor rhythms through the seasons. Farm families used their produce themselves, bartered with neighbors, or sold to local merchants. This strategy allowed flexible responses to market fluctuations. Like on a stool with three legs, farm families could lean on use, barter, or sale depending on market prices for their produce.[17] These farms provided a stark contrast to agricultural intensification in the image of industry. Farmers in challenging regions could not follow ideals of specialization, monoculture, high financial investment, and market production without significant adaptation.[18]

[17] For the concept of composite farming, see Daniel Vickers, "Competency and Competition: Economic Culture in Early America," *The William and Mary Quarterly*, Third Series, 47, no. 1 (January 1, 1990): 3–29; Daniel Vickers, *Farmers and Fishermen: Two Centuries of Work in Essex County, Massachusetts, 1630-1850* (Chapel Hill: Published for the Institute of Early American History and Culture, by the University of North Carolina Press, 1994). See also, Brian Donahue, *The Great Meadow: Farmers and the Land in Colonial Concord*, Yale Agrarian Studies (New Haven: Yale University Press, 2004).

[18] For Maine, see Stephen J Hornsby, Richard William Judd, and Michael J Hermann, *Historical Atlas of Maine* (Orono, ME: University of Maine Press, 2015), plate 29, 53; James B. Vickery, Richard W. Judd, and Sheila McDonald, "Maine Agriculture, 1783-1861," in *Maine: The Pine Tree State from Prehistory to the Present*, ed. Richard W. Judd, Edwin A. Churchill, and Joel W. Eastman (Orono, Me: University of Maine Press, 2011), 242–61; Clarence Albert Day, *Farming in Maine, 1860-1940*, University of Maine Studies, 2d ser., no. 78 (Orono: University of Maine Press, 1963). For the Sauerland, see Karl Ditt, "Aufstiege und Niedergänge: Sektoren, Branchen und Räume der Wirtschaft," in *Westfalen in der Moderne 1815-2015: Geschichte einer Region*, 2nd ed. (Münster: Aschendorff, 2015), 235–68; Michael Kopsidis, *Marktintegration und Entwicklung der westfälischen Landwirtschaft 1780-1880: marktorientierte ökonomische Entwicklung eines bäuerlich strukturierten Agrarsektors* (Münster: Lit, 1996); Bernward Selter, *Waldnutzung und ländliche Gesellschaft: landwirtschaftlicher "Nährwald" und neue Holzökonomie im Sauerland des 18. und 19. Jahrhunderts* (Paderborn: F. Schöningh, 1995).

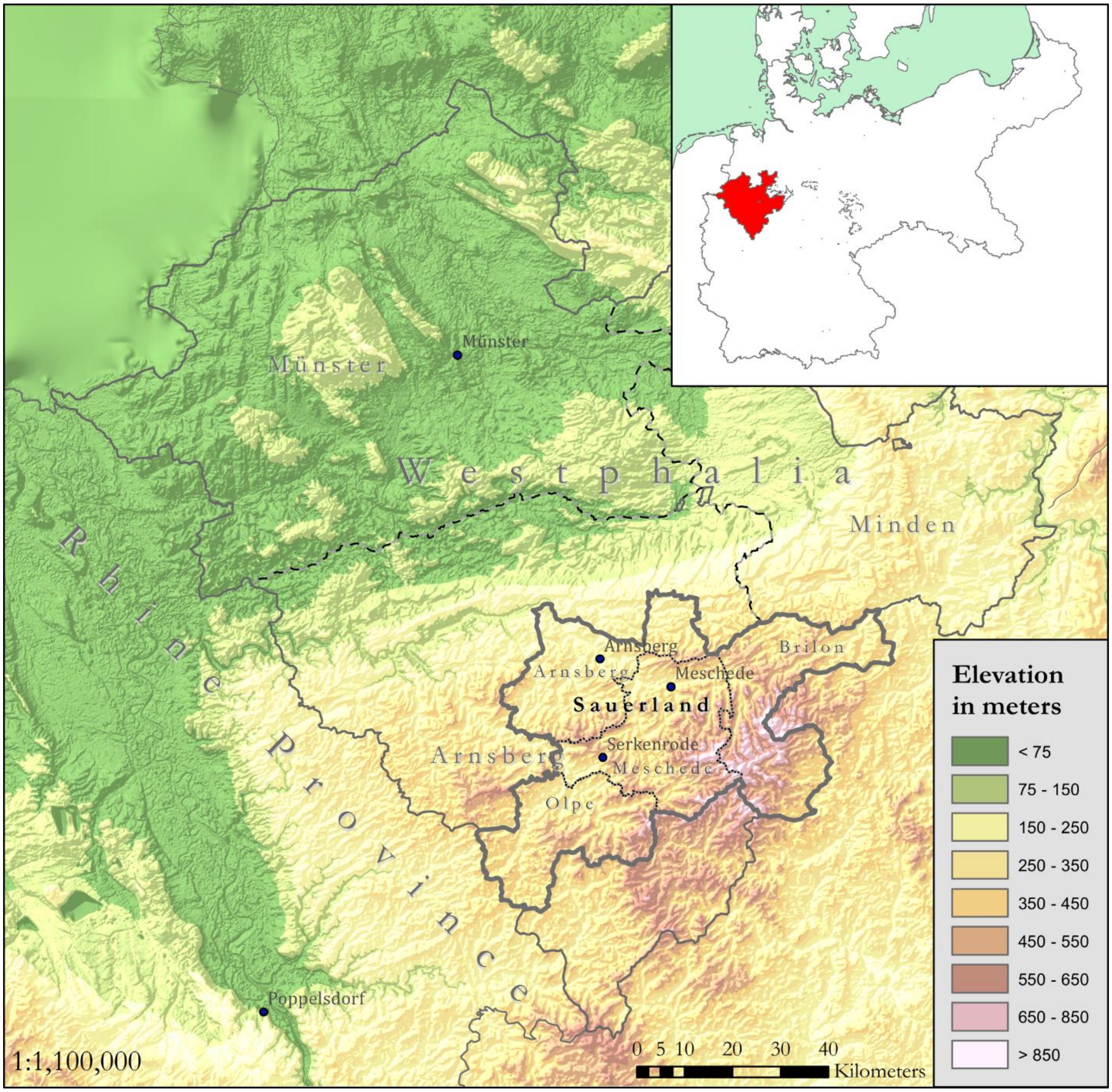


Figure 1. The Sauerland study area in Westphalia, Germany, in 1890.[19]

[19] The map was made from these datasets: Digitales Geländemodell Gitterweite 200 m, Bundesamt für Kartographie und Geodäsie, GeoBasis-DE, 2021. Retrieved from https://gdz.bkg.bund.de/index.php/default/digitale-geodaten/digitale-gelandemodelle/digitales-gelandemodell-gitterweite-200-m-dgm200.html; Administrative District Boundaries, Germany, 1890s. [Shapefile]. Harvard Geospatial Library. Retrieved from https://earthworks.stanford.edu/catalog/harvard-germany-admin-1890; Tom Patterson and Nathaniel Vaughn Kelso. 1:10m Physical Vectors, Natural Earth. retrieved from https://www.naturalearthdata.com/downloads/10m-physical-vectors/.

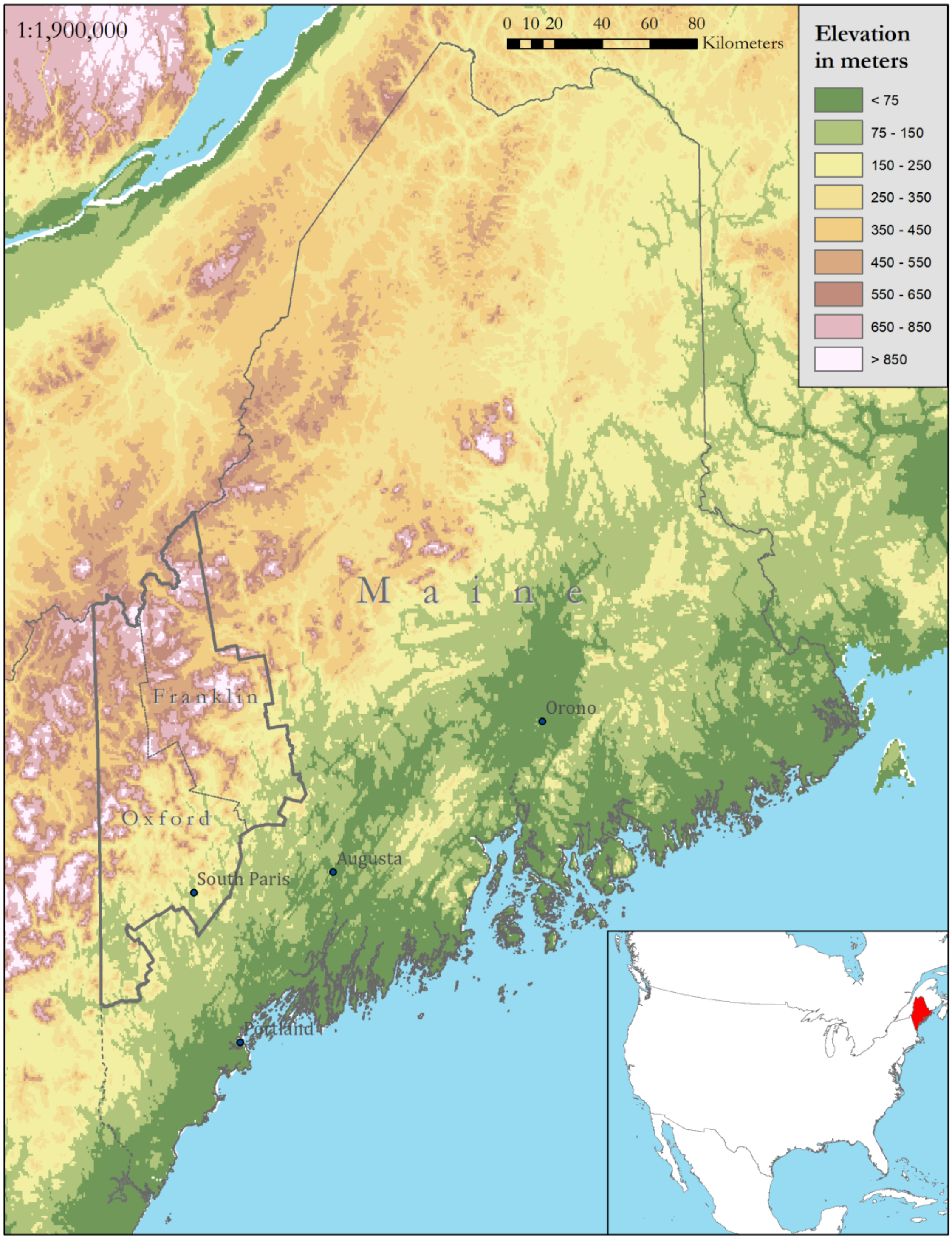


Figure 2. The Western Maine study area in Maine, United States, in 1890.[20]

[20] The map was made from these datasets: 30 arc-second DEM of North America, National Aeronautics and Space Administration (NASA), the United Nations Environment Programme/Global Resource Information Database

While similar in their challenging conditions within their contexts, western Maine and the Sauerland were of course different from each other in specific ways. Generally, they demonstrate the difference between American and European farming. Land was abundant in the United States but labor was scarce. Land was scarce in Europe but there was much more labor available. Where the Sauerland contained around 700,000 acres (285,000 hectares), the settled southern third of Western Maine was slightly larger than that.[21] Western Maine contained far fewer but much larger farms than the Sauerland (see Figures 3 and 4). Even though American census takers excluded "mere cabbage and potato patches, family vegetable gardens,"[22] which Prussian census takers did not, it becomes clear that there were many more smallholders in the Sauerland than in western Maine but also that "small" was relative (see Figures 5 and 6). Their remote location, as farmers and improvers identified it themselves, was also relative. Market links depended most on railroad connections in the late nineteenth century. Railroad construction in Maine happened through private companies whereas the German state built railroads in the Sauerland. South Paris was among the first towns in western Maine to gain a station in 1850, and thus a direct link to

(UNEP/GRID), the U.S. Agency for International Development (USAID), the Instituto Nacional de Estadistica Geografica e Informatica (INEGI) of Mexico, the Geographical Survey Institute (GSI) of Japan, Manaaki Whenua Landcare Research of New Zealand, and the Scientific Committee on Antarctic Research (SCAR). Retrieved from: https://www.arcgis.com/home/item.html?id=5771199a57cc4c29ad9791022acd7f74#!; Steven Manson, Jonathan Schroeder, David Van Riper, Tracy Kugler, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 15.0, US County 1890, 2008 Tiger Line. Minneapolis, MN: IPUMS. 2020. http://doi.org/10.18128/D050.V15.0; Tom Patterson and Nathaniel Vaughn Kelso. 1:10m Physical Vectors, Natural Earth. retrieved from https://www.naturalearthdata.com/downloads/10m-physical-vectors/.

[21] I define the Sauerland to be north of the Siegerland, the mountains to the south of it, where there was a considerable mining industry which shaped the local agricultural economy to be not quite as challenging as in the Sauerland. The county boundaries only approximate the less defined geographical and cultural boundaries of the Sauerland, but they capture the topography, challenging environment, and identifications as the "mountain counties" (*Gebirgskreise*) of the time, excluding the lower counties closer to the industrial Ruhr region to the west. For the economic considerations for my definition, see Kopsidis. For definitions of the Sauerland, especially as a "backward" region, see Karl Ditt, "Einleitung," in *Westfalen in der Moderne 1815-2015: Geschichte einer Region*, 2nd ed. (Münster: Aschendorff, 2015), 13–23.; Harm Klueting, "Kurkölnisches Herzogtum Westfalen oder (kur-) kölnisches Sauerland: Zur Einleitung," in *Das Herzogtum Westfalen: Das ehemalige kurkölnische Herzogtum Westfalen im Bereich der heutigen Kreise Hochsauerland, Olpe, Soest und Märkischer Kreis (19. und 20. Jahrhundert)*, ed. Harm Klueting and Jens Foken, vol. 2, 2 (Münster: Aschendorff, 2012), 13–20; Hans-Joachim Behr, "Staat und Politik im 19. Jahrhundert," in *Das Herzogtum Westfalen: Das ehemalige kurkölnische Herzogtum Westfalen im Bereich der heutigen Kreise Hochsauerland, Olpe, Soest und Märkischer Kreis (19. und 20. Jahrhundert)*, ed. Harm Klueting and Jens Foken, vol. 2, 2 (Münster: Aschendorff, 2012), 21–82.

[22] Census Office, *Ninth Census, United States, 1870: Instructions to Assistant Marshals* (Washington: Government Printing Office, 1870), 18.

Portland and Boston to the south and Canada to the west. The slow railroad expansion through the narrow valleys of the Sauerland, however, reached Serkenrode in 1911, making it one of the last towns to gain a rail connection in the region.[23] For the comparative sections of this study, these differences are important, but for the functional analysis of knowledge negotiation, their broadly similar contexts as challenging regions provide a basis for comparing their agricultural histories.

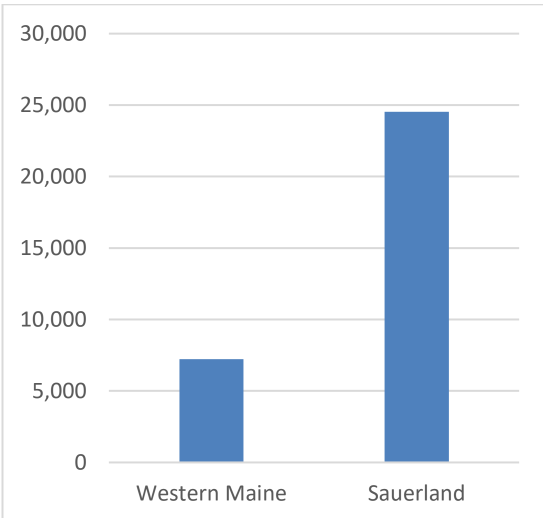


Figure 3. Number of farms in western Maine in 1880 and the Sauerland in 1882.[24]

[23]William Berry Lapham and Silas P. Maxim, *History of the Town of Paris, Maine* (Somersworth, N.H: New England History Press, 1983), 175-176; Hornsby, Judd, and Hermann, *Historical Atlas of Maine*, plate 43. For Serkenrode and the Sauerland, see Arbeitsgemeinschaft Dorfchronik Serkenrode/Schliprüthen, *Serkenrode Und Das Kirchspiel Schliprüthen Im Kurkölnischen Sauerland* (Paderborn: Bonifatius Druckerei, 1991), 499-500; Ralf Roth, *Das Jahrhundert der Eisenbahn: die Herrschaft über Raum und Zeit 1800-1914* (Ostfildern: Thorbecke, 2005); Christopher Kopper, “Räumliche Integration: Verkehr und Mobilität,” in *Westfalen in der Moderne 1815-2015: Geschichte einer Region*, 2nd ed. (Münster: Aschendorff, 2015), 213–32; Wilfried Reininghaus und Karl Teppe, *Verkehr und Region im 19. und 20. Jahrhundert: westfälische Beispiele* (Paderborn: F. Schöningh, 1999).
[24] Steven Manson, Jonathan Schroeder, David Van Riper, Tracy Kugler, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 15.0, 1880 Census: Agriculture Data [US, States & Counties]. Minneapolis, MN: IPUMS. 2020. http://doi.org/10.18128/D050.V15.0; Königliches Statistisches Bureau in Berlin, *Die Ergebnisse Der Berufszählung Vom 5. Juni 1882 Im Preussischen Staate: Landwirthschaftsbetriebe sowie Hauptberuf Und Religionsbekenntniss Der Bevölkerug*, vol. 3, Preussische Statistik, LXXVI (Berlin: Verlag des Königlichen Statistischen Bureaus, 1885), 186-187, 190-191.


Figure 4: Land in Farms in western Maine in 1880 and the Sauerland in 1882.[25]

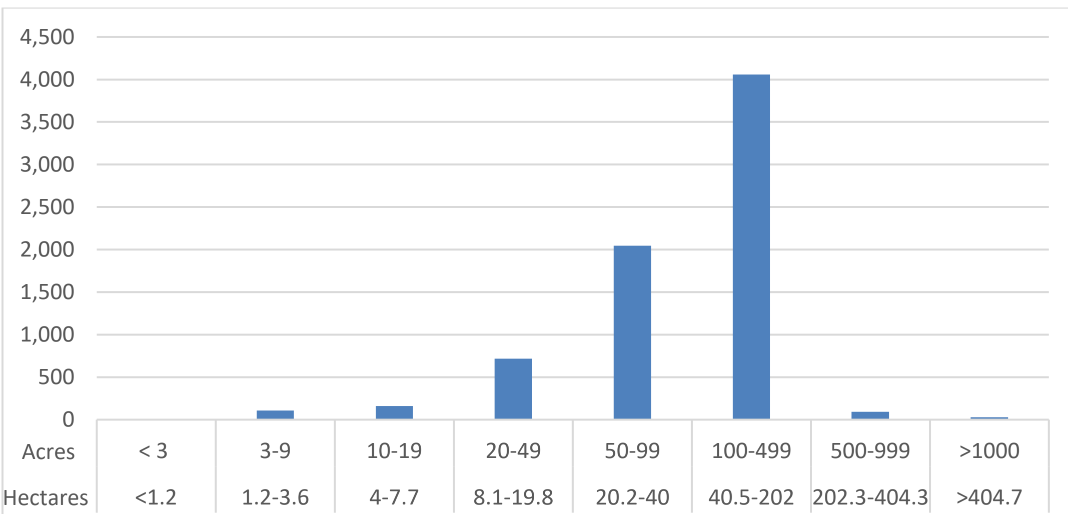


Figure 5: Number of farms by size in western Maine in 1880[26]

[25] Ibid.
[26] Manson et al.

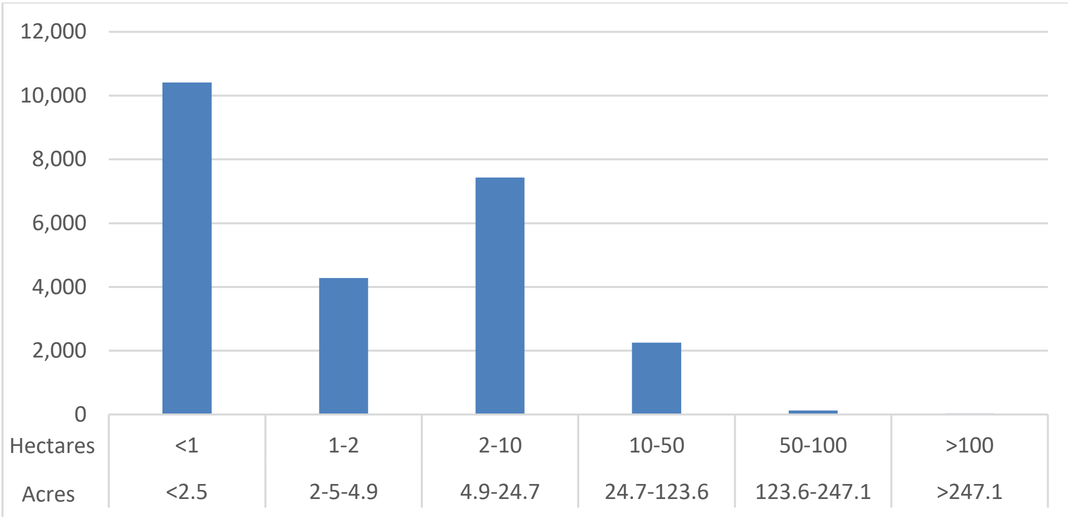


Figure 6: Number of farms by size in the Sauerland in 1882[27]

Of the many challenging farm regions within the United States and Germany, I have chosen western Maine and the Sauerland also for personal reasons. I argue that personal familiarity with the geography and landscape of the places I study is essential to understanding their history. I grew up in the Sauerland and made western Maine my new home. I learned to see the ridges in Sauerland hillsides that mark where farmers once built fences to divide their now merged fields. I have walked along the crumbling stone walls Maine farmers built around their fields now reclaimed by forest. Personal connection to these places was also helpful in building relationships with local historians and descendants of the farmers I study, accessing their private collections, and thus finding sources linked to a particular farm or town, rather than having to rely on insular anecdotes. As a result, I was able to develop microstudies of a well-documented farm in South Paris, Maine, and a well-documented local agricultural association in Serkenrode in the Sauerland. Much of the chapters that follow is written from the vantage points of these towns in their regional contexts.

I join the sources for these case studies with sources for regional and national contexts. For scientists, I trace their academic and popular publications as well as reports and lecture transcripts of

[27] Königliches Statistisches Bureau in Berlin, 186-187, 190-191.

scientist and improver association meetings. Sources to document improver knowledge negotiations include agricultural association and state agency reports and the transcripts of lectures and discussions they contain. I enlarge this source base with the correspondence of agricultural association leaders with state officials as well as articles in farm journals and general newspapers. The chapter on market agents adds to these kinds of sources trade journals, marketing brochures and leaflets, and print advertisement in farm journals and general newspapers. The case studies of farmers use personal records, notebooks, and correspondence by one farm family, association minute books and annual reports, local newspapers, and town records. Spatial and statistical analysis of farm communities in South Paris and Serkenrode is enabled by cadastral and census data.

## Innovation in cattle feeding: An entangled and comparative history of knowledge

Beginning in the 1870s, farmers in challenging agricultural regions like western Maine and the Sauerland faced an existential economic challenge. One of their main cash crops were cereals, especially wheat. In the 1870s, the integration of larger, transatlantic markets through railroads and steamboats connected these challenging regions to the bread baskets of Europe and America.[28] The sprawling wheat fields of the American Mid-West and East Prussia were located in environments that enabled agrarian-industrial economies of scale. Even when transported across the continent or across the Atlantic, the wheat from these regions undercut the prices that made cereal farming in western Maine and the Sauerland profitable. Maine and Sauerland farmers had to find new cash crops, leveraging their farm environments to fill niches in a globalizing market.[29] Farmers in both regions turned to livestock farming to fulfill the demand for meat and especially dairy products of the urban centers in their vicinity. Farmers in western Maine sold to the growing city of Portland, Maine, down the coast to Boston, Massachusetts,

[28] Compare Uekötter, "Why care about dirt?"
[29] Similar processes created commodity frontiers around the globe: finding commodities produced most efficiently in particular environments and most profitably on a global market, compare Sven Beckert, *Empire of Cotton: A Global History*, First edition (New York: Alfred A. Knopf, 2014); Eric Vanhaute, "Commodity Frontiers and the Global History of Capitalism: A Discussion about Sven Beckett's 'Empire of Cotton,'" *Journal of World History* 28, no. 1 (2017): 101–5. See also the journal by the Commodity Frontiers Initiative, https://commodityfrontiers.com/journal/.

and beyond. Farmers in the Sauerland sold to the industrial cities of the Ruhr region.[30] Pushed by changing economies, agricultural intensification and the shift from cereal to livestock farming required a change in agricultural knowledge and practice. This study analyzes the negotiations of agricultural innovation enabling this change.

To elucidate the interactions between actor groups as constituent of knowledge negotiation, I trace one particular area of innovation in its movement between actor groups and places: the feeding of livestock. Historians of agricultural knowledge have produced insightful studies of soil as arguably the most fundamental farm input. Fertilizer was one of the earliest links to industry and global markets. Soil chemistry was the first area where agricultural scientists established their expertise.[31] For late-nineteenth-century western Maine and the Sauerland, however, farmers invested in fertilizers largely to continue cereal farming rather than shift to livestock farming. To analyze this shift, livestock feeding provides a useful example because it was the most immediate way to intensify production. In both regions, various actors identified dairy farming as a solution to loss of cereals as cash crops. They identified more efficient feeding as one of the first and most promising measures to boost milk flow and profits. Cows eat plants. Feeding connected the soil of the farm to its livestock. Industrial food processing increased in late-nineteenth-century Germany and the United States and provided its byproducts as commercial feeds.[32] The most effective of the new industrial byproduct feeds came from processing crops grown by non-white farmers in colonies and the American South. In this light, feeding also connected the soil and livestock of domestic and colonized farmers across the globe. Also, animal nutrition became the second area for agricultural scientists to establish their expertise. Livestock feeding was an area of innovation which connected all key actor groups of the agrarian-industrial knowledge society within the Sauerland and western Maine as well as across the Atlantic and the globe.

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[30] For Maine, see Hornsby, Judd, and Hermann, plate 53; Day. For the Sauerland, see Ditt, "Aufstiege und Niedergänge;" Kopsidis.
[31] See e.g. Uekötter, *Die Wahrheit ist auf dem Feld*; Steven Stoll, *Larding the Lean Earth: Soil and Society in Nineteenth-Century America*, 1st ed (New York: Hill and Wang, 2002).
[32] I generally use the term "feed" to describe plants or plant products added to hay, which I distinguish as "fodder" or "rough fodder" also to include the various grass and legume species which were used to make hay.

The history of agricultural knowledge negotiation in late-nineteenth-century western Maine and the Sauerland is an entangled and a comparative history. As suggested by Jürgen Kocka, such a history requires analysis of interconnections and comparisons between cases.[33] Farmers in Maine and the Sauerland were part of an agrarian-industrial knowledge society which developed across Europe and North America. Scientists' universal claims, improvers' particular trial reports, and market agents' products traveled within and between these continents. They were also the substance of the interactions between these actor groups. Innovations also arrived in the local contexts of South Paris and Serkenrode. This study therefore compares the specific ways in which farmers, scientists, improvers, and market agents produced, received, and adapted new knowledge to particular places. This is a history of how ideas travelled from a Hohenheim laboratory in Germany to a South Paris barn, how peanuts grown in Rufisque, West Africa, were eaten by Serkenrode cows, and how cottonseed meal imported from the American South was discussed in Westphalian farm journals. But this history also uses failed movement and negotiation to reveal the shape of knowledge systems. So this is also a history of how an innovative grass mix did not travel beyond the Sauerland and how a global hype for a new legume variety came to nothing. The differences and similarities between these interactions strengthen my argument: knowledge systems and negotiation processes were shared across the agrarian-industrial knowledge society in North America and Europe, but those systems and processes were always geographically and historically contingent.

## **Institutions and media as knowledge infrastructure: The history of agricultural education and extension in the United States and Germany**

Agricultural education and extension were the institutionalized ways of teaching farmers of all ages how to farm. Extension taught the adults, agricultural education the adolescents. To allow the following chapters a clearer focus on the processes of agricultural knowledge negotiation, I provide here an overview of the institution building which enabled and shaped knowledge negotiations. In this frame

[33] Jürgen Kocka, "Comparison and Beyond," *History and Theory* 42, no. 1 (2003): 39–44.

of reference, I combine American and German histories of agricultural education and extension from the vantage point of Westphalia and New England to showcase their similarities for a functional history of agricultural knowledge. Adapting to different conditions, Americans typically developed functionally equivalent institutions and media shortly after their German counterparts.

Many previous histories of agricultural knowledge have emphasized official institutions and media of education and extension as the only history of how agricultural knowledge and practice changed. A focus on multi-tiered knowledge negotiation makes this perspective problematic. As a result, I reframe the expansive historiography of agricultural extension and education. Creating institutions and media of learning was the building of knowledge infrastructure: a knowledge one-way street, designed to transmit universal claims of scientists without distortion "down" to as many farmers as possible. This was a historical process of centralization, standardization, and hierarchy building between improvers, scientists, and state agents to control agricultural knowledge translation. The substantial role of state funding comes to the fore in this story, first legitimizing improvers, then scientists, and finally promoting their convergence into education and extension.[34]

In the late eighteenth century, enlightenment thinkers and educated elites established the first associations dedicated to the improvement of agriculture in the United States and in Germany. Associations like the Kennebec Agricultural Society established in Hallowell, Maine, in 1787, or the Westphalian Oeconomic Society (*Westfälische Ökonomische Gesellschaft*), established in Hamm and Unna in 1791, connected with kindred individuals and societies but remained largely decentralized and did not attract significant state support. Most importantly, they included not common farmers but wealthy estate owners and local elites employed in state bureaucracies, education, and religion. The goal of these associations was amassing knowledge of how enlightened experimenters or farmers tried new ideas,

[34] Other agricultural histories have chosen different concepts and terminology to describe the same process but have made different emphases which largely accepted the monopolization claims of contemporaries. See e.g. the concept of an "institutional matrix" in Uekötter, *Das Wissen ist auf dem Feld*. Diffusion of innovation studies in the model of Everett M. Rogers include these media and institutions neutrally with all "communication channels" without examining their directed creation. The work of Rogers himself began within extension itself and remains attached to the knowledge system it promotes. See Rogers, *The Diffusion of Innovations*.

methods, materials, or tools to make agricultural production more efficient and more productive. Some of their members published or republished books to promote this knowledge. Removed from the mass of practicing farmers, however, even though these early associations laid foundations for organizing agricultural inquiry, they failed to find comprehensive ways to educate farmers.[35]

A movement of agricultural improvement that included practicing farmers began to develop in the early nineteenth century in both the United States and Germany. Between the 1810s and the 1850s, forerunner associations multiplied and assumed the shape and function they would continue into the twentieth century. Still under the leadership of wealthy estate owners and farmers, these associations included more common farmers in their ranks. Association activities aimed at reaching their farmer members: agricultural fairs often with premium competitions, regular meetings with common readings, discussions, and lectures, and agricultural journals like the *Maine Farmer*, established in 1833, or the *Landwirthschaftliche Zeitung für Westfalen und Lippe* (LZWL), started in 1843.[36] With state governments more interested in knowing and developing natural resources and their agricultural economy, agricultural associations also began to garner limited state funding and institutional support. In both countries, the collaboration between improvers and state agents produced a hierarchical structure of state boards of agriculture down to county agricultural associations and local farmers' clubs, all with partial state funding. After the modest beginnings of the late nineteenth century, improvers sought state support to

[35]Alfred Charles True, *A History of Agricultural Education in the United States, 1785-1925.*, United States. Dept. of Agriculture. Miscellaneous Publication No. 36 (Washington: Govt. Print. Off., 1925), 7-17; Samuel Lane Boardman, *Agricultural Bibliography of Maine. A List of Maine Writers on Agriculture with Biographical Sketches and a Catalogue of Their Works. Also an Index to the Volumes on the Agriculture of Maine from 1850 to 1892.* (Augusta: Burleigh & Flynt, printers to the state, 1893), 1-5; Matthias Frese, "Zwischen Beratung und Lobbyismus: Interessenvertretungen der Landwirtschaft," in *Westfalen in der Moderne 1815-2015: Geschichte einer Region*, 2nd ed. (Münster: Aschendorff, 2015), 385-386; Hans-Joachim Behr, "Das Landwirtschaftliche Vereinswesen Westfalens Im 19. Jahrhundert," *Westfälische Forschungen* 39 (1989): 180-182; Clarence Albert Day, *A History of Maine Agriculture, 1604-1860*, University of Maine Studies, no. 68 (Orono, Me: Printed at the University Press, 1954). See also Marcus Popplow, *Landschaften agrarisch-ökonomischen Wissens.* Marcus Popplow, "Economizing Agricultural Resources in the German Economic Enlightenment."

[36] Both publications began under different names in these years and only changed these permanent names subsequently.

institutionalize their educational programs, increase the number of associations, and thus expand their reach to adult and adolescent farmers.[37]

At the same time, scientists began to turn to agriculture as a field of academic study and learning. In the early nineteenth century, agriculture became a commercial subject of study rooted in the natural sciences. Eighteenth-century German administrative sciences (*Kameralwissenschaften*) included agriculture from a state-management perspective but included practice or experiments in farming as much as classical studies in both German and American universities: not at all. In response, both countries experienced movements for the establishment of agricultural schools which combined scientific study with practical farming.[38]

In Germany, this movement was successful in garnering state funding and improver collaboration. Following the model of Albrecht Daniel Thaer's agricultural academy at Möglin, founded in 1806, the agricultural academy became the dominant institution for formal training in agriculture until mid-century. By 1858, eleven such academies had been established in German lands, prompting practice-oriented reform at universities devoted to the administrative sciences and the establishment of lower-level

[37] Marten Pelzer, "Landwirtschaftliche Vereine als Wissensagenturen: ökonomische Aufklärung und Agrarmodernisierung am Beispiel der 'Höferegulierung' im ehemaligen Fürstentum Lüneburg," *Rheinisch-westfälische Zeitschrift für Volkskunde*, 2013, 29–58; Marten Pelzer, "'Was die Schule für das heranwachsende Geschlecht ist, das ist der landwirtschaftliche Verein für die ältere Landwirte ...': Bildungsanspruch und -wirklichkeit landwirtschaftlicher Vereine im 19. Jahrhundert," *Zeitschrift für Agrargeschichte und Agrarsoziologie* 52, no. 2 (2004): 41–58; Behr, "Das Landwirtschaftliche Vereinswesen Westfalens Im 19. Jahrhundert;" Frese; True, *A History of Agricultural Education*, 23-94; Pawley, *Nature of the Future*; Sally McMurry, "Who Read the Agricultural Journals? Evidence from Chenango County, New York, 1839-1865," *Agricultural History* 63, no. 4 (October 1989): 1–18; Boardman, *Agricultural Bibliography of Maine,* 5-18; Thomas Reznick, "From the Fair to the Laboratory: The Institutionalization of Agricultural Science and Education in Maine," *Maine History* 43, no. 4 (2008): 411–32.; Day, *A History of Maine Agriculture, 1604-1860*; Stoll. A similar process unfolded in Canada, see Graeme Wynn, "Exciting a Spirit of Emulation Among the 'Plodholes': Agricultural Reform in Pre-Confederation Nova Scotia," *Acadiensis* 20, no. 1 (1990): 5–51

[38] Albrecht Daniel Thaer was the most influential actor in this shift, but he was part of larger historical process legitimizing the academic study of agriculture. Verena Lehmbrock, *Der denkende Landwirt: Agrarwissen und Aufklärung in Deutschland : 1750-1820* (Köln, Weimar, Wien: Böhlau Verlag, 2020); Verena Lehmbrock, "Lob Des Handwerks: Wissenstheorie Heute Und Bei Albrecht Daniel Thaer (1752-1828)," *Zeitschrift Für Agrargeschichte Und Agrarsoziologie* 62 (2014): 30–41. Women were also among Thaer's contemporaries shaping this shift, see Heide Inhetveen, *Pionierinnen des Landbaus* (Uetersen: Heydorn, 2000); Heide Inhetveen, "Women Pioneers in Farming: A Gendered History of Agricultural Progress," *Sociologia Ruralis* 38, no. 3 (1998): 265–84.

agricultural schools, such as the agricultural school (*Ackerbauschule*) at Riesenrodt established in 1845.[39] Established in 1847 and raised to the status of an academy in 1861, the agricultural academy at Poppelsdorf near Bonn was the most influential academy for Westphalia.[40]

In the United States, the period from the 1820s to the 1850s saw several proposals for agricultural schools which all failed for lack of state funding. Inspired by young American scholars' educational tours through western European universities, early-nineteenth-century traditional colleges carefully began integrating programs in the natural sciences. These programs enabled some of their graduates who were involved with bourgeoning state agricultural societies to develop concepts for agricultural schools. Opened in Gardiner, Maine, in 1823, the Gardiner Lyceum was the first of such schools in the United States but operated only until 1832. As professor of agriculture and later the Lyceum's principal, Ezekiel Holmes shaped the integration of academic study and practical farming on an attached experimental farm much as Thaer did at his academy. Where Thaer managed to attract state funding to his initially private academy, Holmes saw the state legislature withdraw funding once matching private funding dried up. While the Gardiner Lyceum functioned as a role model for subsequent schools, none of them received enough state funding or improver support to survive beyond the first few years of operation.[41]

Concepts for agricultural schools barely included research – a gap that scientists who were orienting themselves towards the natural sciences wanted to fill. In both countries, this drive developed in the wake of Justus Liebig and his publications in agricultural chemistry beginning in 1840. Chemical laboratories as a site of purifying nature became not just a metaphor for the perspective of scientists

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[39] For Riesenrodt, see Konrad Krägeloh and Landeskulturgesellschaft für den Regierungsbezirk Arnsberg, *Geschichte der Landeskulturgesellschaft für den Regierungsbezirk Arnsberg 1809 - 1959*, 1967, 87-89; *75 Jahre Landwirtschaftsschule und Wirtschaftsberatungsstelle für den Kreis Altena in Lüdenscheid herausgegeben aus Anlaß des 75jährigen Bestehens der Landwirtschaftsschule am 1. November 1961*, 1961, 29-39.
[40] For the history of the agricultural academy at Poppelsdorf, see Thomann Björn, "Die Landwirtschaftliche Hochschule Poppelsdorf," *Internetportal Rheinische Geschichte* (blog), May 28, 2021, http://rheinische-geschichte.lvr.de/Epochen-und-Themen/Themen/die-landwirtschaftliche-hochschule-poppelsdorf/DE-2086/lido/57d129c2151c87.11701370; Harwood, *Technology's Dilemma* 78-80, 131-137.See also Lehmbrock, "Lob des Handwerks."
[41]Nathan M. Sorber, *Land-Grant Colleges and Popular Revolt: The Origins of the Morrill Act and the Reform of Higher Education* (Ithaca: Cornell University Press, 2018), 18-44 True, *A History of Agricultural Education*, 35-36; Clarence Albert Day, *Ezekiel Holmes, Father of Maine Agriculture*, University of Maine Studies, 2d Ser. No. 86 (Orono: University of Maine Press, 1968); Boardman, *Agricultural Bibliography of Maine*, 13-16.

striving to create a respected academic discipline. They also became part of the dominant agricultural research institution: the agricultural experiment station. Agricultural scientists concentrated field, barn, and laboratory experiments in one institution to argue that they produced universal principles of agriculture, removed from space and time.

These institutions needed even more funding than agricultural academies and scientists needed support by improvers and state agents. Scientists leveraged their universal claims to appeal to state agents and improvers. Scientists promised state agents long-term increases in state and national economies. They lured improvers' support with promises of individual profit and unified solutions to the problems of varied farm environments. Scientists proposed to centralize and standardize the highest form of knowledge and make themselves arbiters of agricultural truth. However, this alone was not enough. Scientists had to produce a more immediate and economic use for improvers to support them. They found it in fertilizer control. The quality and chemical content of new fertilizers could not be judged by sight or smell, only by chemical analysis. Scientists would serve improvers by regulating sellers of fertilizer to prevent what improvers feared the most: being cheated by fraudulent market agents. Scientists at agricultural experiment stations divided their time between fertilizer, seed, and feed control and research.[42]

The agricultural experiment station was first developed in German states. After the establishment of the first station in in 1851 in Möckern, near Leipzig, came an unsteady decade of openings and closing of stations throughout German states. The 1860s and 1870s saw a steady increase of new stations across Germany, some attached to universities or academies, as the Poppelsdorf experiment station established in 1857, others standing alone like the Münster agricultural experiment station founded in 1871. By 1878, there were 64 stations across Germany, linked by joint annual meetings and a specialized academic

[42] See especially Alan I. Marcus, *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations,1870-1890,* The Henry A. Wallace Series on Agricultural History and Rural Studies (Ames: Iowa State University Press, 1985).

journal. Funded by the state, agricultural associations, and charges for chemical analysis, agricultural scientists had established the experiment station as the prime institution of agricultural research.[43]

German agricultural experiment stations welcomed students and visitors from abroad, many of whom returned home to campaign for stations of their own. Even though the numerous stations in Germany varied, campaigners abroad identified a German success model which would only have to be adapted to domestic contexts. American visitors to German stations and chemical laboratories began to argue for American equivalents as early as the 1840s but generally found less willing funders. Chemical laboratories at private universities, the first foothold for agricultural scientists, were soon part of the integration of natural science programs. Gradually established in the late 1850s, the Sheffield Scientific School at Yale became an early American center of research in the natural sciences including agriculture. The first American agricultural experiment station was founded at nearby Wesleyan University in 1875 but moved to the Sheffield Scientific School in 1877. Campaigns for state funding for experiment stations were successful in more than a dozen states by 1887, including the Maine Fertilizer Control and Agricultural Experiment Station founded in 1885. The Hatch Act in 1888 then created an experiment station in every state of the Union with federal funding. As in countries around the globe, the agricultural experiment station became the institutional home for the research of agricultural scientists in the United States.[44]

In the second half of the nineteenth century and into the early twentieth century, scientists' drive to make agricultural science its own discipline also changed concepts of agricultural schools. In the early 1860s, German agricultural scientists, led by Justus Liebig, challenged agricultural academies as inadequate institutions for scientific education. Their critique enabled the first institute for agricultural

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[43] Uekötter, *Die Wahrheit ist auf dem Feld*, 64-65.
[44] Mark R. Finlay, "Transnational Exchanges of Agricultural Scientific Thought from the Morrill Act through the Hatch Act," in *Science as Service: Establishing and Reformulating Land-Grant Universities, 1865-1930*, ed. Alan I. Marcus, Nexus : New Histories of Science, Technology, the Environment, Agriculture & Medicine (Tuscaloosa: The University of Alabama Press, 2015), 33–60; Margaret W. Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880*, Yale Studies in the History of Science and Medicine 9 (New Haven: Yale University Press, 1975); Marcus, *Agricultural Science and the Quest for Legitimacy*.

science at a university, established in Halle in 1862. Beginning in the late 1860s, the number of institutes increased while the number of academies dwindled. While institutes leaned towards teaching the natural sciences and academies towards practical farming, their institutional design converged after World War I to focus on natural sciences without excluding practical farming.[45]

In the United States, agricultural colleges went through a similar process of convergence as in Germany. The Morrill Act of 1862 established an agricultural college in every state of the union through the sale of federal land grants. As German academies and university institutes, these land-grant colleges began at opposing positions between "theory" and "practice," depending on the particular context in each state. The Maine legislature decided to establish a new agricultural college which included practical farming and developed extension programs in collaboration with their improver challengers. Not aligned with the state-supported structure of agricultural associations, the Patrons of Husbandry (popularly called the Grange) rose in the mid-1870s and grew to be the most vocal group of improver critics of New England land-grant colleges that did not provide manual training, broad access, and extension programs. For example, the Connecticut legislature used Morrill Act funds to improve Yale's Sheffield Scientific School. Once improvers faced economic crisis, the Grange attacked this allocation of land-grant funds and finally succeeded in 1893 to have the funds reallocated to an agricultural college similar in design to the college in Maine. By World War I, New England agricultural colleges had converged to integrate research, education, and extension.[46]

In the second half of the nineteenth century, scientists, improvers, and state agents in both the United States and Germany negotiated the character and functions of agricultural institutions as top-down knowledge infrastructure. These negotiations situated each university, college, academy, school, experiment station, association, and state board into a particular institutional landscape, serving the needs of local and regional players in politics, education, and the economy. If agricultural associations challenged experiment stations or colleges as too focused on research removed from improver concerns,

[45] Harwood, *Technology's Dilemma,* 80-84.
[46] Sorber.

these institutions provided more extension services. If experiment station scientists complained fertilizer analysis took too much time away from research, state agents and improvers could be convinced to increase funding for more research. Still, all institutions served the idea that scientists researched new agricultural knowledge mainly in agricultural experiment stations and all other institutions would transmit scientists' findings all the way down to farmers. All students at agricultural colleges, university institutes, and academies were educated to translate scientist knowledge to farmers – without distorting it as self-taught improvers would. Whether in official contexts as agricultural teachers, extension agents, or state bureaucrats, or in unofficial contexts as educated farmers in agricultural associations and farm communities, graduates were to convince farmers to apply scientists' innovation. The goal of education was not to teach every farmer directly. The functional goal of education was extension.

In Germany, the negotiation process resulted in a hierarchical constellation of specialized institutions. Agricultural experiment stations produced scientific knowledge. A state-funded, tiered school system educated and employed extension agents in the form of agricultural teachers, state bureaucrats, and elite improvers. Sons of upper class estates attended universities, middle-class improver sons attended agricultural schools (*Ackerbauschulen*), and lower-class farmer sons attended winter schools. Rural continuation schools (*ländliche Fortbildungsschulen*) provided the educational link between elementary schools (*Volksschulen*) and winter schools, creating a complete track of agricultural education for farm youth. Agricultural associations supported these schools and filled lecture circuits and journal pages with their teachers and graduates who were often employed in state agencies. Agricultural teachers served as formally educated advisors to local farmers outside of the schools' semester. Partial funding for these schools and programs was allocated through centralized state agencies such as the Prussian Agricultural Advisory Council (*Landesökonomiekollegium*) and the strictly hierarchical structure of provincial, district (*Regierungsbezirk*), county (*Kreis*), and local agricultural associations. This was also the case in Westphalia. Two state-funded Ackerbauschulen in the late 1860s largely replaced earlier privately founded schools modeled after Thaer's academies. Winter schools were established in every Westphalian county through the 1880s and 1890s. In the 1890s and 1900s, rural continuation schools (*ländliche Fortbildungsschulen*) were established across the region.[47]

In the United States, the same model of top-down knowledge infrastructure found its institutional home in the agricultural colleges. Experiment stations were usually situated there to create synergies between personnel, research, and costs. In the late nineteenth century, agricultural colleges developed short-term courses for practical farmers, including winter courses very similar to the winter schools in Germany. Their professors held lectures or farmers' institutes for agricultural associations and farmers' clubs. Several states formalized these extension services before the Smith-Lever Act of 1914 established extension services at every land-grant college, eventually with official extension agents in every county of the United States. Since its founding in 1862, the United States Department of Agriculture coordinated all the institutions and programs associated with land-grant colleges. It also coordinated the campaign to include more agricultural education in elementary schools. So, unlike Westphalia, Maine had one central agricultural college rather than a network of agricultural schools. The Maine State College of Agriculture and the Mechanic Arts in Orono began operations in 1868. It housed the Maine Agricultural Experiment and Fertilizer Control Station beginning in 1885, and became the center of extension offices which were established gradually over the late 1910s.[48]

The agricultural knowledge infrastructure was complete in concept by the 1920s. The relatively high farm density of Germany, Westphalia, and the Sauerland allowed the creation of a specialized institutional system with comprehensive coverage and large staff which integrated education and extension. The relatively low farm density of the United States, New England, and Maine favored

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[47]Marten Pelzer, "'Was die Schule für das heranwachsende Geschlecht ist'"; Harwood, *Technology's Dilemma*; Uekötter, *Die Wahrheit ist auf dem Feld*, 99-105; Behr, "Das Landwirtschaftliche Vereinswesen Westfalens Im 19. Jahrhundert;" Frese.

[48] Marcus, *Agricultural Science and the Quest for Legitimacy*; Sorber; Alan I. Marcus, ed., *Science as Service: Establishing and Reformulating Land-Grant Universities, 1865-1930*, Nexus : New Histories of Science, Technology, the Environment, Agriculture & Medicine (Tuscaloosa: The University of Alabama Press, 2015); David C. Smith, *The Maine Agricultural Experiment Station: A Bountiful Alliance of Science and Husbandry* (Orono, Me: Life Sciences and Agriculture Experiment Station, University of Maine at Orono, 1980); David C. Smith, *The First Century: A History of the University of Maine,1865-1965*, 1st ed (Orono, Me: University of Maine at Orono Press, 1979); Karmen; State of Maine: Department of Education, *Agriculture in Elementary Schools* (Augusta, ME, 1914).

centralized agricultural education at agricultural colleges and comprehensive coverage in extension with low staff numbers. Education and extension had to cover areas of different size but still developed knowledge infrastructure very similar in concept and function.

**Chapter Overview: The perspectives of scientists, improvers, market agents, and farmers**

The following four chapters analyze the negotiation of agricultural knowledge within and beyond this knowledge infrastructure. Chapter 1 analyzes how agricultural scientists produced universal claims about the nature of farming in contingent and collaborative settings. It traces scientists' strategies to communicate animal nutrition and ideal rations to improvers between the 1850s and 1880s first in Germany and then in the United States and New England. Scientists communicated their principles of animal nutrition as superior to all other knowledge. However, making the laws of animal nutrition credible and useful outside the circles of German scientists required flexibility and granting some expertise to others. Agricultural scientists designed the method of assembling ideal rations to be flexible so it would be portable to other places and users. Scientists collaborated with improvers to push for institutionalization of extension, which conferred the expertise of communicating innovation in principles to scientist-trained extension agents. Even so, the knowledge system of scientists was based on a clear hierarchy with scientists at the top, policing other actors and their communication of innovation in principles.

Improvers saw themselves as situated connecters between actor groups and geographic and institutional scales. Chapter 2 traces their negotiations amongst each other, with farmers, and with scientists comparing processes and results in the Sauerland and western Maine. Improvers used multiple knowledge sources, only one of which were scientists, to produce innovation in place. However, lasting change in local agricultural practice depended on collaboration with all other actors of the agrarian-industrial knowledge society. Improvers in Maine were successful in this collaboration when they negotiated strategies and evidence to communicate scientists' ideal rations and the purchase of industrial byproduct feeds. They paved the way for extension. Improvers in the Sauerland opposed scientist advice as inadequate for the conditions of the Sauerland and favored an alternative approach developed locally.

Once scientists began to delegitimate the expertise of Sauerland improvers, collaboration with all other actor groups faltered. These contrasting examples illustrate the centrality of collaboration for the knowledge system of improvers.

Market agents also relied on collaboration but identified farmers as more important collaborators than scientists, improvers, or state agents. The latter served merely to give credibility to market agents' new products – innovation in things – whereas farmers kept market agents in business. Market agents saw farmers as consumers who voted with their wallets. Chapter 3 traces three new kinds of feed products in their movement around the globe to reach as many farms as possible. Advertising was knowledge communication and salesmen were educators much more numerous than extension agents. They relied on clearly knowable products, evidence provided by all other actor groups, and communication strategies geared towards all farmers. Where a new legume variety failed to generate collaboration with other actor groups, industrial byproduct feeds succeeded. In the early twentieth century, feed manufacturers confronted scientists and established their own expertise to turn principles of animal nutrition into ready-made ideal ration feeds. From mere suppliers of farm inputs, to be regulated by watchful improvers and scientists, market agents rose to partners on eye level and builders of an extension system from the bottom up.

Farmers took notice of the innovations promoted to them, but the other actors occupied a very small space in their daily lives and decision-making. Far from hapless executers of professional advice, farmers adapted select innovations to the people, animals, plants, and things on their farm, in their neighborhood, and in their town. Farm families turned new feeds and feeding practices into innovation at home. Chapter 4 traces how the Serkenrode agricultural association largely rejected industrial byproduct feeds, whereas the Robinson-Parsons family in South Paris, Maine, tested and then integrated such feed into their agricultural practice. Cooperative movements for dairy factories paired with arguments for better feeding in both Serkenrode and South Paris. Economic incentive was an integral part of how both of these farm communities negotiated innovations in feeding and dairy processing. They adjusted to the inflexibility of scientific and business imperatives of dairy processing and marketing with flexibility in feeding practice, farm operations, and collaboration among farm families. Farm families were not just moving targets for education and extension. They shaped the agrarian-industrial knowledge society on the ground.

## CHAPTER 2

## INNOVATION IN PRINCIPLES

> Instead of uniting to make collaborative experiments on a large scale and by their results balance out the conflicting views, they accused each other of ignorance – the chemist accused the farmer of ignorance of theory, the farmer accused the chemist of ignorance of practice, and things continued to stand precisely where they stood.[49]

In 1852, this is how an anonymous writer "S." in the agricultural journal for Westphalia and Lippe (*Landwirtschaftliche Zeitung für Westfalen und Lippe*) summarized the recent history of agricultural science. Inspired by the revolutionary theories of Justus Liebig, agricultural scientists through the 1840s had made promises to improvers and farmers that they could not keep. In the early 1850s, both sides stood in stronger opposition than before. Of course, this was not where things continued to stand. But S. had a remarkable gift of imagination. His description of the past of chemistry and agriculture was able enough, but his vision for the future was brilliantly simple.

> So, the farmer shall shake hands with the chemist and the chemist with the farmer! Each one of them shall inform the other out of the rich treasure of his experience; they arrange practical-scientific experiments, prepare them collaboratively and make them together; then magnificent successes, rich harvests for science will be achieved within a few years.[50]

He would have to wait several decades in which scientists and improvers learned how to get along.

Presenting famers and scientists as equal partners was already a strategy to win over farmers to the agrarian-industrial knowledge system imagined by scientists. Almost imperceptibly, S. had slipped up in the very end. He listed only science as the beneficiary of the combination of theory and practice. Science was the superior repository of better knowledge. Somehow, he already assumed that progress in science would benefit the farmer automatically. It did not. Not even close.

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[49] S. "Chemie und Landwirthschaft," in *LZWL*, Jan 29, 1852, 70. Original: "Anstatt sich zu vereinigen, um gemeinschaftliche Versuche in großem Maßstabe anzustellen und durch deren Resultate die widerstrebenden Ansichten auszugleichen, warf man sich gegenseitig Unkenntniß vor – der Chemiker dem Landwirth Unkenntniß der Theorie, der Landwirth dem Chemiker Unkenntniß der Praxis, und so blieben die Sachen stehen, wo sie eben standen."

[50] Ibid, 72. Original: "Es reiche also der Landwirth dem Chemiker, der Chemiker dem Landwirth die Hand! Jeder von ihnen mache dem Andern fortwährend Mittheilung aus dem reichen Schatze seiner Erfahrungen; sie verabreden praktisch-wissenschaftliche Versuche, bereiten sie gemeinschaftlich vor und führen sie zusammen aus; dann werden binnen wenigen Jahren herrliche Erfolge, reiche Ernten für die Wissenschaft erzielt werden."

Improvers in the early nineteenth century had already learned about the massive effort required to produce innovation and bring it to farmers. In the second half of the nineteenth century, it took a vast infrastructure of agricultural knowledge communication to bridge the gap between scientists and farmers. The introduction to this book described how this infrastructure developed. This chapter explains scientists' vision of the agrarian-industrial knowledge system: how it was supposed to be organized and what scientists' contribution would be.

I trace the development of scientists' vision for the agrarian-industrial knowledge system through one particular scientific innovation: feeding standards. The science of feeding was founded on the idea of determining the most efficient and thus most profitable feed rations for livestock. It was scientists' answer to an economic problem. Farmers had wondered how to best feed their animals for a long time, of course. But agricultural scientists began to make this economic problem into its own subdiscipline of agricultural science in the middle of the nineteenth century. They put their hopes in animal physiology, animal digestion, and the organic chemistry of plants and other feeds. Similar to Liebig's balance between soil supply and plant demand of nutrients, animal nutrition scientists defined principles of animal demand, feed supply, and matching the two. This second pillar of research was key in establishing agricultural scientists as experts of innovation in principles.

## **On top of the hierarchy: The knowledge system of scientists**

Agricultural scientists in both countries faced the same problem. They had to make farmers understand the new knowledge that scientists' methods produced. Without users translating laboratory and trial field findings to increased production, agricultural scientists would be useless experts. At the same time, scientists had to police the boundary to improvers and farmers vigilantly if they wanted to keep their standing within the academy and thus access to the means and credibility that allowed scientific research in the first place. However, credibility among farmers rested on a personally reliable source, a clear economic self-interest, and evidence as visible and economic as possible: all qualities respectable scientists could not have. Agricultural scientists in both countries found the same solution. They plugged their knowledge production and communication into the knowledge system of improvers and tried to reshape it. Scientists advocated for specializing the functional roles of knowledge communication just as they advocated for specializing agricultural production. Improvers became translators. They enabled scientists to keep their academic status as innovators. Yet, unbound by scientific conventions, improvers as translators represented a credible knowledge source to farmers as users. Their role in the middle would communicate farmer problems to scientists and scientist solutions to farmers.

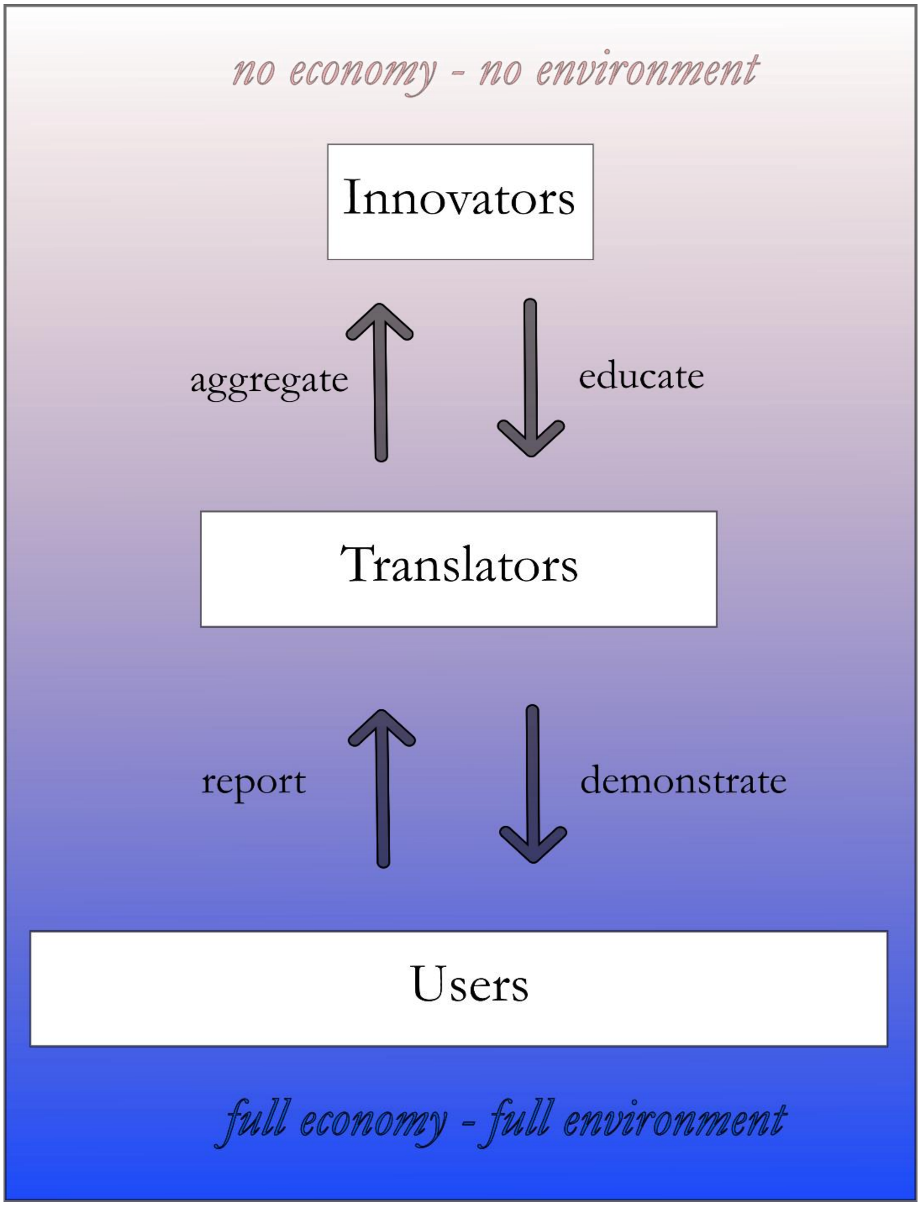


Figure 7: The knowledge system of scientists

The only truly valuable innovation to scientists was innovation in principles. And only scientists with their specialized methods could crack nature open to reveal its laws. Scientists as innovators generated new universal principles of agricultural knowledge in institutions removed from economic pressures and through processes of knowledge purification removing the environment. Innovators valued knowledge over a crop. With state or private funding for their institutions and salaries, a failed crop in a fertilizer trial was not a devastating economic blow, but rather a useful research result. They could starve livestock in feeding trials and count the knowledge of a feeding minimum as a success. Observations which claimed anything less than universality, innovators saw as evidence for their principles found by experiment. By the same logic, innovators went to great lengths to educate, discipline, and police translators so that the universal principles they translated down the hierarchy to users would not be distorted.

The role of the translator had the most prominent communication position. It was to be filled most often by improvers and later also extension agents and market agents (see chapters 3 and 4). Translators had to understand communication by innovators as well as users. And they had to translate each into language and concepts the other could understand and believe. They had the role connecting innovation and use. Without them, innovators and users would not understand or recognize the credibility of one another. Translators had the intellectual and economic means to adapt the universal principles provided by innovators to the particular environmental, social, and economic conditions of users. They produced evidence within the local economy, society, and environment and communicated in user conventions. Given the temporal reproduction cycles of the biotic resources of farming and the great variability of environmental conditions, this usually took time. The trials of translators were relatively shielded from economic pressures by their varied or extensive income. They could provide credible evidence for innovators if observations were properly reported by translators. This was also true for reports of user behavior. Translators would aggregate their impressions and communications of the more numerous users and translate them to innovators. They completed the feedback loop and provided innovators with new or updated agricultural problems that gave direction and license to innovators' research. This translation position granted them the power to interpret user reports. Had they followed the example or instructions of translators sufficiently or had they changed the standardized knowledge passed down by innovators? In short, the key characteristic scientists saw in translators was their position both within and outside of users' economy, environment, social networks, and communication conventions.

As imagined by scientists, users had the role of putting agricultural innovation adapted for them into action. By and large, users were farmers. To be sure, translators used innovation in principles for their own benefit too. But unlike translators, users either did not understand science or distrusted it. Farming under the full brunt of economic pressure and embedded in their particular environment, users produced the mass evidence to validate the expert status of scientists as innovators. This was economic evidence. The questions users posed to translators and scientists were economic problems to begin with. This position gave users a certain degree of veto power. Users had influence to effect further adaptation or even generate new problems for innovators to solve, but only if a critical mass of them managed to convince translators of the shortcomings or failures of the innovation. Any farmer who proved unwilling or unable to use translated innovation in principles was excluded from the knowledge system as backward. All roles had to police the scientific knowledge system to make sure it continued to work smoothly. In fact, this was the Janus face of the scientific knowledge system: submit to science and play your role or get out of farming.

Individual actors could shift between some of these roles. Scientists could play the role of translator if they lacked other actors to fulfill this function. Improvers might play the role of innovators if they abnegated all their ties to using agricultural knowledge for a personal profit and otherwise demonstrated their abilities to operate within scientists' conventions. Improvers could play the role of user rather easily by putting into action farming methods adapted by a translator. Farmers could play the role of translator if they learned to understand and adapt innovators' solutions. Thus, an education in agricultural science provided upward mobility to the more powerful role of translator.

The translations between these roles find examples in the historical record. When scientists wrote textbooks, when they lectured at meetings of agricultural associations or state agricultural boards, or when they designed standard curricula for winter school teachers or extension agents, scientists as innovators were educating improvers as translators. When estate owners explained or demonstrated to their farmer neighbor their updated farm system or farming method, adapted from instructions in lectures, journals, or books, when well-read journal editors answered farmers' queries about how to calculate ideal rations in their particular case, when extension agents or winter school teachers came to farms to provide advice and know-how, improvers as translators demonstrated to farmers as users. When farmers discussed their experience with a new farming method in a meeting of their local farmers' club, when they submitted a short article to an agricultural journal about their results using a new fertilizer, feed, animal breed, or seed variety, or when they criticized the advice given by extension agents or winter school teachers, farmers as users were reporting to improvers as translators. When presidents of agricultural associations sent their reports about the current state of farming in their area to editors of county, state, or national reports, when estate owners discussed the practical results of farmers in their town or county with scientists at agricultural board or state commission meetings, or when a rural pastor as avid reader of scientific publications wrote a book describing the recent changes to farming in his town, improvers as translators were aggregating for scientists as innovators.

## Becoming a discipline: Farming + chemistry = agricultural scientists

Emil Wolff would become the most influential agricultural scientist behind feeding standards because of his efforts translating scientific knowledge to farmers. He worked at a time when agricultural scientists strove to make agricultural science into a proper academic discipline. As historian of early modern Europe Donald R. Kelley has argued, academic disciplines are usually defined by characteristic method, specialized terminology, community of practitioners, canon of authorities, agenda of problems to be addressed, and more formal signs of professional condition, such as textbooks, courses of study, libraries, rituals, journals, social gatherings. Emerging disciplines sought legitimacy by drawing upon other established disciplines while at the same time differentiating themselves from them. They became a community of experts among experts.[51]

Members of emerging disciplines also had to demonstrate the same values and higher goals used as guiding stars by established scientists to set themselves apart from lowly artisans. These changed over time in emphasis and composition. In late nineteenth-century Germany, a reverence for pure science emphasized disinterestedness, impartiality, and objectivity. As historian of science Lorraine Daston has revealed most prominently, these ideals were strategies to enable cooperation and reach consensus between far-flung scientists. Character traits and personal habitus could grant credibility to communication detached from the specifics of space, place, and time, as could standardized formats of reporting and fine-tuned instruments.[52]

What challenged agricultural scientists was their split allegiance to pure science and farmers. Historian of science and technology Jonathan Harwood called this general problem “technology’s dilemma” for applied sciences. If no farmer implemented the innovations generated by agricultural scientists, they would have been robbed of their legitimacy. If no scientist believed what kernels of knowledge agricultural scientists pulled out of the dirt, how would they continue to harvest food for thought? Usually, agricultural scientists and the institutions they served threw in their lot with one of the two sides. As Harwood showed, this decision often depended on the individual and institutional proximity to esteemed universities, regulating ministries, and demanding players in the agricultural economy. Scientists could not do their work without funding, so their decisions about their audience and thus their communication strategies were influenced by money. Only a few tried to straddle the divide. Emil Wolff was one of them. His career, work, and decisions within the emerging discipline of agricultural science

[51] Donald R. Kelley, “The Problem of Knowledge and the Concept of Discipline,” in *History and the Disciplines: The Reclassification of Knowledge in Early Modern Europe*, ed. Donald R. Kelley (Rochester, N.Y.; Woodbridge: University of Rochester Press, 1997), 13–28.
[52] Consider e.g. Lorraine Daston, “The Moral Economy of Science,” *Osiris* 10 (1995): 2–24.

illustrate what divided scientists from improvers. His effort also illuminates the strategies of knowledge production and communication intended to bridge the old trenches from laboratory to field.[53]

Wolff's career was intertwined with the enterprise of establishing agricultural science as a discipline. Born in 1818 in Flensburg, he began his studies of the natural sciences, especially chemistry, at Humboldt University in Berlin in 1840. This was also the time when Justus Liebig published several foundational books. Much as Wolff would build on others' work but find fame through skillful promotion, Liebig built on previous foundations that applied chemistry to agriculture for the improvement of farming by scientific means.[54] In 1843, Wolff continued his training and research at Halle University, where he began publishing supplements to agricultural chemistry textbooks. He continued to publish on agricultural chemistry and fertilizer when he moved on to a teaching position at the private agricultural school of his colleague Ernst Theodor Stöckhardt near Bautzen in 1847. This led to his appointment as the director of the first agricultural experiment station in Möckern near Leipzig in 1851. This was a new type of institution, directly inspired by the Rothamstead agricultural experiment station established in 1843 in Hertfordshire, England, in part to test Liebig's theories in agricultural chemistry. The agricultural experiment station, and agricultural institutes at universities, were different from the agricultural academies that had previously been the predominant institutional locus of agricultural research. Modeled after Albrecht Daniel Thaer's agricultural academy in Möglin founded in 1806, a number of agricultural academies across German lands combined research and teaching, chemistry and manual farming, as well as the production of knowledge and crops for the financial upkeep of the institution. In contrast, the experiment station and university institutes focused on research and transmitting the resulting agricultural innovations to those in farming. While they stood at various points on the spectrum between theory and practice, agricultural experiment stations and university institutes marked the shift to professionalizing research in the second half of the nineteenth century. After two very active years, Wolff followed the call

[53] Harwood, *Technology's Dilemma*.

[54] Carl Sprengel is the best-known transformative link from the agricultural improvement model by Albrecht Daniel Thaer to the application of chemistry to agriculture which Justus Liebig built on and popularized. See e.g. Hans-Peter Blume, "Sprengel, Carl," in *Neue Deutsche Biographie* (Berlin: Duncker & Humblot, 2010).

to become a professor of chemistry and agricultural chemistry at one of the last surviving agricultural academies at Hohenheim in 1853. Here, he also contributed to the establishment of an agricultural experiment station in 1865. Wolff continued his research and teaching at Hohenheim through an unprecedented period of growth in the scientific study of agriculture until his retirement in 1894.[55]

The discipline of agricultural science and its practitioners built upon the work of a long line of agricultural improvers who developed the foundations of evaluating feeds and understanding animal digestion. Improvers in the mid to late eighteenth century had already begun to compare different feeds to production. Increasing summer stall feeding and the expansion of new feeds, such as potatoes, beets, and clover, had brought the question of what to feed farm animals to the attention of farmers and agricultural writers. In 1809, Thaer arranged his own and others' observations into the most influential method of comparing different kinds of feed in the first half of the nineteenth century. His "hay values" aimed to replace hay with other feeds, so he equated the weight of hay to the weight of various feeds to describe their nutritional value. When Thaer argued that e.g. 100 lbs of hay were equal to 200 lbs of potatoes, 266 lbs of carrots, or 90 lbs of young clover hay, he gave farmers clear values to calculate their own feed rations.[56] Developed through feed trials and early chemical analysis, Thaer's hay values were close to the experience and labor of farmers. Improvers praised them as easy to use into at least the 1860s. Not only did the resulting feeding standards allow farmers to navigate the growing range of feeds and create ideal

[55] Karl Stahr, Ulrich Fellmeth, and Hans-Peter Blume, "Emil Theodor von Wolff (1818-1896), Ein Pionier der Agrikulturchemie," in *Persönlichkeiten der Bodenkunde*, ed. Hans-Peter Blume and Rainer Horn, vol. 5, Schriftenreihe - Institut für Pflanzenernährung und Bodenkunde der Universität Kiel 103 (Kiel: Inst. für Pflanzenernährung und Bodenkunde, 2015), 1–29, thoroughly reworked reprint, 2019, at https://www.uni-hohenheim.de/fileadmin/einrichtungen/uniarchiv/Emil_Wolff_Fe_St_05_02_Korr._Raff_08_02_2019.pdf; Harwood, *Technology's Dilemma*; Brendan Matz, "Nutrition Science and the Practice of Animal Feeding in Germany, 1850–1880," in *New Perspectives on the History of Life Sciences and Agriculture*, ed. Denise Phillips and Sharon E Kingsland (Cham: Springer, 2015), 163–82; Uekötter, *Die Wahrheit ist auf dem Feld*. See also Gustav Kühn, "Geschichtliches Über Die Landwirthschaftliche Versuchs-Station Möckern," *Die Landwirthschaftlichen Versuchs-Stationen* 22 (1877): 1–144.
[56] Albrecht Daniel Thaer, *Grundsaetze der rationellen Landwirthschaft*, vol. 1 (Berlin: Realschulbuchhandlung, 1809), 263.

rations, it also allowed price comparisons and thus economic decisions for the whole farm operation. Thaer's simple tables were tools that enabled individual decisions in particular conditions for each farm.[57]

Liebig's methods of chemical analysis and division of feeds into their nutritional components transformed feed evaluations and experiments. Similar to the chemical balance between plant and soil, Liebig suggested a nutritional balance between animal and feed. Liebig applied the economic idea of supply and demand to organic chemistry, which suggested a kind of nutritional accounting. One column recorded animal demands, another column listed feed supplies in nutritional components. Instead of comparing the economic effect of feed on animal production, agricultural scientists compared the nutritional constituents of feeds and their effect. With this new approach, several agricultural researchers tested Thaer's hay values with more systematic feeding experiments. These determined a feed ration which maintained the weight of resting oxen to compare to proposed feed rations for production of milk, muscle, wool, or labor. Early experimenters in the 1840s included August Weckherlin at Hohenheim Academy, Jean Baptiste Boussingault at his experimental estate in Alsace, and Gottlieb Carl Haubner at Eldena Academy. Subsequently, an increasing number of agricultural chemists at experiment stations, universities, and academies got involved in this research. So did Wolff when he began publishing on his 1854 Möckern feeding experiments. "Our science owes particularly important contributions to its formation to the persistent activity of several men."[58] So he wrote in the introduction to his much-celebrated 1861 book on the agricultural science on feeding and the theory of human nutrition (*Die landwirtschaftliche Fütterungslehre und die Theorie der menschlichen Ernährung*), which definitively

[57] Matz; Jens Klemme, "Entwicklung der Ernährungsforschung bei Wiederkäuern im 19. Jahrhundert Fütterungsversuche, Energiehaushalt und Eiweißstoffwechsel" (Dissertation, Hannover, Tierärztliche Hochschule Hannover, 2003). Also see, Moser and Varley, "The state and agricultural modernization in the nineteenth and twentieth centuries in Europe;" Verena Lehmbrock, "Lob Des Handwerks."

[58] Emil Wolff, *Die landwirtschaftliche Fütterungslehre und die Theorie der menschlichen Ernährung.* (Stuttgart: Cotta, 1861), VIII. Original: "Der ausdauernden Thätigkeit einiger Männer verdankt unsere Wissenschaft vorzugsweise wichtige Beiträge zu ihrer Ausbildung."

disproved Thaer's hay values while building on the conventions and results developed by two generations of improvers and scientists over more than half a century.[59]

Wolff's 1861 book was largely a work of synthesis. Previous publications through the 1850s by Wilhelm Henneberg and Friedrich Stohmann at Weende experiment station, Gottlieb Carl Haubner and Julius Gottfried Sussdorf at the Dresden veterinary university, and Ernst Theodor Stöckhardt at the Chemnitz Royal Trade School had already shifted the research focus from raw nutrients to digestible nutrients. They challenged previous nutrient tables published by Wolff in the early 1850s. For example, he had erroneously believed crude fiber to have been indigestible. His colleagues established the fundamental difference between the solution of substances constituting feeds in chemical analysis and actual digestion by the animal. For example, Henneberg showed that nitrogen-rich nutrients were not always digestible to the same degree by all livestock. Wolff adapted his analysis accordingly. Wolff and his colleagues were not singular inventors but merely constituent parts of the emerging expert community of agricultural science which shaped the research process collaboratively and iteratively.

**<u>Overcoming nature: Agricultural scientists produce innovation in principles</u>**

Agricultural scientists were not farmers. Farmers had long observed their animals' tastes, appetites, growth, milk, and labor. Then, improvers differentiated themselves from mere farmers through the concept of the experiment. Thaer differentiated between the two in 1810: observations drew human attention to "matter and potentialities and their interactions coming together by themselves," whereas experiments demanded that humans actively "bring together well-known things in exactly determined ratios, take note of their interactions, and at the same time avoid as much as possible anything foreign or

[59] Klemme; Matz. For more on the balance idea promoted by Liebig in the US context, see Emily Pawley, "Accounting with the Fields: Chemistry and Value in Nutriment in American Agricultural Improvement, 1835–1860," *Science as Culture* 19, no. 4 (December 1, 2010): 461–82; Emily Pawley, *The Nature of the Future*, 189-218. This accounting was a simplification of highly complex materials and interrelations, including, soil, plants, and animals, see for example Frank Uekötter, "Virtuelle Böden: über Konstruktion und Destruktion des landwirtschaftlichen Bodens in den Agrarwissenschaften," *Zeitschrift für Agrargeschichte und Agrarsoziologie* 55 (2007): 23–42.

unknown which can have influence over the success interferes."[60] It was pure science in an agricultural nutshell.

Experiments required specific kinds of experts, scientists argued, and improvers would not cut it anymore. Diligence, disinterestedness, impartiality, impersonality, objectivity: these traits made scientists. And only those worshipping at the same altar could produce evidence that scientists would believe, from expert to expert.[61] In Wolff's 1861 introduction, he exemplified this well in his description of those agricultural scientists coming before him. The first experiments that had an "enduring scientific value"[62] began with the use of the scale and chemical analysis (with August Weckherlin in 1845, not with Thaer and his chemist Heinrich Einhof). This "exact nature research"[63] was the product of rational men who made a "specific, well-considered plan"[64] for experiments with "untiring perseverance and […] unselfish pursuit."[65] Their efforts were "beyond reproach."[66] Wolff counted himself among these exemplars of science: "I may perhaps assert that I have treated the existing material with conscientious diligence and have spared no effort to perform my set task toward all directions equally."[67] In short, scientists argued they were the opposite of improvers.

Scientists designed their experiments to claim universality. Standardization was key. Scientists had to use the same instruments with the same skill in the same processes. While scientists negated personal intervention in their research process, personal intervention was absolutely necessary in achieving methodical standardization and thus portable results. Bringing the ever-growing community of agricultural scientists into line relied on more than just published forays, rebuttals, and revisions shot back

[60] Thaer, *Grundsätze der rationellen Landwirthschaft*, 8. Original: „von selbst zusammentreffenden Körper und Potenzen und deren Einwirkung aufeinander, […] wohlbekannte Dinge in genau bestimmten Verhältnissen zusammenbringen, ihre Wechselwirkung beachten, und dabei möglichst verhüten, daß nichts Fremdes oder Unbekanntes, was Einfluß auf den Erfolg haben kann, sich einmische."
[61] Hardwig, "Epistemic Dependence;" Daston, "The Moral Economy of Science."
[62] Wolff, *Die landwirtschaftliche Fütterungslehre*, VIII. Original: "bleibenden wissenschaftlichen Werth."
[63] Ibid, VIII. Original: "exakter Naturforschung."
[64] Ibid, IX. Original: "bestimmten, wohl überdachten Plane."
[65]Ibid, IX. Original: " unermüdlichen Ausdauer und […] uneigennützigen Streben."
[66] Ibid, X. Original: "untadelhaftes."
[67] Ibid, VII. Original: "Ich darf wohl behaupten, daß ich mit gewissenhafter Sorgfalt das vorhandene Material verarbeitet und keine Mühe gescheut habe, um die mir gestellte Aufgabe nach allen Richtungen hin gleichmäßig durchzuführen."

and forth between cooperative yet competing researchers. Whether at German agricultural experiment stations, university institutes, or academies, agricultural chemists communicated in shared journals and at their own annual meetings. There they negotiated overall research goals and even experimental designs for the advancement of the discipline. In the first two annual meetings in 1863 and 1864, a proposal for joint feeding experiments, developed by an elected commission, granted stronger scientific credibility and ultimately strengthened the discipline and research agenda of agricultural science. In the same breath, the assembly tasked Wilhelm Henneberg at the Weende experiment station to develop a proposal for the standard method of chemical analysis on which he had previously published.[68] Wolff had complained in his 1861 book that the mean nutritional values of feeds were still rather unclear because methods of chemical analysis varied. The results on crude fiber, for example, differed between the French Boussingault, several German experiment stations, and Gilbert and Lawes at Rothamstead in England because of differing concentrations of acids and alkali in varying durations of their use in the process of chemical analysis.[69] In 1864, the assembly unanimously approved the Weender method proposed by Henneberg as the new standard.[70] The short report on this 1864 annual meeting of German agricultural chemists, physiologists, and experiment station directors lauded the positive effect of this meeting for the "communication and unification in the interest of the matter advanced by the experiment stations."[71]

[68]Gustav Kühn and L. Aronstein, "Verhandlungen Der II. Wanderversammlung Deutscher Agriculturchemiker, Physiologen Und Vorstände von Versuchs-Stationen Zu Göttingen Am 15. Und 16. August 1864," *Die Landwirthschaftlichen Versuchs-Stationen* 7 (1865): 1–39; W. Knop, "Bericht Über Die Erste Wanderversammlungdeutscher Agriculturchemiker, Physiologen Und Vorstände von Versuchs-Stationen Zu Leipzig Am 21. Und 22. Mai 1863," *Die Landwirthschaftlichen Versuchs-Stationen* 7 (1865): 39–47.
[69] Wolff, *Die landwirtschaftliche Fütterungslehre*, 315.
[70]Kühn, Aronstein, 8. For their proposal published as an addendum to the meeting agenda beforehand, see "Anlagen Ad Nr. 5 Der Tages-Ordnung Der II. Wanderversammlung Deutscher Agriculturchemiker Etc.: 'Gemeinschaftliche Fütterungsversuche," *Die Landwirthschaftlichen Versuchs-Stationen* 6 (1864): 496–98.
[71] "Vorläufige Kurze Notizen, Betreffend Die 2. Wanderversammlung Deutscher Agriculturchemiker Und Vorstände Landwirthschaftlicher Versuchs-Stationen Zu Göttingen Am 15.-17. August 1864.," *Die Landwirthschaftlichen Versuchs-Stationen* 6 (1864): 446. Original: "Verständigung und Vereinigung im Interesse der von den Versuchs-Stationen vertretenen Sache. "

Situated and historically contingent negotiations within the emerging expert community of agricultural scientists enabled their universal claims.[72]

These claims also rested on materials and skills only available to scientists. The Weender method for the chemical analysis of feedstuff composition was an elaborate process which required specialized skills in handling a long list of instruments and chemicals. To take the analysis of crude fiber as an example: chemists boiled in a porcelain bowl 3 g of the feedstuff in constantly renewed water for 30 minutes and then in a mixture of 50 ml 10% hydrochloric acid and 150 ml water before decanting and pipetting the cooled down liquid to leave only cellulose. This was then boiled again with water, then with a mixture of water and lime potash, and then again with water. The remaining substance was filtered with a suction apparatus, the filter washed out with water until there was no more discoloration, and the remaining substance rinsed with hot alcohol and ether, dried at 110° C, and finally weighed.[73] These were no household items. Improvers generally had no access to the specialized instruments, purified substances, and manual skill to bring them together. As much as agricultural scientists insisted that theirs was a labor of the mind, which distinguished science from improvement, they did use their hands an awful lot. Even some of their illustrations included the hands to use instruments (see Figure 8). Tacit knowledge was part of scientific training and there was quite a lot of manual skill involved in controlling natural phenomena, isolating individual factors, and thus purifying chemical analysis. Agricultural scientists set themselves apart from improvers when they stripped away the natural shell that kept the nutritional components of feedstuffs hidden from the ordinary eye. "An experiment is a question brought before nature to which she, if it is properly arranged, necessarily must give an answer, even if it is just by yes or no."[74] Ironically, Thaer had already laid the foundations for agricultural scientists superseding

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[72] On the standardization of language in chemistry, see Bernadette Bensaude-Vincent, "Languages in Chemistry," in *The Cambridge History of Science. Volume 5: The Modern Physical and Mathematical Sciences*, ed. Mary Jo Nye, The Cambridge History of Science (Cambridge: Cambridge University Press, 2002), 174–90. On objectivity and its production, see Daston and Galison, *Objectivity*; Daston, "The Moral Economy of Science."
[73] Klemme, 16.
[74] Thaer, *Grundsätze der rationellen Landwirthschaft*, 9. Original: "Ein Versuch ist eine der Natur vorgelegte Frage, worauf sie, wenn er gehörig eingerichtet ist, durchaus eine Antwort – sey es auch nur durch Ja oder Nein – geben muss."

improvers by suppressing their human intervention in the belief of making nature speak. In reality, it took scientists a lot of work, materials, skill, and thought to produce portable, sociable measurements that had little nature left.[75]

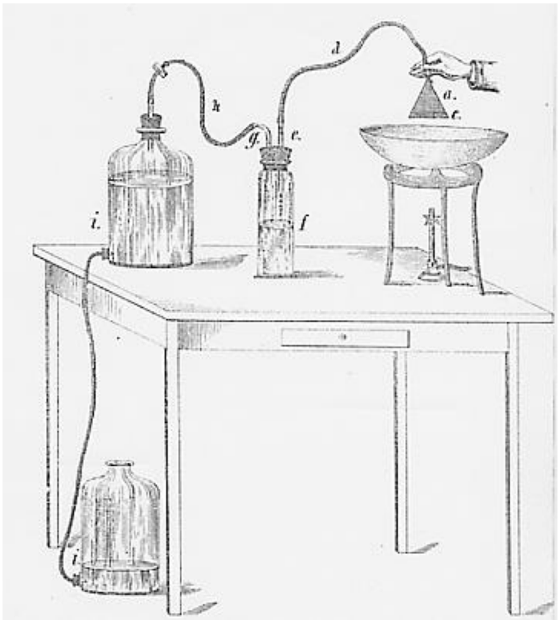


Figure 8: Bunsen's suction apparatus for the improved siphoning of the boiled liquid for the crude fiber determination as part of a simplified Weende method.[76]

Once nature was cracked open, it would not leave scientists alone. When it was clear that digestion could not be adequately simulated with laboratory instruments, agricultural scientists needed the real thing even more than before. However, bringing their test animals into the laboratory surely was not practical. To establish base lines of which feeding regiment would maintain the weight of resting animal

[75] Kathryn M. Olesko, "Tacit Knowledge and School Formation," *Osiris* 8 (1993): 16–29; Albert van Helden and Thomas L. Hankins, "Introduction: Instruments in the History of Science," *Osiris* 9 (1994): 1–6; Lissa Roberts, Simon Schaffer, and Peter Dear, eds., *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation*, vol. 9, History of Science and Scholarship in the Netherlands (Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2007). See also Catherine M. Jackson, "Visible Work: The Role of Students in the Creation of Liebig's Giessen Research School," *Notes and Records of the Royal Society*, January 11, 2008; Catherine M. Jackson, "Chemistry as the Defining Science: Discipline and Training in Nineteenth-Century Chemical Laboratories," *Endeavour* 35, no. 2 (June 1, 2011): 55–62. For further insight into the history of digestion research, see Frederic L. Holmes, "The Physical Sciences in the Life Sciences," in *The Cambridge History of Science. Volume 5: The Modern Physical and Mathematical Sciences*, ed. Mary Jo Nye, The Cambridge History of Science (Cambridge: Cambridge University Press, 2002), 219–36.
[76] H. Wattenberg, "Eine Vereinfachte Methode Der Weender Rohfaser-Bestimmung," *Journal Für Landwirthschaft* 28 (1880): 278. Digital image courtesy of Hathitrust, URL: https://hdl.handle.net/2027/uc1.b3022458?urlappend=%3Bseq=295.

bodies, the sheep, cows, and oxen had to lie or stand still. But tying them tightly to their stall or putting them in cages just big enough was not enough. As scientists' eyes like most eyes could not see inside the animal body, they had to take account of everything that went in and everything that went out of this opaque body. Chemical analysis should be the accountant but could not do the trick alone. Most feedstuffs were grown plants in one form or another, and they were far from uniform. Researchers of animal feeding, much like their colleagues researching soils, could not control the nutritional variation caused by the myriad of environmental influences on outdoor fields. They could merely record and mathematically account for it with ranges and means as Wolff did in his results.[77] Plants within the same crop were a different matter. Hay plants, for instance, varied in their nutritional components even between parts of a single plant. Then take the actual haystack! Agricultural scientists managed this diversity by a method described by Wolff in 1876, taking samples from all parts of the haystack and again after shifting its layers. Similarly, potatoes or beets were sampled from specimens of all sizes to achieve a uniform and representative measurement. In 1861 still, Wolff complained that analyses could not possibly be absolutely accurate since "it is almost impossible in experiments with larger animals to clean the entirety of feedstuffs so completely of dust and dirt as the small samples that are used for chemical analysis."[78]

[77] In field trials, agricultural scientists usually managed uncontrollable environmental factors by equalizing all factors except one by planting experimental plots right next to each other. These could then be compared across multiple years with varying conditions to isolate as much as possible individual and combined factors. Through comparison, research questions and results became relative and thus portable. The seasonal periods of plant reproduction made these field experiments longer and more tedious than feeding experiments. And even with these managing strategies, the soil across an outdoor experimental plot could vary significantly, complicating the results. Agricultural scientists also grew plants in controlled soils in the laboratory to isolate factors and managed to produce insightful results, such as Hermann Hellriegel's method of growing plants on nitrogen-free sand to prove definitively that leguminous plants drew nitrogen from the air. Still, the simplification of the laboratory could not untangle the combinations and reciprocal effects of factors in a field trial. See Uekötter, *Die Wahrheit ist auf dem Feld*, 81-89, Wolfgang Böhm, "Die Stickstoff-Frage in Der Landbauwissenschaft Im 19. Jahrhundert," *Zeitschrift Für Agrargeschichte Und Agrarsoziologie* 34, no. 1 (1986): 31–54; Justus Hillebrand, "But Can the Farm Travel?: Translating Knowledge From Germany to the United States in Late-Nineteenth-Century Agricultural Education," in *Transatlantic Encounters in History of Education: Translations and Trajectories from a German-American Perspective,* ed. Fanny Isensee, Andreas Oberdorf, and Daniel Töpper, Routledge Studies in Cultural History (New York and London: Routledge, 2020), 184–96.
[78] Wolff, *Die landwirtschaftliche Fütterungslehre*, 368. Original: "es bei Versuchen mit größeren Thieren fast unmöglich ist, die Gesammtheit der Futtermittel so vollständig von Staub und Erde zu reinigen, wie die kleinen Proben, welche zur chemischen Untersuchung benutzt warden."

Despite all the efforts to manage nature into submission, the nooks and crannies of plants continued to bear witness to their natural origins.[79]

Time was not on the side of agricultural chemists either. In 1860 already, Henneberg and Stohmann had drawn attention to the change in chemical composition of feeds stored during longer feeding experiments. Experimenters had to avoid decomposition and repeat chemical analysis of freshly cut green fodder throughout the experiment. Still, once the input was more or less managed, the temporal workings of ruminant digestion were the next problem to solve. Early experiments had lasted only a few days, but during the late 1850s several researchers suggested that ruminants kept feed in their digestive tract longer than the monogastric animals often used in other digestion research. Wolff and his colleagues divided and incrementally extended the feeding phases before to 6-8 days and during the experiment when excrement would be collected to 6-10 days. Excrement collection, then, posed the final frontier. Excrement also changed its chemical composition over time. Laboratory assistants tended to the animals from 7 am to 10 pm to collect urine and feces immediately or the next morning to provide excrement as fresh as possible for chemical analysis. Several generations of urine funnels and feces bags tied to the animals slowly improved the collection process as picking up feces meant adulteration and leaks meant fluid loss (see Figure 9). These devices managed the intricacies of male animal anatomy in time but found their limit in the cow. The separate collection of feces and urine was anatomically easier with oxen, so they became the standard test animal throughout the second half of the nineteenth century except for experiments on milk production. It was only in 1895 when Hagemann constructed an efficient device to achieve the separate collection of feces and urine in cows, another step in overcoming the natural intricacies of animal anatomy and temporality (see Figure 10). Still, scientists could never discipline their subjects completely. They had to add to the static method of chemical analysis significantly in instruments, skills, and assistants using them, hidden in their results, of course, to manage the dynamic

[79] Klemme; Wolff, *Die landwirtschaftliche Fütterungslehre.*

nature of plants, animals, and their products. And they could only achieve this just enough to explain away nature's variation mathematically.[80]

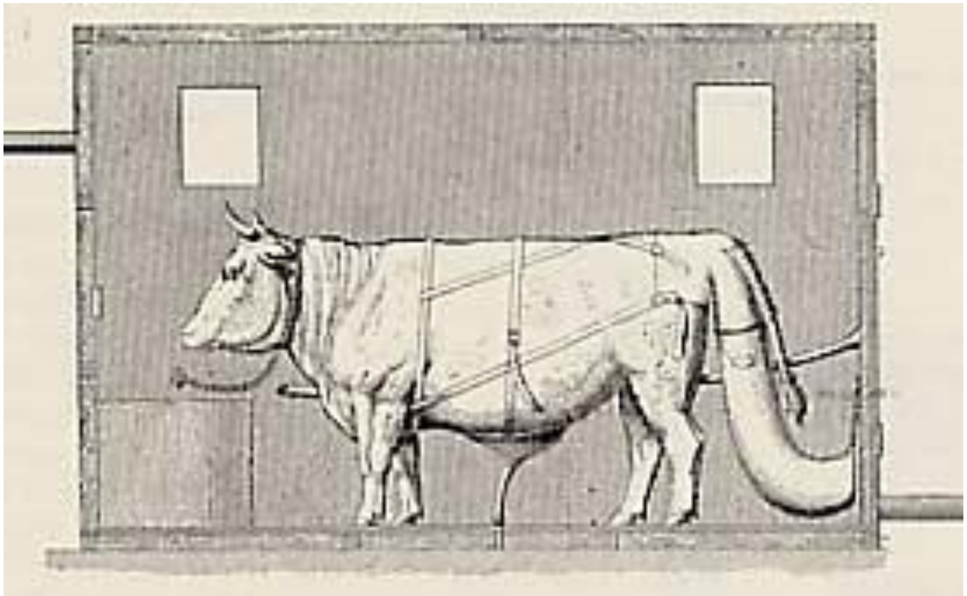

Figure 9: Ox with urine funnel and feces bag in Grouven's respiration chamber.[81] By the end of the nineteenth century, respiration chambers became highly intricate instruments to measure the heat production and breathing activity of farm animals and humans, yet focused more on the animal and human biology of nutrition rather than ideal feed regimen.

[80] Klemme. These conflicts and adaptations between scientists and their subjects mirror the conflicting energy sources and temporalities between industry and agriculture described by Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*.
[81] Hubert Grouven, *Physiologisch-chemische Fütterungsversuche über den Nährwerth einiger allverbreiteten, stickstofflosen Nährungsbestandtheile, ausgeführt zu Salzmünde in der Jahren 1861 u. 1862* (Berlin: Wiegandt u. Hempel, 1864), as included by Klemme, 24.

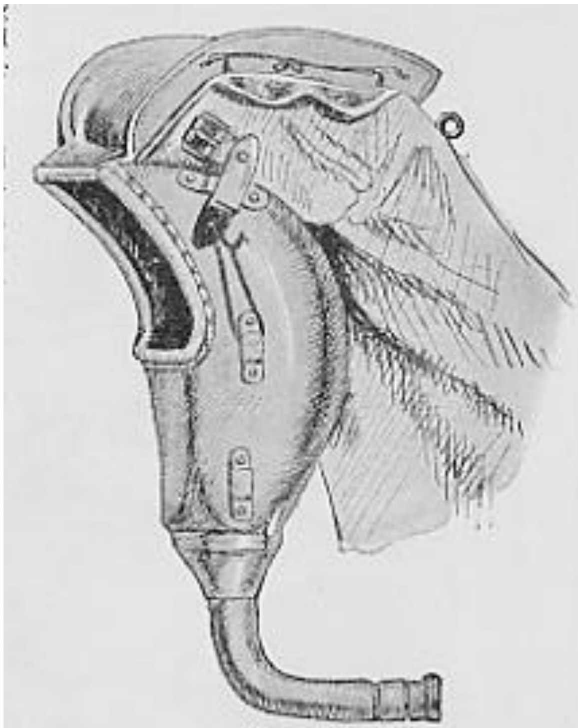

Figure 10: Urine funnel and feces catcher for cows by Oscar Hagemann.[82]

Scientists erased the last remnants of nature by mathematical operations to argue that their results were not just accurate and thus comparable but universal. In the introduction of his 1861 book, Wolff set out his goal: "For years I have endeavored to make the accurately executed feeding experiments useful to science and practice by calculating anew in various directions the directly found weighing results and compiling them under common aspects."[83] This evidence base, however, was still unstandardized. It varied in the kinds of results and conditions reported, the animal species and sexes as well as feed rations used. Based on chemical analysis of feeds, Wolff calculated the approximate nutritional components of all feed rations used in other experiments, even if they had not been reported. After treating all tested animal species individually, he neglected animal species and sex as influential factors in determining feed rations

[82] Oscar Hagemann, "Beiträge Zur Rationellen Ernährung Der Kühe," *Landwirtschaftliche Jahrbücher* 24 (1895): 283–308.
[83] Wolff, *Die landwirtschaftliche Fütterungslehre*, VI. Original: "Schon seit Jahren bin ich bemüht gewesen, die Ergebnisse der genau durchgeführten Fütterungsversuche für die Wissenschaft und Praxis recht nutzbar zu machen, indem ich die direct gefundenen Wägungsresultat nach verschiedenen Richtungen hin neu berechnete und unter gemeinschaftliche Gesichtspunkte zusammenstellte."

and digestibility. Instead, he mostly leaned towards oxen as the standard animal. With the influence of animal digestion standardized, he calculated a digestibility coefficient for specific feeds rather than animals. He compared the weight of nutritional components in feed to that in excrement to determine the portion of the feed that had been digested. These values he then made relative to the animal by calculating the weight of nutrients to 100 pounds live weight of the animal. Then, he made the adjusted weight of nutrients relative to the feed by expressing its percentage in the feed. The results were standardized, comparable values for the digestibility of feeds in totality and in their nutritional components. Wolff averaged and selected results, neglected factors, and recalculated to relative values to produce authoritative data tables that stripped out the specificity of each feeding experiment and chemical analysis. By mathematical means, he integrated the situated work of a dispersed community of agricultural scientists into table-shaped universal principles.[84]

In the second half of the nineteenth century, agricultural scientists built feeding experiments, chemical analysis of feedstuffs, and calculations of numerical results into their domain. These were the boundaries of their expert community. Scientists excluded improvers and farmers to be taken seriously as a legitimate academic discipline and avoid being called "professor of manure."[85] Agricultural scientists leaned heavily on chemistry as a discipline but built their own academic community with their own specialized terminology, professional meetings, academic journals, and research institutions. In Germany, their idol was no longer Thaer but Liebig. Scientists reshaped in their own image what improvers had called scientific inquiry into agriculture. Yet, once improvers and scientists had separated into their own disciplines, their differences in conventional communication and media required translation which their remaining commonalities allowed.

## Overcoming the necessary disconnect: Scientists translate knowledge to improvers

[84] Wolff, *Die landwirtschaftliche Fütterungslehre*, 315-322, 363-482.
[85] One colleague of Julius Kühn, the first German professor of agriculture, at the university of Halle called him professor of manure behind is back. Harwood, *Technology's dilemma*, 83.

Within the academic community of agricultural science, Emil Wolff stood on the practical side, closest to improvers. He worked at the Hohenheim agricultural academy, an institution originally modeled after Thaer's academy at Möglin. Throughout the second half of the nineteenth century, the Hohenheim academy adapted to accommodate more scientific research, such as with the establishment of an experiment station in 1864 and professorships in zoology and mineralogy in the 1870s, but still mainly trained farmers in the improving tradition. The curriculum treated hallmarks of agricultural science including chemistry as "ancillary sciences" (*Hilfswissenschaften*), faculty published frequently in improvers' agricultural journals, faculty qualifications included experience in farming or managing estates, and research interests prominently included agricultural economics and farm management. Its practical orientation caused Hohenheim's low esteem within established agricultural science in the second half of the twentieth century. While scientists came to see Hohenheim as a higher trade school at best, it attracted and bred some reputable agricultural scientists. Together with Wolff, Heinrich Wilhelm Pabst and director Gustav Walz had investigated Liebig's mineral fertilizer in trials and criticized it heavily. That was also why Hohenheim figured so prominently in Liebig's damning critique of academies in the 1860s as outdated trade schools. Wolff exhibited a rare combination: he was an agricultural scientist by the merit of his work yet not detached from the concerns of improvers. When he synthesized scientists' experimental work on feeding into one coherent standard, Wolff shaped his research to suit both debate with scientists and translation for improvers.[86]

The central medium for the translation of Wolff's feeding standard was the agricultural calendar or farmer's almanac, specifically *Mentzel und v. Lengerke's Landwirthschaftlicher Hülfs- und Schreibkalender*. This annual publication was founded in 1847 by Alexander von Lengerke, a prolific improver and first general secretary of the Prussian Agricultural State Commission, and breeder Oswald Lengerke. The editors added a second part to the pocket note-keeping calendar that functioned as reference guide and educational reading. Data tables on various weights, measures, average prices, and

[86] Harwood, *Technology's Dilemma*, 148-158; Stahr, Fellmeth, and Blume.

calculations found their place next to the genealogy of the Hohenzollern royal family and registers of all German agricultural colleges, schools, experiment stations, and fairs. Adding to this practical information, contributing authors also kept readers up to date with annual summaries of changes to any laws pertaining to agriculture and current scientific debates and innovations. Next to these translations of complex debates were educational essays on specific topics on all things farming. For example, the calendar for 1864 included essays by prominent agricultural scientist, Julius Kühn, on the use of microscopes by farmers; by a nobleman on the storage of crops; by a Prussian civil servant on the breeding of pigs; by a seed grower on recent improvements in the seed market; and by an estate owner on his experience feeding lupine to foals. Improvers out of the upper echelons of agricultural societies and government offices wrote next to scientists from Germany's academies and universities. Theory and practice in the same handy publication, small like a pocket calendar but too hefty to be carried around, record keeping, reference work, and textbook at once. The agricultural calendar was a publication for improvers. It represents in a compact format how improvers communicated with each other and how scientists, including Wolff, translated their findings to their most important audience.[87]

In 1854 and the following years, Wolff built on previous work mainly by Boussingault and published data tables of hay values (improved by scientific inquiry) and simplified nutritional values. In his fundamental 1861 book, he continued to bring together scientific research on the digestibility of various nutrients and the simple use of the single hay value numbers. He did not strive for scientific exactitude in this, but rather a sufficient compromise that would guide farmers to improved feeding results. The portable elements in scientists' feeding research were nutrient groups and their ratios as components of feeds, most importantly the ratio of nitrogen-rich to nitrogen-free substances, which roughly equates to the ratio of proteins to carbohydrates. Out of the specific ratios for various production

[87] Matz; Hans-Peter Blume, "Lengerke, Alexander Von," in *Neue Deutsche Biographie* (Berlin: Duncker & Humblot, 1985); O. Mentzel, Dr. Lüdersdorff, eds., *Mentzel und v. Lengerke's Verbesserter Landwirthschaftlicher Fülfs- und Schreib-Kalender auf das Jahr 1864*, Vol. 17, Part 2 (Berlin: Wiegandt & Hempel). Consider the digitized copies of the calendar for 1863-1867 on Hathitrust: https://catalog.hathitrust.org/Record/005972480?type%5B%5D=all&lookfor%5B%5D=Mentzel&ft=ft and for 1869 by the Bayerische Staatsbibliothek: https://reader.digitale-sammlungen.de/resolve/display/bsb10296066.html

goals, Wolff selected what he deemed the most common, namely meat or milk production, which was a ratio of one nitrogen-rich to five nitrogen-free parts. Not coincidentally, this ratio of 1:5 was also found in common hay. There was a reason why farmers and improvers identified common hay as the most natural feed. Using nutritional analyses, he calculated two sets of hay values based on this 1:5 ratio for over 150 common feeds, one corresponding to total and the other to digestible nutritional components. He translated the principle of digestibility into improver conventions. These scientific hay values were exact enough to improve feeding results and shield users from waste. In his first publication of these tables in 1854, Wolff attested to agricultural chemistry's "low stage of development" but also drove home the "effort of this youthful science to consecrate itself to [the farmer's] service."[88] Wolff claimed authority for science through innovation in principles, yet translated them into the method developed and used by improvers.[89]

In 1864, however, this compromise could not hold anymore. For the first time, Wolff did not include hay values alongside nutritional components in the data tables published annually in the calendar. In his accompanying article, Wolff reframed his previous translation into hay values as merely educational. The contrast between the hay values and the nutritional values had been intended to transition farmers to the correct system of nutritional values. Instead of hay values, Wolff added columns for the nutritional values of phosphoric acid and calcium oxide, minerals which scientists could now detect in chemical analysis and found to be important in nutrition.[90] Scientific complexity replaced ease of use. He explained this decision as the result of the complexity that scientific research had found in the subject of animal nutrition. Improvements in chemical analysis and new experimental findings about

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[88] Wolff, "Futterwerttabellen" in Hamm'sche Agronomische Zeitung, 1, 1854, as quoted in Wolff, *Die landwirtschaftliche Fütterungslehre,* 467. Original: "Die Tabelle gibt dem Landwirth Kunde von der niedrigen Entwicklungsstufe, auf welcher die Agriculturchemie noch gegenwärtig sich befindet, sie zeigt ihm aber auch das Bestreben dieser jugendlichen Wissenschaft, seinem DIenste sich zu weihen, in seinem Interesse thätig zu seyn."
[89] Wolff, *Die landwirtschaftliche Fütterungslehre*, 440-482
[90] Wolff summarized that fats were as of yet not understood enough to warrant inclusion in the data table. Until these would be sufficiently researched, Wolff had no problem filling this gap in the text with knowledge "very widespread in practice" combined with the limited experimental results available. Emil Wolff, "Bemerkungen Über Futtertabellen Und Futtermischungen," ed. O. Mentzel and Dr. Lüdersdorff, *Mentzel Und v. Lengerke's Verbesserter Landwirthschaftlicher Hülfs- Und Schreib-Kalender* 17, no. 2 (1864): 63.

nutrient digestibility, especially in certain nutrient combinations, made the compromise of single equivalent values between feeds impossible. “And with that,” Wolff wrote, “the time is forever past in which one believed to be able to replace in the daily feed of animals e.g. a specific amount of hay or straw with potatoes, turnips, or grains simply and exclusively according to their hay value numbers.”[91] That was his way of telling improvers that scientists’ knowledge had superseded theirs irreversibly.

At the same time Wolff replaced hay values with his own translation of scientific findings into a practical method. As before, he provided the percentages of each nutrient group contained in feeds (organic substance, wood fiber, nitrogen-rich nutrients, and nitrogen-free nutriens) – the supply side – and feeding norms in pounds of nutrients for specific production goals for each animal – the demand side. Wolff knew how to use these values to calculate specific feed rations ideal for each goal and animal. But he did not provide the mathematically complex instructions to do so. Instead, Wolff did the calculations for users and presented example rations of 2 to 7 feed ingredients with their respective pound amounts per one hundred pounds live weight of the animal. He had modeled these on what he identified as common rations used in practice with the key difference that he had improved them nutritionally. To adapt these standard feed rations, users should simply replace single feed ingredients of the ration with another feed with similar nutritional values as specified on the provided table. For example, users could substitute the same weight of Serradella hay with red clover hay, or lupin straw with pea straw. Finally, he qualified these instructions with exceptions for specific substitutions based on scientific research and with practical concerns that lay beyond feed ration calculation. For milk cows and calves, users had to pay attention to only perform substitutions that still included the same amounts of mineral nutrients, such as phosphoric acid. Feed rations should always be changed slowly to avoid decreased digestion of nutrients and thus waste, whether to a better or seasonal ration. Users should make sure their rations were palatable to their animals, a piece of general advice deemed outside the purview of scientists. Wolff translated his

[91] Wolff, “Bemerkungen Über Futtertabellen Und Futtermischungen,” 50. Original: “und damit die Zeit für immer vorbei, wo man im täglichen Futter der Thiere z.B. eine gewisse Menge von Heu oder Stroh durch Kartoffeln, Rüben oder Körner einfach und ausschließlich nach deren Heuwerthszahlen ersetzen zu können glaubte.”

calculation of nutrition-based rations into a method as simple and as close to the expectations of his improver audience as possible. [92]

Still, this method was more complex than hay values. Why should improvers choose this method over hay values? First of all, nutrition-based rations were more certain and efficient in their effect than those based on hay values. Nutrition-based rations guaranteed the same results independent of their feed composition. Also, feeding experiments had shown the true and thus less wasteful or more profitable nutritional demands of animals. Wolff argued that scientists had found the actual feed demand of resting oxen was much lower than hay values had prescribed and promised substantial savings. He supported his argument with lengthy experimental reports but also with situated application examples. Wolff specified the breed of oxen, their weight, the weights of ration components, the result in bodyweight, and the specific labor demanded of the oxen on specific estates in the winter of 1860/61. This echoed improver reports that usually added more specifics to help their audience adapt trial results to their farm. But Wolff only presented the nutritional components to explain why these rations, so much lower than hay values would allow, showed positive results: the oxen had either gained weight or performed labor without weight loss over the winter. Scientific feeding improved efficiency.[93]

Second, scientific feeding increased profits. When Mentzel introduced Wolff's standard feed rations in the 1869 calendar, he addressed this: "The effort which the assembly of these […] feed mixes causes is compensated abundantly by the highest possible utilization of the specific feeds."[94] Wolff promised the end of waste and optimum profit – exactly what improvers had wanted for decades. Users only had to put in the labor and the money. His precalculated rations for milk or meat production frequently included industrial byproduct feeds only available for purchase from feed dealers, such as

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[92] Wolff, "Bemerkungen Über Futtertabellen Und Futtermischungen;" O. Mentzel, ed., *Mentzel und v. Lengerke's Verbesserter Landwirthschaftlicher Fülfs- und Schreib-Kalender auf das Jahr 1869*, Vol. 22, Part 2 (Berlin: Wiegandt & Hempel) 10-18.
[93] Wolff, "Bemerkungen Über Futtertabellen Und Futtermischungen," 74-75.
[94] Mentzel, *1869*, 10. Original: "Die Mühe, welche die Zusammenstellung dieser oder doch im Wesentlichen sich nähern der Futtermischungen verursacht, wird durch die möglichst hohe Verwerthung, welche dadurch die einzelnen Futtermittel erfahren, reichlich aufgewogen."

rapeseed cake, potato “slump” (*Kartoffelschlempe*), brewers’ grains, and pressed remnants of sugar beet processing. The underlying method of calculating ideal rations generally relied on purchasing concentrated feeds rather than growing them on the farm. Market agents were part of scientist recommendations only implicitly as passive suppliers of agricultural inputs. The professed advantage of scientific feeding was comparing the feeds available on the market based on their financial and nutritional value. So, the argument of Wolff and nutritional research in general was the intensification of agriculture. More labor invested in feeding also meant specialization. While these economic arguments were usually just undercurrents in scientists’ publications, they were no different from improver calls for increased investment in innovation generally. Whether farmers bought expensive machines to increase efficiency or expended time and money to learn, calculate, and assemble ideal rations, the message was the same: intensify and specialize to survive.

If farmers refused, they were backward and stubborn conservatives of yesteryear. This third argument to use scientific feeding was really an implicit threat. Wolff justified his decision to omit hay values in the 1864 calendar by pointing to the widespread adoption of his nutritional method. “A more rational, more scientifically-founded feeding method has gained currency, the older calculation method using hay values has been abandoned by the intelligent farmers.”[95] Scientists frequently identified farmers who used their suggested methods as intelligent, progressive, turned towards the future. Using scientific methods became a form of distinction. If farmers decided to use scientific methods and could even afford to do so, they were better than their neighbors who did not. Intensification and specialization with scientific agriculture made the farmer of the future. Not skepticism. Not backtalk. Not the belief that farmers could do without the fundamental innovations and leadership provided by scientists. Agricultural scientists like Wolff made sure to praise the buy-in of improvers into the elevated circles of scientific

[95] Wolff, “Bemerkungen Über Futtertabellen Und Futtermischungen,” 50. Original: “Eine rationellere, mehr wissenschaftlich begründete Fütterungsweise hat Verbreitung gefunden, die ältere Rechnungsweise nach Heuwerthen ist von den intelligenten Landwirthen aufgegeben…”

agriculture led by scientists. In the reverse, this increased the pressure to comply lest improvers could be left behind in the dust of history.

In truth, few "intelligent" farmers had yet transitioned when Wolff proclaimed it a fait accompli in 1864. His statement was more a strategy to claim authority than a description of fact. It expressed scientists' worldview in which only science could provide the answers improvers needed. When Wolff proclaimed the hay values a thing of the past, the improver editor of the calendar, Oscar Mentzel, included them right underneath Wolff's tables at least until 1869. He anticipated the demands of his audience. It was a slower transition than Wolff made it out to be.

And a more contested one. When improvers and scientists came together at their almost annual Meeting of German Farmers and Foresters (*Versammlung deutscher Land- und Forstwirthe*) in 1865 in Dresden, Saxony, the adoption of the new nutritional feed calculations was on the docket for discussion in the livestock breeding section. In the absence of statistical evidence, a Saxonian aristocratic estate owner from Saalhausen with the last name Günther reported the "known impression" that nutritional feeding had "more or less found introduction in rational agriculture in recent times almost everywhere and that namely in Saxony on small farms one also starts to set the greatest value on purposeful feed mixes."[96] Making a clear difference between improvers employing rational agriculture and small farmers trailing behind them, Günther's description makes clear that Wolff's new age of feeding had not yet won the day. Günther agreed with the efficiency and flexibility of scientific feeding but criticized its practicality and prophesied that, in the face of nutritional complexity, individual observation and decision-making informed by scientific principles would be key in the future. With both improvers and scientists at the table, Günter walked the tightrope between acknowledging the validity and utility of scientific methods, defending improver authority over knowledge evaluation, and challenging scientists' translation skills.

[96] *Amtlicher Bericht über die 25. Versammlung deutscher Land- und Forstwirthe zu Dresden, vom 25. Juni bis 1. Juli 1865* (Dresden: G. Schönfeld's Buchhandlung, 1866), 338. Original: "Ich muß mich deshalb darauf beschränken, die bekannte Wahrnehmung zu wiederholen, daß die Futtermischungslehre in neuerer Zeit bei der rationellen Landwirthschaft fast überall mehr oder weniger Eingang gefunden hat und man namentlich in Sachsen auch in kleinen Wirthschaften anfängt, auf zweckmäßige Futtermischungen den größten Werth legt."

How could scientists lead improvement if they could not provide practical solutions? Like other section participants, chairman and veterinarian Dr. Gottlieb Carl Haubner agreed with Günther's criticism of the practicality of calculating with two or three nutritional values rather than one hay value. Still, concerns over ease of use could not halt the shift scientists made in their communication of innovation in principles. [97]

In the 1870s, Wolff exemplified the general turn by agricultural from translation to education. Rather than translating nutritional feeding into pre-calculated rations, Wolff changed his strategy to explaining his method for calculating ideal rations from scratch. He deemed the position of agricultural science strong enough, and his audience as receptive enough, to make this shift. With the rise of agricultural science as a discipline, institutions of scientific research and higher education in agriculture had increased substantially. Wolff himself judged the knowledge in animal nutrition science as complete enough to summarize in a textbook. What came to be known as Wolff's "agricultural science of feeding" (*landwirthschaftliche Fütterungslehre*), broke animal feeding down to its basic principles of animal physiology and digestion, feed composition, and ration compilation. Wolff intended this book for use at all institutions of agricultural learning but also dedicated the book to "all farmers that strive for rational feeding."[98] When it came to agricultural science, students of agriculture and improvers now stood on the same level: they had to be taught the basics.

Going into the 1880s, German agricultural scientists had perfected their combination of instruction, policing, and flexibility to claim universality for innovation in principles. By 1882, Wolff also printed his textbook instructions for calculation in the Mentzel and v. Lengerke calendar, where he now was co-editor with a member of the Prussian agricultural ministry. With direct control over the content of this former improver-edited calendar, he could also prevent the print of hay values next to his own. In his

[97] *Versammlung deutscher Land- und Forstwirthe* 1865, 338-343. See also, Matz.
[98] Emil Theodor von Wolff, *Die rationelle Fütterung der Landwirthschaftlichen Nutzthiere: Auf Grundlage der neueren Thierphysiologischen Forschungen ; Gemeinverständlicher Leitfaden der Fütterungslehre* (Berlin: Wiegandt, Hempel und Parey, 1874), VI. Original: "Diese Schrift ist allen Landwirthen gewidmet, welche eine rationelle Fütterung ihrer Nutzthiere anstreben."

textbook as in the calendar, Wolff explained how to calculate and adapt ideal rations from feeds commonly grown on farms or available for purchase. On his ever-growing list of feeds, he only included the digestible amounts of nutrients which he repeatedly referred to as the actual or real nutritional components, clearly arguing for unquestionable scientific authority over this matter. Credible feed rations had to conform to scientists' innovation in principles and scientists provided the proper instructions on how to assemble them. Wolff also provided examples of how to calculate rations. Here, he described the average demands and supplies in organic substance, protein, carbohydrates, and fat as a mere "guideline" that need not be "anxiously"[99] matched. By 1880, the calendar also included the minimum and maximum nutritional contents of feeds in addition to their averages. The variation in individual animals, feeds, and conditions would require individual adaptation. Principles were inflexible and unassailable by non-scientists. Their application was flexible and could be adapted to particular conditions without contradicting the universal claims of principles.[100]

German agricultural scientists had completed their vision of the agrarian-industrial knowledge system. Their expertise was the laws of nature, superior to their pedestrian application. Wolff and his colleagues no longer translated principles into established improver methods. They expected all non-scientists to learn enough science to understand innovation in principles. With scientists' expert status established, translating principles to users was no longer their concern. They delegated this to those they taught. Their students largely became either improvers or agricultural teachers who would bridge the necessary disconnect to farmers, translate innovation in principles, and multiply their effect into national economic growth as promised to state agents. German agricultural scientists moved toward the realm of the pure sciences within the academy, with a commensurate increase in prestige and state funding. Their students and colleagues from abroad soon began to take note and follow their example.

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[99] Ibid, 191

[100] Ibid; Emil Wolff, "Bemerkungen Zu Den Tabellen Über Futtermittel Und Fütterungsnormen." Henry Prentiss Armsby took the tables including Kühn's value ranges from the 1880 calendar in: Henry Prentiss Armsby, *Manual of Cattle-Feeding; a Treatise on the Laws of Animal Nutrition and the Chemistry of Feeding-Stuffs in Their Application to the Feeding of Farm-Animals.* (New York: Wiley, 1880).

## **Across the Atlantic: Moving innovation in principles, moving the knowledge system**

Germany had become the center of agricultural science in the second half of the nineteenth century. The knowledge and the model of a knowledge system that German agricultural scientists produced moved beyond Germany. The foundation of German agricultural scientists' claim to power had been their exclusive means of producing placeless and thus portable knowledge. We might expect that moving their universal principles would be easy, given their basis in extensive experimentation and scientists' exclusive expertise. Yet, adaptation proved critical. Transcontinental translation of agricultural science to the United States provides a ripe example of this process. American agricultural scientists not only had to manage different environments in the United States but a different society, government, economy, scientific community, and, most importantly, farm audience. Adapting German institutions of agricultural science to American contexts was intertwined with translating their innovation in principles. The establishment of agricultural science as a discipline involved a lot of movement of people, things, and the ideas they carried across the Atlantic.

The most insightful resource for the translation of feeding science was Mentzel and von Lengerke's agricultural calendar. All of the books, journals, and chemical instruments and the knowledge, skills, and ideas which numerous American visitors had acquired at European, especially German, laboratories, universities, and experiment stations: the calendar compressed them into a handy, up-to-date reference work that traveled easily. The calendar was present when the first director of an American experiment station failed to translate its contents to improvers, when his mentor succeeded, and when one of its chemists wrote the introduction to scientific feeding in the United States. Inconspicuous in size, yet most prominent in translation, Wolff's data tables on feeding standards traveled within the calendar. American agricultural scientists translated them in different ways, as exemplified by Wilbur Olin Atwater, Samuel William Johnson, and Henry Prentiss Armsby. They had to learn the register, evidence, and arguments effective with an American improver audience, which was deeply knowledgeable of their farm environment. These American scientists could not break free of the particularities of environment so different from Germany. Far from creating universal principles, the process of moving them came with new challenges and some that agricultural scientists had faced in Germany.

**Jumping ahead: How translation of universal principles failed**

On the afternoon of February 11, 1874, Wilbur Olin Atwater held the Mentzel and von Lengerke agricultural calendar in his hand as he stood before an assembly of agricultural improvers in the courthouse of Wiscasset, Maine. The organizers of the annual winter meeting of the Maine Board of Agriculture had invited Atwater as one of nine speakers in their three-day event. They had chosen this location to promote more interest in agricultural improvement in Lincoln County, which apparently lagged behind efforts elsewhere in the state. In the audience, there were at most a few trained agricultural scientists, more local improvers, and some invited New England greats of the movement. These were not Atwater's people. He had studied at Wesleyan University before getting his doctorate in 1869 at Yale University's Sheffield Scientific School, one of the centers of agricultural science in the country. As usual for young and hopeful American agricultural scientists in the mid-nineteenth century, he had done a tour through European, mostly German, laboratories, universities, and experiment stations, including the first one in Möckern but most prominently the one in Weende, known for animal nutrition research. After two years and extensive travel, he had returned to the United States in 1871 to teach one-year terms at East Tennessee University and at the Maine State College of Agriculture and the Mechanic Arts. He had left his Maine position only about six months prior to his speaking appearance in Wiscasset. The 29-year-old stood in front of the assembled improvers of Maine as professor of chemistry at Wesleyan University and gave a lecture that would later be heralded as the first introduction of scientific feeding to the farmers of Maine.[101]

[101] On the biography of Atwater, see Kenneth J. Carpenter, "The Life and Times of W. O. Atwater (1844–1907)," *The Journal of Nutrition* 124, no. supplement 9 (September 1, 1994): 1707S-1714S; Catherine Atwater Galbraith, "Wilbur Olin Atwater," *The Journal of Nutrition* 124, no. suppl_9 (September 1, 1994): 1715S-1717S. On the Atwater lecture as one of the first introductions of scientific feeding to Maine, see David C. Smith, *The Maine Agricultural Experiment Station*, 2-3.

And as a professor he spoke. Atwater's lecture was an attempt to convey the basics of nutritional research to a college audience. Deeply entrenched in the complex details of feeding experiments and current research questions of the field, Atwater translated scientific knowledge in the way that German agricultural scientists like Wolff translated knowledge to German improvers in the 1870s. He expected a basic education in animal nutrition and showed little concern for what his audience knew and how best to reach them. He spoke about feeding experiments, chemical analysis, eminent German scientists, the first respiration calorimeter, and (provided in the written record) numerous tables. Atwater laboriously developed the fundamental question of determining the most economical ways of feeding cattle by likening the stable to a factory where the animals, as machines, turned the raw materials of feed into products.[102] He called his long passages about the specifics of feeding research "too abstruse" to then turn to the "practical bearing"[103] of this research. Like his German role models, he took on improvers' supposed questions about feeding as starting points to launch into experiment design, description, and results. To Atwater, credible agricultural knowledge relied on scientists' conventions of communication, regardless of his audience.

When Atwater translated the nutritional value of specific feeds into dollar amounts, he came close to speaking the language of improvers. Yet, his prices for feed, labor, and agricultural outputs came from German markets, as reported in German books and evaluated by German scientists – inapplicable to American contexts. When Atwater got to the application of all this science to improvers' farms, he pulled out the Mentzel and von Lengerke agricultural calendar: "a little book, a farmer's pocket dairy (sic!)—a German work—which many thousands of the best German farmers carry in their pockets."[104] The tables contained therein, "in vogue in Germany," allowed the calculation of ideal rations, of course, not to be "blindly followed"[105] as Wolff had warned. In early 1874, the agricultural calendar still contained Wolff's

[102] On the industrial understandings and language of agricultural improvers and scientists in the late nineteenth century, see Auderset, Moser.
[103] Samuel L. Boardman, *Nineteenth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1874*, (Augusta: Sprague, Owen & Nash, 1874), 47.
[104] Ibid, 64.
[105] Ibid, 64

precalculated example rations. So, like Wolff, rather than “giving rules and directions for calculating” ideal rations for each kind of animal and production based on animal weight, Atwater presumed his audience “would be better pleased with the calculations already prepared.”[106] However, while Atwater also supplied a selection from Wolff’s table on nutritional components of feeds, he did not explain how to substitute feeds in the rations. Rather, he had to explain exactly what several German grain meals and industrial byproducts were. He pointed out that “many of the mixtures will be too complicated for use here,” but that they were useful in learning about European intensive farming, “toward which we are surely tending.”[107] Atwater translated little to nothing from German to American contexts. And this came as no surprise. Trained in Germany, he used exactly the content and presentation of agricultural knowledge his teachers used. “It is not the blind copying of fodder tables that makes economical foddering, but the learning and application of the principles upon which these tables are founded,” he said.[108] And principles were true anywhere.

His audience begged to differ. Two responses by audience members were recorded in the meeting report. Both came close to rejecting what Atwater had to offer, meeting “the approval of the entire audience.”[109] Hall C. Burleigh, a “noted breeder of Herefords” from Fairfield, Maine, attested to the shared belief among improvers that the combination of science and practice was key to improving agriculture. His turn of phrase was quite telling: “practice with science.”[110] There was a hierarchy and new-fangled scientists surely did not come out on top. Burleigh reported that he had read more than one hundred published feeding experiments but had found few of them to be of value. Instead, as a successful cattle breeder making farming pay in Maine, he assumed the position of the true expert. The mark of his status came in the conventional guise of improver knowledge communication: “A pair of two year old steers which he once owned,” the meeting report noted, “gained 14 ½ inches in girth in six months by

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[106] Ibid, 64.
[107] Ibid, 67.
[108] Ibid,Figure 11 65
[109] Ibid, 71
[110] Ibid, 71. The author of the report, influential Maine Board of Agriculture secretary Samuel L. Boardman, used indirect voice to quote the speakers, so this turn of phrase might have been Boardman’s.

feeding them with good early cut hay, and two quarts per day of corn, barley and bean meal mixed in equal parts."[111] This was localized, particular evidence and instruction, proven to be profitable, and expressed in a measurement used on working farms. Why would improvers weigh their cattle other than for sale or slaughter? Furthermore, he estimated that 18 ½ bushels of corn or oatmeal were equal to a ton of good quality hay. While hay values had not been formalized as in Germany, improvers already thought in hay equivalents, comparing feeds to what they thought of as the most natural cattle feed there was. Unlike in German scientist circles, hay equivalents were not passé in Maine. The American audience had not undergone Wolff's "educational arc" to accept scientists' innovation in principles as superior. So when Atwater employed Wolff's translation of scientific findings into a supposedly practical method, he missed that his American audience refuted the expert status of agricultural scientists and the usefulness of what they claimed as universal.

The second response recorded after Atwater's lecture was more blunt. Harris Lewis, the president of the New York state agricultural society, tore down any authority Atwater might have had built up.

> Hon. Harris Lewis said the experiments reported by Prof. Atwater were very elaborate, and he feared we should underrate them – and yet, they were not of the slightest value to our farmers. It is true that science is founded on experiments – but these German experiments are worthless to us, because their crops, soil and climate are so different from our own.[112]

The hot American summers dried out hay faster than farmers could harvest it and American farmers would never be able to feed their less nutritious straw at a profit. "The German system of feeding is unpracticable here," Lewis proclaimed, because "we have not a chemist at every barn door."[113] As a representative of New York's admired dairy industry, Lewis' dismissal carried weight in Maine. Without accounting for the real effects of the American and particularly Northeast environment on farming, American scientists could not enroll German evidence, even from the notable agricultural calendar, to establish themselves as experts.

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[111] Ibid, 71
[112] Ibid, 71
[113] Ibid, 71.

**No need for particulars: How translation of universal principles succeeded**

In more able hands, however, the calendar and all it represented could in fact serve American agricultural scientists. In December 1873, two months before Atwater's lecture in Wiscasset, his mentor Samuel William Johnson brought Atwater and the Mentzel and von Lengerke calendar to the winter meeting of the Connecticut board of agriculture at Meriden. Johnson had been similarly enthusiastic about German agricultural science and its experiment stations. After finishing his studies at Yale in 1853, he spent two years studying with Liebig in Munich and met Wolff at Möckern. When his initial attempts at convincing New York improvers of the value of experiment stations failed, he began to hone his translation skills. As professor of agricultural chemistry at Yale's Sheffield Scientific School, he spent almost two decades teaching, wrote two successful textbooks, advocated for more scientific investigation in the agricultural press, and worked closely with the Connecticut state agricultural society and Connecticut board of agriculture once it was established in 1866. By 1873, the board had close ties with Yale and counted among its members a botanist, an entomologist, and a chemist, Johnson himself. Unlike in the Wiscasset episode, almost two decades of opposition by improvers and tireless advocating by scientists for the grand goal of introducing experiment stations to the United States, had prepared Johnson and his improver audience at this board meeting to agree on the utility of agricultural scientists as experts.[114]

Far from getting bogged down in Atwater's specifics, Johnson argued for the benefits of agricultural science as a whole. The 43-year-old introduced Atwater as his own crop and as one of the most able chemists of the country, freshly returned from Germany, armed with the latest scientific research. Atwater gave a lecture about what he had witnessed firsthand at German experiment stations in general and on fertilizer control in particular. For years, warding off fertilizer fraud had been the hook Johnson and other American agricultural scientists had used to land positions as state chemists and to argue for an experiment station. Scientific feeding entered the mix. Building on the report of his direct

[114] Rossiter, 127-171.

witness, Johnson employed some of the same arguments as his German colleagues: less waste, more efficiency, more reliability, more profit for farmers, the state, and the country, lest they fall further behind their European counterparts. However, he reframed these arguments in the context of American improvers. Johnson was deeply familiar with the endless but unresolved back and forth of situated trial reports in the agricultural press. Agricultural scientists could resolve these opposing views on the same subject by establishing universal principles. By way of demonstration, Johnson said: "The question has been asked here to-day—'What is the result, in manure, of feeding an animal on hay?'"[115] With that, he pulled out Mentzel and von Lengerke's agricultural calendar. Not only did this "little work" provide the exact answer to this question, it also contained "in the most condensed form, the essence of the established numerical data which the German farmer needs for daily use."[116] Going through all of the German calendar's specific forms and tables, the method of using "perhaps the most valuable table of all," Wolff's feeding standards, amounted to studying tables and "a little figuring."[117] Johnson did not give the improvers in front of him specific instructions. He diffused their skepticism of the complexities of agricultural science with a little book that compressed all science into easy-to-use and authoritative answers to all improver questions. Agricultural scientists' innovation in principles stood at their service.

Johnson also generalized geographic translation of German findings to Northeastern farms. Unlike Atwater in Wiscasset, he continuously pointed out that German findings were useful in German contexts. Of course, German agriculture was different from American agriculture. Instead, he argued that general principles discovered in Germany were true anywhere. All it took was some adaptation. The few sample rations he presented from the calendar were "more important in Germany than they would be here" because of a supposed greater German variety in crops and industrial byproducts. "Still, they are not much different from the combinations that we might make, even in Connecticut. We can get malt waste from the breweries, oil-cake of various kinds, cotton-seed meal, wheat bran, Indian meal, fish pomace,

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[115] T. S. Gold, *Seventh Annual Report of the Secretary of the Connecticut Board of Agriculture. 1873—'74*, (Hartford: The Cae, Lockwood & Brainard Co., 1874), 80.
[116] Ibid, 80-81.
[117] Ibid, 83.

and straw of all kinds, as well as hay."[118] The nutrients within feeds were the same anywhere. They existed in German feeds just like they existed in Connecticut feeds. With just a hint at adapting universal principles based on organic chemistry and mathematics to practical use, Johnson made German science not just credible but relevant to American farmers.

Finally, Johnson voiced improvers' greatest complaint about American farming to establish the usefulness of agricultural scientists and their innovation in principles. In the early 1870s, Connecticut improvers saw Northeastern farming in crisis. Western staples production threatened Eastern markets, prompting shifts in production from cereals to fruits, meat, and dairy. Rather than eek out a living on hillside farms, the younger generation had been moving westward for decades. There, they practiced extensive farming and continued what Northeastern improvers had identified as the root of all evil: waste. Even though historians refute this, New England improvers were convinced that their forefathers had already begun to exhaust their "virgin lands" and left their sons with the fallout: diminishing returns.[119] Johnson sold them the cure, created by German agricultural scientists. A Connecticut experiment station would provide Connecticut improvers with what German stations had offered German farmers: making old land pay. And this is what distinguished the improvers in front of him from lesser farmers. They understood that the wisest thing to do was to put American agricultural scientists into the service of improvers. When Johnson mimicked the quarreling between farmers, their "guess work," their "'my neighbor thinks so and so, and I reckon he is right,'" he actually invited his improver audience into the enlightened inner circle of agricultural progress. They were not so stupid to believe, Johnson implied, that the old ways of farming would solve the current crisis, that improvers could do it by themselves. No, they had seen the light. And it was this: "The object of an experiment station is to bring every farmer up to the

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[118] Ibid, 84

[119] Brian Donahue most convincingly showed the sustainable land management system of early Americans in Concord, Massachusetts. Brian Donahue, *The Great Meadow*. For analyses of New England improvers' impressions of agricultural crisis, see Stoll; Hal S. Barron, *Those Who Stayed behind: Rural Society in Nineteenth-Century New England*, Interdisciplinary Perspectives on Modern History (Cambridge [Cambridgeshire] ; New York: Cambridge University Press, 1984).

scientific method of investigation, the scientific method of looking at truth."[120] The surest sign of progress was not translating science to farmers but educating farmers in science. Just as Wolff and his colleagues had lured and threatened their improver audience, Johnson used the idea of progress to offer improvers continued status and profit as opposed to backwardness and ruin. All they had to do was accept scientists as experts who knew more about natural laws than did improvers.

The audience agreed with him. No recorded response of the assembled improvers expressed doubt in the utility of an agricultural experiment station or agricultural science at large. Rather, these representatives of farmers, voted for by county agricultural societies or appointed by the state legislature, found attractive the scientists' promise of a unified, definitive, and authoritative method to determine agricultural best practice. This would solve the problem of soil exhaustion. Scientific education for their sons would keep them on the farm. And improver access to the resource of singular farming solutions would cement their elite social status. Nathan Hart, the representative of the Litchfield county agricultural association and also treasurer of the board, saw neither the availability of funds nor able scientists as the problem, but the farmers themselves. "Our work, it seems to me, is to bring the agricultural community up to this stand-point of a better system of agricultural labor and improvement, and to bring a higher intelligence to bear upon our labor, and upon our profession as farmers."[121] Scientists' innovation in principles would solve improver problems on the farm but also with farmers. A Dr. Riggs, an improver from Hartford, made this clear. "Our farmers will be better educated, and instead of spending their evenings drinking sour cider, and eating apples, playing dominoes, or telling stories at the village store, while roasting their shins over the fire, they will spend them in the study of these subjects."[122] Science would civilize backward farmers far beyond just their farm practices. These elite improvers saw science as a source of power over their social inferiors, to benefit the agricultural economy, the professional

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[120] Gold, 76.
[121] Ibid, 87
[122] Ibid, 89.

image of farming, and their own elite status.[123] The assembled improvers decided to form a committee to bring the establishment of an agricultural experiment station before the state legislature.

Johnson had succeeded in showing his improver audience what they stood to gain from throwing in their lot with scientists. There were several keys to this success: long-term lobbying for agricultural science in general to normalize scientists' universal claims; downplaying the challenge of translating innovation in principles into practice; framing the economic benefits in the specific context of crisis identified by his audience; and promising social prestige and thus control over less educated farmers. Johnson had taken several leaves from the playbook of German agricultural scientists while adapting them to American contexts and his American improver audience.

**Experts fortified: How education replaced translation, again**

After Atwater had directed the privately subsidized experiment station at his alma mater Wesleyan University from 1875 to 1877, the state legislature took over the station in 1877, moved it to Yale, and appointed Johnson as director.[124] Johnson refined the same strategies of knowledge translation and negotiation that he had employed to rally support for the station. He provided the services improvers actively asked for: analyzing fertilizer to prevent fraud and resolving farming questions by scientific means. In his responses, he did expect fundamental knowledge of nutrition of improvers but was not above translating scientific findings into metaphors and simple answers. He compared proteins in feed with building a wooden house: "No amount of nails will supply a deficiency of wood, and no amount of wood can economically take the place of nails. […] When albuminoids are deficient, their quantity limits the value of the ration."[125] And as promised, Johnson also adapted pre-calculated rations to available

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[123] Historians have identified the broader move of eastern farming elites in the early nineteenth century to subscribe to improvement as a means of social control. These elites wanted to keep less educated and poorer farmers from moving west and becoming even less "civilized." Keeping more farmers in the east would also make them available as inexpensive labor force, an idea modeled after Europe's rural population and labor patterns. Upper class improvers stood to gain from creating a rural labor class, and they saw improvement and science as its sharpest tool to achieve this goal. See Stoll; Pawley, *The Nature of the Future*, 23-38.
[124] Rossiter, 167-171.
[125] *Annual Report of the Connecticut Agricultural Experiment Station for 1879*, (New Haven: Kirschner & Craig, 1880), 87.

feeds in New England. He summarized Wolff's instructions for calculating rations from scratch, substituting easily available cotton seed meal for Wolff's rape seed cake. Johnson entertained a tricky relationship with improvers. They seemed to think they employed scientists as technicians when Johnson also used improvers as technicians. He used the samples of fertilizer and hay sent in by improvers from Connecticut and Massachusetts to begin scientific arguments about environmental influences on hay composition. As director, Johnson let improvers guide the research of the station and had to translate results in return for state funding and expert status.[126]

Johnson's strategies lay the groundwork for the fortification of agricultural scientists as experts on American farming. The work of his student, Henry Prentiss Armsby, exemplified the strategies employed to achieve this goal. Armsby had trained under Johnson at Yale's Sheffield Scientific School, leading to a doctorate in 1879, after a year under Gustav Kühn at the Möckern experiment station in 1876. While he finished his doctorate at the Sheffield School and worked as chemist at the experiment station, Armsby wrote the first comprehensive book on scientific feeding in the United States.[127] Where Atwater had failed and Johnson had generalized, Armsby's "Manual of Cattle-Feeding" brought specific German findings to bear on American farming contexts. He and his colleagues at the experiment station applied the skills, instruments, journals, books, and standards brought with them from their tours to German laboratories and experiment stations to American feeds. They turned the hay samples and descriptions sent in by New England improvers into German-style nutritional values for American categories of hay. That is where the Mentzel and von Lengerke agricultural calendar came in. Using German standards, Armsby could now integrate American feed values into Wolff's table from the calendar, making American findings comparable. Armsby could now argue with specific evidence in hand that the principles established by German scientists also applied to American contexts. Improvers had told

[126] *Annual Report of the Connecticut Agricultural Experiment Station for 1879.*
[127] Francis Gano Benedict, *Biographical Memoir of Henry Prentiss Armsby, 1853-1921* (Washington: National Academy of Sciences, 1938).

Armsby and his colleagues that New England hays were less nutritious than German hays, but the scientists could now quantify how different they were and to what feeding effect.[128]

Armsby managed the unavoidable variation in feed components with the same flexibility his German colleagues used. Scientists simply filled the gaps in what they knew with improver knowledge. For example, in his *Manual of Cattle-Feeding*, Armsby explained that moister German and English climates demanded longer times for drying hay than the one day possible in hot American summers. Also, the lower protein level of "American, or at least New England, hay, as compared with that raised in Germany and Austria […], is [probably] owing to its having been raised on poorer soils."[129] Armsby managed these broad generalizations of unquantifiable environmental influences with the up-to-date measures in the calendar. On his data table of American and German values, he used Julius Kühn's minimum, maximum, and average numbers. The ranges that quelled doubts over varying results in Germany produced the same unassailable authority in the United States. Reproducing German methods of knowledge production and translation was the key to actually moving portable knowledge.

Armsby also reproduced the power move of his German role models in the 1880s. He refused to translate his research for anyone but students of scientific feeding. Armsby's "manual" was far from Wolff's textbook synthesis. Rather than Wolff's 224 pages, Armsby expected his audience to master a whopping 496 pages. Armsby had begun his manual as a translation of Wolff's much slimmer textbook but had found substantial additions and rewrites necessary. He included recent research to provide "a reliable exponent of the present state of knowledge on the subject of cattle-feeding." Armsby expected readers to learn the current state of the field so that they could "appreciate and utilize further progress"[130] before calculating any ideal rations (see table 1).

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[128] Armsby, *Manual of Cattle-Feeding.* Tellingly, American agricultural scientists like Armsby tackled nutritional composition of American feeds, especially hay, first. This only required chemical analysis rather than feeding experiments, fitting their small budgets, little time allotted for research, and short timeframes until they had to deliver results of economic significance to improvers. They built their initial claims for universal principles on the assumption that American livestock functioned the same as German livestock. This assumption remained unchallenged by their improver audience. The environment affected plants, not animals.
[129] Armsby, *Manual of Cattle-Feeding*, 289.
[130] Ibid, IV.

| **Part I: The General Laws of Animal Nutrition** | **Part II: The Feedings-Stuffs** | **Part III: The Feeding of Farm Animals** |
|---|---|---|
| The Composition of the Animal Body | Digestibility | Feeding Standards |
| Components of Fodders—Nutrients | The Coarse Fodders | Feeding for Maintenance |
| Digestion and Resorption | Concentrated Fodders | Fattening |
| Circulation, Respiration, and Excretion | | Feeding Working Animals |
| Method of Investigation | | Production of Milk |
| Formation of Flesh | | Feeding Growing Animals |
| The Formation of Fat | | The Calculation of Rations |
| The Production of Work | | |

Table 1: Chapter titles of Henry Prentiss Armsby's *Manual of Cattle-Feeding* (1880).[131]

While his instructions for calculation were more concise than Wolff's, he valued correctness over ease of use. Armsby justified the inclusion of Kühn's value ranges: "This method, though less simple than merely taking average percentages of digestible ingredients from a table, is likely to give results corresponding more closely to the truth, when intelligently carried out."[132] Rather than using the three to four averages of nutritional components, difficult enough in itself, Armsby expected users to estimate the nutritional components of the feeds in front of them. Ideally, they should send in samples to the growing number of agricultural experiment stations for chemical analyses. The chemist at every barn door should become reality, according to Armsby. But just in case this proved impractical to users, they should use the averages of feed components to estimate for themselves. "To this end he will take into account the richness of the soil on which the fodder was grown, its stage of growth, and, in short, all those influences mentioned in Part II., Chapters II. and III., as affecting the composition of coarse fodder in particular."[133] Claiming the power of the true expert, Armsby drove the amount of translation to improver conventions to new lows. If they wanted to use innovation in principles, improvers had to learn agricultural science.[134]

[131] Ibid, VII-X.
[132] Ibid, 467-468
[133] Ibid, 469.
[134] Ibid.

## Conclusions

American agricultural scientists began to catch up with their European counterparts in the 1870s and early 1880s. They adopted German standards to adapt German findings and move universal claims. If American agricultural scientists wanted to join the increasingly international discipline of agricultural science, they had to standardize skills, methods, instruments, instruction, institutions, publications, language, and more. Johnson and Atwater had to establish their status as useful experts with improvers to build institutions of agricultural science and learning adapted from German models. Armsby and all who came after him could expand on this expertise and enact scientists' vision of the agrarian-industrial knowledge system. Despite differences in their particular contexts, audiences, and arguments, scientists' knowledge system was the same in both the United States and Germany. Moving innovation in principles also moved the knowledge system.

In the minds of agricultural scientists, innovation in principles was an exclusive privilege. They could not just work hand in hand with non-scientists. To them, the drive for universality required the disconnect from those using principles in practice. It is important to remember, however, that this was a choice, if a habitual one for scientists in general. Agricultural scientists chose to strive for status within the sciences rather than invite some users into the circle of innovators. Some scientists collaborated with improvers – and closely at that – but discovering the laws of nature still required the exclusive toolkit of the scientist so that their arguments would transcend time and place.

Despite their universal claims and much to their dismay, however, scientists' innovation did not give them universal power over agricultural knowledge. By themselves, scientists and their principles were not convincing to all. They needed to fill the necessary disconnect their expertise required. Other experts filled the gap. Each set of experts had power over agricultural knowledge and innovation in their context. There were no more renaissance men. Improvers were the most important and, in fact, the most competitve set of experts for scientists. Their expertise and their knowledge system had longer standing. Agreement over their position in the agrarian-industrial knowledge society had to be reached.

## CHAPTER 3

## INNOVATION IN PLACE

> Then, again, the German system of feeding is unpracticable here. We have not a chemist at every barn door, as they have in Germany, to tell our farmers how to feed, and they don't need one. Our farmers cannot have every foddering of hay or straw analyzed, to see how much flesh, fat or milk-forming elements it contains—but they know there is nothing better than good grass to feed an animal; for when a cow is in a pasture of rich, sweet, abundant food, that is a cow heaven to her.[135]

Harris Lewis, the president of the New York Agricultural Society, had an alternative vision of animal feeding. And it did not match what Wilbur Olin Atwater had presented to him at the 1874 annual meeting of the Maine Board of Agriculture, as discussed in chapter 1. Feeding experiments and chemical analyses in far-away German laboratories could not, in his mind, offer guidance on how New England farmers should feed their livestock. Instead, Lewis relied on knowledge production and communication that had a long history with improvers. He watched his animals, adapted his methods, and told his fellow farmers about it. Comparisons to humans could provide insight into animals. Describing one of his own feeding experiments, Lewis "presumed he would have been feeding fodder corn to this day if he had not found out that his cows knew more than he did."[136]

In the 1870s and 1880s, a globalizing market certainly demanded new cattle feeding solutions. A never-before seen amount of grain production in the bread baskets of the American Mid-West and Eastern Europe flooded an increasingly connected global market. Farmers elsewhere who had previously sold grain to market could no longer compete and had to change their production. This was the great challenge that farmers faced and that scientists, improvers, and market agents wanted to help them with, if for their own reasons. Both in western Maine and the Sauerland, they promoted dairy farming to unlock nearby urban markets. They identified intensification of animal feeding as essential to this shift. Driven by market pressures, improvers and scientists agreed upon the means to improve cattle feed in particular: producing better rough fodder and either producing or purchasing concentrated feeds, such as corn meal,

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[135] Samuel L. Boardman, *Report Maine Board of Agriculture 1874*, 71.
[136] Ibid, 72.

cotton seed meal, and peanut cakes, or mangolds, turnips, and many more. The extension of the railroad into these two regions brought an ever-increasing list of potential concentrated feeds to farmers. The same globalization trends that necessitated the shift in farming in the first place also offered the means to achieve it. Or so good farming conditions suggested. Less than ideal conditions complicated these solutions.

In Maine, both growing better hay and accessing concentrated feeds were generally available to famers, if only to those on older farms in the fertile valleys. Several grass and legume varieties thrived in the environment of northern New England, promising rich hay harvests. Farmers in western Maine also had increasing access to cash crops with the expanding sweet corn canning industry and marketing apples as far as England. There were environmental and economic avenues to improve animal feed if farmers had the means to take them. The alternative solution was to leave. The number of farms and improved acres decreased in Maine and all of New England in the late nineteenth century. Settler colonialism in the West provided land that was fertile and cheap or even free. Growing urban and industrial centers also lured farm sons and daughters into employment away from the farm. The pressures to shift away from cereals in the East, the potential to partake in the gains of large-scale cereal production in the West, and the attraction of industrial jobs and urban life drew younger generations away from hillside farms. For these market conditions and available mobilities, farmers had overextended the cultivated area onto soils that could not produce at a profit anymore. For those who stayed behind, keeping their communities from shrinking and eventually dying meant farmers had to make farming pay for the next generation where they were. As elsewhere in New England, farmers in western Maine had to find ways to access better rough fodder and concentrated feeds. In the process, western Maine improvers collaborated with scientists.[137]

[137] See e.g. Richard William Judd, Edwin A. Churchill, and Joel W. Eastman, eds., *Maine: The Pine Tree State from Prehistory to the Present* (Orono, Me: University of Maine Press, 2011); Hornsby, Judd, and Hermann, *Historical Atlas of Maine*; Hal S. Barron, *Those Who Stayed behind*; Clarence Albert Day, *A History of Maine Agriculture, 1604-1860*; Day, *Farming in Maine, 1860-1940*.

In the Sauerland, by contrast, neither growing more nutritious hay nor purchasing or growing concentrated feeds was easy. Clover failed repeatedly and all other rough fodder plants – grasses and legumes suitable for haying – conventionally suggested by improvers and scientists elsewhere did not produce sufficient harvests. The recent connection to globalizing markets via the railroad had not just made cereal production unprofitable but also the previous cash crops of charcoal and tanbark – oak bark used for tanning leather. The iron and steel industry shifted to mineral coal. Imported tanbark and later chemically produced substitutes replaced Sauerland tanbark. Leaving was certainly an option. For those not inheriting a big enough part of a farm, industrial centers were easier destinations than the colonized lands beyond the sea. Still, the population generally grew despite out-migration or emigration, especially to America. Those farmers with enough land to support a farmstead, even if it included hillsides with thin soils, rarely left. They tried to find a solution other than the capital-intensive, frequent reseedings of rough fodder plants and purchases of concentrated feeds. In the process, Sauerland improvers challenged scientists.[138]

Starting from similar circumstances, these stories went into opposite directions in pursuit of the same goals to arrive at the same destination. The particular adaptations to the conditions of the Sauerland and western Maine resulted in different strategies to establish improver expertise, bound the improver community, negotiate agreement with other actor groups, and effect change in practice. Still, these negotiations demonstrate how American and German improvers in the late nineteenth century had the same vision of how the agrarian-industrial knowledge system should work. Improvers imagined

[138] For descriptions of Sauerland contemporaries, see e.g. F. Gabriel, L. Mues, "Gehorsame Bitte des Esloher landwirthschaftlichen Vereins um Beihülfe zum Anlegen eines rationellen Futterbaus," in *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 1784, "Einführung des sogenannten Wagner'schen Futterbaus;" W. Wagner, *Ausdauernder Gemengefutterbau (Wagners Futterbau)*, 3rd ed. (Haus Ruhr bei Westhofen: W. Wagner, n.d.); J. V. E. Strecker, "Landwirtschaftliches," in *Mescheder Zeitung*, March 18, 1879; Th. Freiherr von Dücker, et. Al., to Friedrich Nobbe, Serkenrode Dec 27, 1880, in Landesarchiv NRW Abteilung Westfalen, K333, 410, "Landwirtschaftlicher Kreisverein I." For historians' analysis within the larger context of Westphalia, see Karl Ditt, "Aufstiege und Niedergänge;" Karl Ditt, "Polarität und Nivellierung: Ländliche und städtische Gesellschaft," in *Westfalen in der Moderne 1815-2015: Geschichte einer Region*, 2nd ed. (Münster: Aschendorff, 2015), 431–57; Markus Küpker, "Bevölkerungsentwicklung und Migration," in *Westfalen in der Moderne 1815-2015: Geschichte einer Region*, 2nd ed. (Münster: Aschendorff, 2015), 459–82.; Rötger Belke-Grobe et al., eds., *Bauern im südwestfälischen Bergland*, vol. 1 (Münster: Ardey-Verlag/CVK, 2006).

themselves as the knowledge agency of agriculture, as German agricultural historian Marten Pelzer has described them.[139] Improvers communicated with all knowledge sources. With the growing influence of scientists in the 1870s and 1880s especially, improvers had to renegotiate this role. The integration of their knowledge systems would become extension services, the fundamental formation of agricultural knowledge production and communication of the twentieth century. On the road to extension, collaboration with scientists and challenging them were two sides of the same improver coin.

**Connecting everyone: The knowledge system of improvers**

It is important to differentiate between how these historical actors defined themselves and their ideal knowledge system and what I mean with the term "improver." The latter has been much debated in the literature. From the perspective on knowledge production and communication, I choose to define improvers and farmers as actors on the same continuum. All improvers were farmers, and all farmers were improvers. They all practiced agriculture in some way to produce crops that would contribute to their livelihood directly, either by use, barter, or sale. They produced visual and economic evidence for composite farming first-hand on working farms.[140] This differentiated them from scientists and market agents. The difference between improvers and farmers lay in the degree to which they were able to produce, adapt, and communicate new agricultural knowledge. Trying something new was a risk. Whether farmers developed their own ideas, followed their neighbor's advice, or found instructions in a book, any new agricultural knowledge had to be adapted to one's own particular farm. From one farmer to the next, there was always a difference in environment, economy, and society. The degree of divergence determined the difficulty of adapting agricultural knowledge to place. In my definition, improvers were very much able to resolve this divergence. They stood on one end of the spectrum. Farmers stood on the other. In their adaption of agricultural knowledge from elsewhere, farmers only had the means to handle very little divergence in conditions. So, the key axis of the continuum between

[139] I take the term "knowledge agency" from Marten Pelzer's work on German agricultural associations as "Wissensagenturen" in the Lüneburg region. Marten Pelzer, "Landwirtschaftliche Vereine als Wissensagenturen."
[140] For the concept of composite farming, see Vickers, "Competency and Competition;" Vickers, *Farmers and Fishermen*. See also, Donahue, *The Great Meadow*.

improvers and farmers ran along the ability and willingness to take the risk of adapting new knowledge to place. Key factors were wealth, education, media literacy, and ability to communicate. Stereotypical improvers had the economic means to be vocal, early adapters of innovation to place with a drive to turn innovation from any source into higher economic and social status. Stereotypical farmers were tight-lipped onlookers, slowly drawing conclusions from their neighbor's field to make ends meet for their family. Most historical actors moved somewhere between these two theoretical extremes.[141]

The ideal knowledge system envisioned by improvers was their key characteristic. Improvers saw themselves as knowledge brokers between all other actor groups of the agrarian-industrial knowledge society.[142] Whether it was translating scientists' research findings, explaining market agent's new products, highlighting farmers' interesting results, or relaying state agent's endorsements of new ways to farm, all had to go through improvers. As knowledge brokers it was also their job to make all these knowledge sources useful to farming. While all these actors could produce innovation in their own right, it was improvers who used it to innovate in place. In the reverse, improvers then also informed all actor groups of their trials and adaptations to spur responses, support, and further development. Their prime targets were of course farmers, who were the mass of users of improvers' innovation in place. Like scientists, improvers also excluded uncooperative or unconvinced farmers from the agrarian-industrial knowledge society as backward and irrational lost causes.[143] Above their own leadership, improvers only acknowledged state agents as the deciders bestowing official status and funding for innovations. This was

[141] Other historians of agricultural knowledge have drawn different lines around the term improver, such as Emily Pawley, who defined them as not necessarily farming themselves. She included all actors involved in antebellum agricultural improvement including what I define as market agents, for example. Where she defines all historical actors involved with changing agriculture as improvers, I define improvers and market agents as roles between which historical actors could shift back and forth. Emily Pawley, *The Nature of the Future*, 5-7.
[142] Historian of science Evelyn L. Forget neatly summarized the concept of the knowledge broker as "facilitating the creation, sharing and use of […] knowledge." The work of her main protagonist, political economy textbook author Jane Marcet, "was not a simple vulgarization of knowledge created by others, but rather active work at the boundaries of various bodies of discourse." I vary this definition slightly in that I contend that improvers as brokers created new knowledge in their own right. See Evelyn L. Forget, "Jane Marcet as Knowledge Broker," *History of Economics Review*, no. 65 (December 2016): 15+.
[143] This discourse developed as early as the eighteenth century. Experts of the economic enlightenment in Germany had already complained about the irrational, uneducated farmer or peasant who simply repeated his ways of farming without thought or understanding. See Verena Lehmbrock, *Der denkende Landwirt*.

also related to their ideas of agricultural improvement for the good of the nation. Their government and its department of agriculture certainly knew best how to steer agricultural improvement. Scientists and market agents were just supporters of improvers. They produced important knowledge and provided fundamental materials as agricultural inputs and certainly provided innovation, but they were not farming themselves. So, they really had no business interfering with the use of even their own innovations by improvers and farmers. Improvers saw themselves as the centers of the agrarian-industrial knowledge society without which it would grind to a halt.[144]

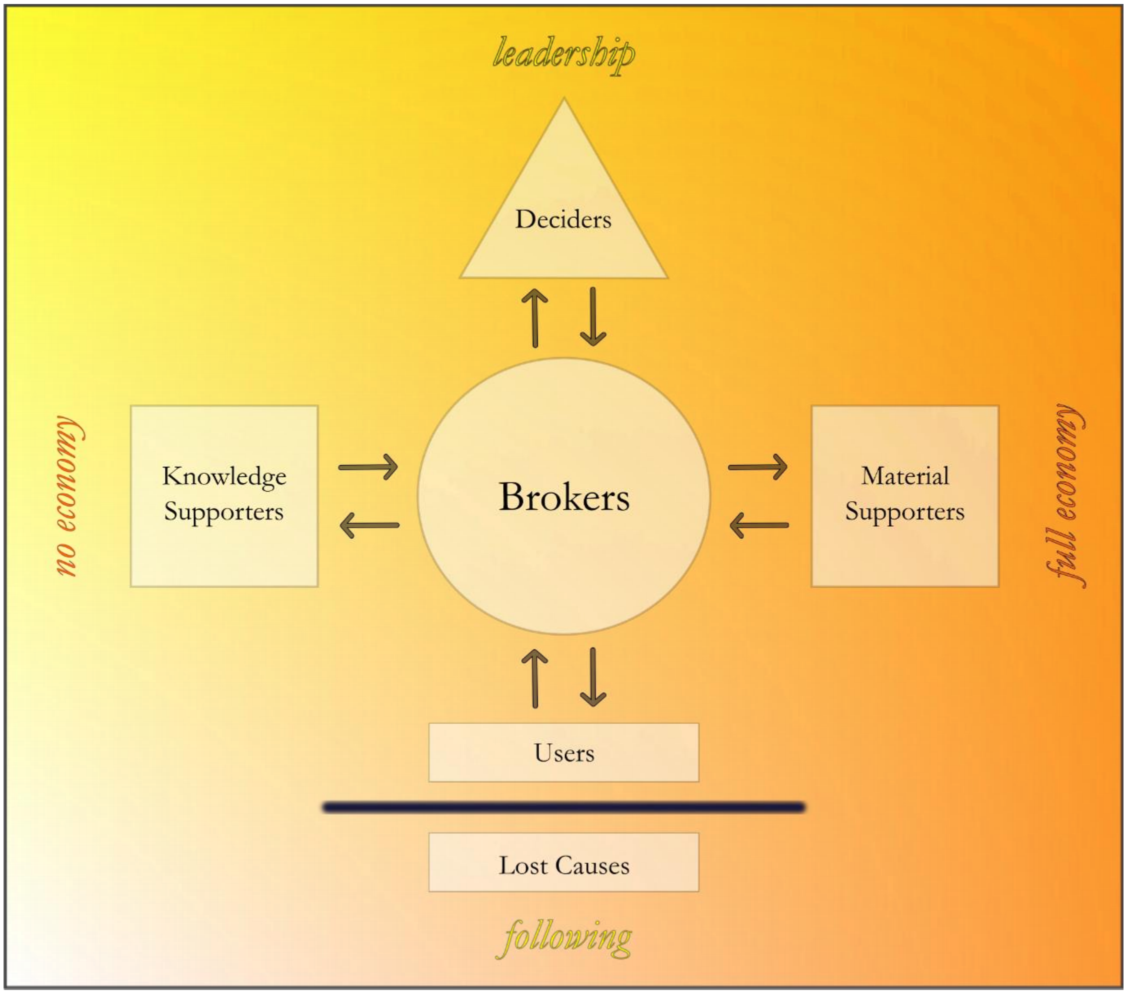


Figure 11: The knowledge system of improvers

[144] Frank Uekötter and Jonathan Harwood developed the idea that the “practical” side of improvement used several credible knowledge sources rather than just one as the “theoretical” side of improvement did. Uekötter, *Die Wahrheit ist auf dem Feld*; Harwood, *Technology’s Dilemma*. For an application of these ideas, see also Matz. Compare also to Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*.

**Feeding animals in dollars: Improver innovation in place in Maine**

On January 25, 1872, the winter session of the Maine Board of Agriculture assembled regional and local improvers in Paris, Maine. On the third of four days of lectures and discussions by able improvers from near and far, the topic shifted to cattle feeding. And given the current pressure to extend the milking season, the main concern this afternoon was winter feeding. How could farmers bring their cows and steers through the winter not only surviving but giving milk or gaining weight? The speaker was L. L. Lucas, the elected member of the board for Somerset county and himself a farmer of considerable means in St. Albans, a small town set in the midst of challenging conditions in central Maine. He gave several lectures at meetings of the board in the 1870s and early 1880s in which he professed his beliefs in the education and professionalization of farmers. He advocated for farmers to read agricultural journals and annual reports and learn the language of scientists to be able to use their findings to the advantage of farmers.[145] If farming in a marginal location, he was an improver through and through. And his lecture that afternoon demonstrates well how improvers produced knowledge.

Just as the quote by Lewis opening this chapter has suggested, improvers observed their animals and gave them the power to show their keepers what was best for them. Informed by comparisons to humans, Lucas operated under the assumption that if cows needed to produce more, they needed "better feed and more of it."[146] He faulted farmers for feeding late-cut, rough hay through the winter because it had little feeding value, animals did not like to eat it, and, if forced to eat it, filled them up so they could not eat anymore. His solution was cutting hay early, so it had less volume but more feeding value, and adding provender, the improver term for concentrated feeds like "Indian meal, shorts or fine feed."[147] Cows would eat this mix with more "avidity" while gaining sufficient "nourishment"[148] from it. This was

[145] In addition to his 1872 lecture, see for example, Stephen L. Goodale, *Sixteenth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1871*, (Augusta: Sprague, Owen & Nash, 1872), 20-28; Stephen L. Goodale, *Eighteenth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1873*, (Augusta: Sprague, Owen & Nash, 1873), 150-163.
[146] Stephen L. Goodale, *Seventeenth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1872*, (Augusta: Sprague, Owen & Nash, 1873), 150.
[147] Goodale, *Report Maine Board of Agriculture 1872*, 151.
[148] Ibid, 152.

the result of an improver feeding experiment. Lucas weighed how much feed he gave his animals, how they reacted, and if they looked healthy and had gained weight in the spring. Determining feed palatability had central importance to improvers because it was evident in their own observations of their cattle and it made sense on a human level.

Unlike scientists who isolated individual factors in animal nutrition, improvers integrated animal feeding into a holistic perspective of the farm. They contended with the interactions of factors beyond just feeding the animal. Like several other lecturers throughout the 1870s, Lucas connected winter feeding to warmer stables. Not only was it "inhuman" to keep cattle in stables that were not "as warm and as comfortable as a common sitting-room in our houses without a fire."[149] It also did not pay. Animals in the cold ate more feed to stay warm. He estimated that the cost of the extra feed to keep ten head of cattle in a cold stable for sixty days would pay for the construction of a warm stable. He enumerated very concisely the steps in the construction that "any mechanic that can saw a board and drive a nail"[150] could do at little expense given the benefits. And the result would not just be feed savings and an eased conscience but also the saved labor in stable cleaning. Manure would no longer stubbornly freeze to the floor. Improvers turned their experiments not just into knowledge about animal physiology but also into palpable improvements for the whole farm operation.[151]

The most important measure for the success of feeding experiments were profits. If a new method of feeding did not pay, it was no good. Lucas set up a hypothetical scenario to drive home the point that better feeding paid. In November, farmers A and B have oxen equal in all their characteristics and labor

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[149] Ibid, 151.
[150] Ibid.
[151] Another lecturer in 1878 broke this lesson down to this: lumber is cheaper than fodder, so make your barns warm. Samuel L. Boardman, *Twenty-Third Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1878*, (Augusta: Sprague, Owen & Nash, 1879), 59. In 1876, the manager of the college farm, Joseph R. Farrington, at the Maine State College reported on their new, warm barn more elaborately. The barn had been criticized for what was perceived by farmer representatives in the legislature as excessive costs. So, Farrington was sure to point out the great cost savings that this state-of-the-art stable allowed. Samuel L. Boardman, *Twenty-First Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1876*, (Augusta: Sprague, Owen & Nash, 1876), 92-93. For insights into changes in New England farm architecture in the late nineteenth century, see Thomas C. Hubka, *Big House, Little House, Back House, Barn: The Connected Farm Buildings of New England* (Hanover [N.H.]: University Press of New England, 1984).

demanded of them. Through the winter, A feeds his oxen to keep their weight and girth the same, B feeds for them to gain weight and girth. In May, when the oxen are slaughtered, B sells more beef at a better price per pound, providing a profit greater than A's by $91.40. Lucas used the same conventions that improvers routinely used to report the results of their experiments. Even though he left out the cost of the extra feed expended by B, it becomes clear that improvers measured and recorded the results of their experiments in weight and price of sale. They kept an account for their livestock. So, it did not matter that this scenario was only a hypothetical problem because the result was a relative answer to Lucas' rhetorical question: "which course had better be pursued by farmers in Maine?" Improvers were able to choose one innovation over the other because they calculated their value in dollars and cents.[152]

Improver experiments resembled those of scientists. Both observed animals closely. Laboratory stables were just as warm as farm stables. Feeding experiments measured the feed put into the animals and the benefits that came out. The resulting values of feeds were flexible and portable but had to be adapted to environmental and economic conditions to be used elsewhere. The differences between improver and scientist experiments were the meaning of the animals, the units of measurement, and the goals of production. Scientists saw themselves as stewards of knowledge, responsible for bettering mankind; improvers saw themselves as stewards of their animals, responsible for bettering their family, community, and nation. Where scientists could bring animals close to starvation for experimental results, improvers equated treating animals humanely with financial profit. Scientists made principles; improvers made dollars.

## Institutionalizing innovation in place: A professional improver in the Sauerland

Wilhelm Wagner was a professional improver. He was employed by the agricultural association of district Arnsberg (*Landeskulturgesellschaft für den Regierungsbezirk Arnsberg*) as itinerant teacher and was set the specific task of solving the rough fodder shortage prevalent in the hilly and remote Sauerland. His task was innovating in place and convincing farmers of the results. As historian Marten

[152] Emily Pawley has shown extensively improvers' practice of keeping accounts with their fields, see Pawley, Nature of the Future, 189-218; Emily Pawley, "Accounting with the Fields."

Pelzer has shown, this function had been performed by improvers at least since the early nineteenth century and had then been more and more institutionalized and scaled up into positions of itinerant teachers as early as the 1860s. Wagner was not an improver per se; he was an extension agent for improvers, a result of the scaling up and formalizing of the knowledge system of improvers.[153]

Wagner approached his set task from the perspective of an improver but on a regional scale. He was from Württemberg, where he likely also obtained some formal training in farming and agricultural science. After that, he had been an estate manager in Hungary, a position from which he retired for health reasons. This scientifically informed training as improver in a foreign land had given him a keen eye for analyzing an unfamiliar farm environment. When Wagner started his position in 1876, he began by travelling the challenging landscape of the Sauerland, visiting farms, giving lectures to county and local agricultural associations, and talking to improvers. He learned firsthand the affordances of the land, the workings of the regional market, and the expectations and abilities of the farmers he was supposed to help. Wagner was the knowledge broker and innovator for all improvers and farmers of the Sauerland.[154]

Wagner developed innovation in place by combining various ways of knowledge making. Where scientists observed the variety of wild plants growing around the fields and on uncultivated hilltops as indicators for which cultivated plants the soil and climate would support, Wagner purposefully cultivated the most nutritious wild plants together with suitable cultivated plants. His selection of local plants was based on chemical analysis, and on experimental plantings in pots and improvers' fields across the Sauerland. He identified this individualized mix of native wild and cultivated plants as nutritionally improved "natural" meadows. Wagner combined between ten and twenty varieties of tall grasses with the unconventional legumes meadow pea (*Lathyrus pratensis*), bird vetch (*Vicia cracca*), and bush vetch

[153] Marten Pelzer, "'Was die Schule für das heranwachsende Geschlecht ist;'" Marten Pelzer, "Landwirtschaftliche Vereine als Wissensagenturen."
[154] *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1876*, (Münster: Theissing'sche Buchdruckerei, 1877), 11-12; Wagner, *Ausdauernder Gemengefutterbau*; John W. Jordan, *Genealogical and Personal History of Beaver County, Pennsylvania* (New York: 1914), 1097-1098.

(*Vicia sepium*).[155] These native plants were already accustomed to the wet and cold climate as well as the potash-rich soils of the Sauerland. This approach was possible in all places hospitable to grasses, Wagner argued, but it was most beneficial and necessary in mountainous regions. His perspective, shaped by less than ideal environmental and economic conditions, opposed monocultures of conventional cultivated plants. They exhausted the soil and required costly management in the long run. Only fertile agricultural regions were so forgiving as to allow this practice. Challenging regions should be the guide for sustainable hay cultivation because they could not afford soil exhaustion. Like a scientist, Wagner developed a universal principle of creating sustainable hay fields: tweaking uncultivated into cultivated meadows. He did so from the vantage point of a particular place – improver farms in the Sauerland – not from the supposed nowhere of the laboratory.[156]

This innovation in place was then inherently geared towards Sauerland improver demands. Wagner's selection of fodder plants functioned as their own ecosystem relying on frequent cuttings. Different from monocultures where the same species would regrow for the next cutting, Wagner's mix had other species grow after each cutting. This created overall faster growth and up to five cuttings of palatable hay high in protein where no other plants could. Wagner's hay reduced the need for buying or growing costly concentrated feed. Wagner's meadows also grew on cheap and abundantly available fields at an incline where the grasses and legumes prevented the soil erosion that had come with intensified cultivation. The decomposition of roots provided continued fertilization and kept the cost and labor of spreading fertilizer low during the ten-to-fifteen-year lifecycle of a Wagner meadow. After one initial dressing of lime, only regular stable manure should be applied every other year. While the initial investment in money and labor was high, over the lifetime and drastically increased yields of one of his

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[155] The grasses included: meadow fescue (*Festuca pratensis*), orchard grass (*Dactylis glomerate*), timothy (*Phleum pretense*), tall oat-grass (*Arrhenatherum elatius*), and meadow foxtail (*Alopecurus pratensis*). The clovers included alsike clover (*Trifolium hybridum*), white clover (*Trifolium repens*), zigzag clover (*Trifolium medium*), red clover (*Trifolium pratense*). And finally, the mix included bird's-foot trefoil (*Lotus corniculatus*). See Dr. H. Thiel (ed.), *Landwirthschaftliche Jahrbücher: Zeitschrift für wissenschaftliche Landwirthschaft und Archiv des Königlich Preussischen Landes-Oekonomie-Kollegiums* 9, Supplement 1 (Berlin: Wiegandt, Hempel & Parey, 1880), 205.
[156] Wagner, *Ausdauernder Gemengefutterbau.*

low-maintenance meadows, Wagner argued, the cost was fantastically low. All that improvers had asked of him, Wagner delivered.[157]

What was more, Wagner's collaboration with improvers in perfecting his method of fodder cultivation also served to win them over. Wagner had no farm of his own, so even the first plantings beyond his own pots and plots happened on the fields of collaborating improvers. This gave them a direct stake in the development of Wagner's method. When, in the late 1870s, a large estate owner in the western, lower parts of district Arnsberg expressed interest in Wagner's meadows as pasture rather than hay field, Wagner gladly obliged. The landed aristocracy was a powerful player in agricultural politics and improvement in Westphalia generally.[158] Together with Baron Friedrich Wilhelm von Lilien in Echthausen, Wagner adapted the seed mix to pasturing with decisive success. In 1885, Wagner reported that a 40-hectare planting on the large von Lilien estate had produced five to six years of positive forage results and this convinced surrounding farmers to also use Wagner's method for pastures rather than hay fields. While this approach meant that the material product of his research, the seed mix itself, remained in flux, Wagner's collaboration gave improvers power in the innovation process.[159]

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[157] Wagner, *Ausdauernder Gemengefutterbau*; W. Wagner "Der Futterbau im Sauerland," in *Landwirthschaftliche Zeitung.Märkisch Sauerland*, March 1, 1879, 9-11. Only few copies of this regional agricultural journal survive as in Gemeindearchiv Finnentrop, Folder 1773, "Beförderung der Landwirtschaft und Entschädigung von Wildschäden. Errichtung eines Kreisgewerbe- und Kulturvereins;" Johannes Dornseiffer, "Zur Kritik des Wagner'schen Futterbaues," in *Landwirtschaftliche Zeitung für Westfalen und Lippe* (*LZWL)*, October 24 and 31, 1879, 370-372, 377-379. Dornseiffer's article was also printed in the *Landwirthschaftliche Zeitung.Märkisch Sauerland* and in the general Sauerland newspaper *Sauerländisches Volksblatt*, for which it was originally intended.
[158] Heinz Reif, "Adel Und Landwirtschaftliches Vereinswesen Im Katholischen Westfalen 1819-1862," in *Rheinland-Westfalen Im Industriezeitalter: Von Der Entstehung Der Provinzen Bis Zur Reichsgründung*, vol. 1, 4 vols. (Wuppertal: Peter Hammer Verlag, 1983), 39–60.
[159] *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1876*, 11; *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1884*, (Münster: Theissing'sche Buchdruckerei, 1885), 52-53; Wagner, *Ausdauernder Gemengefutterbau*, 24.

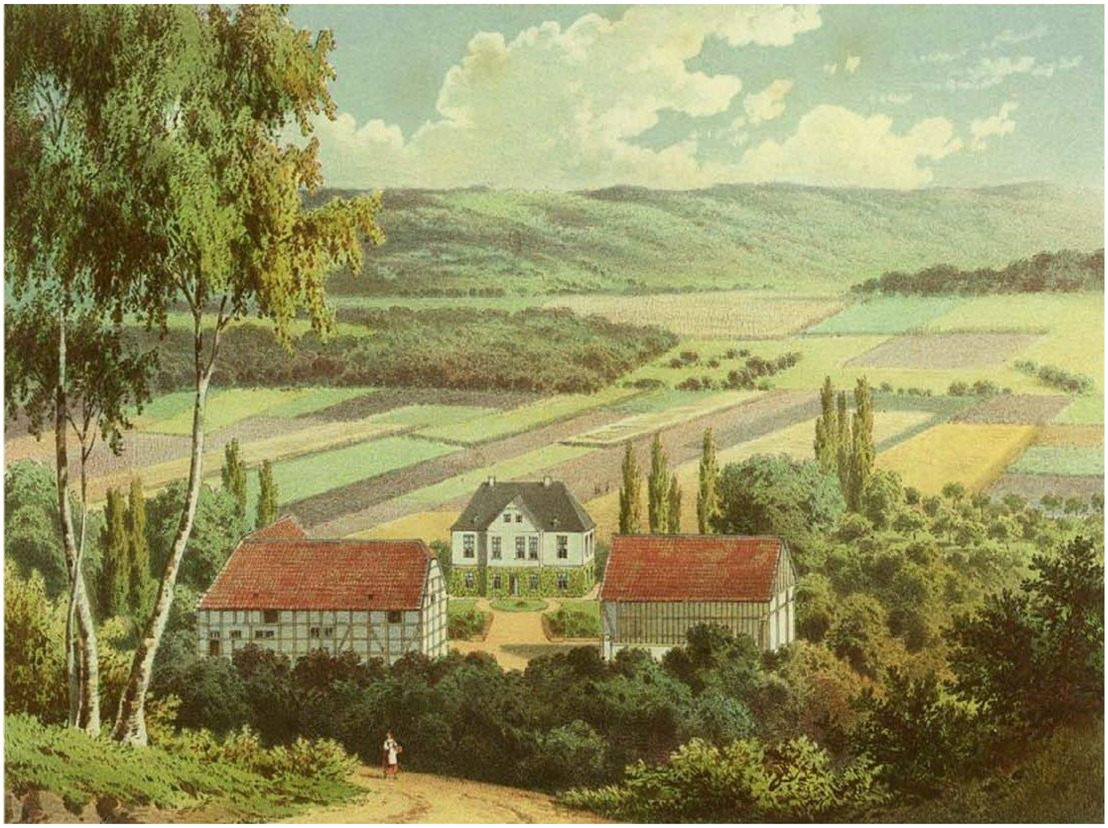

Figure 12: Haus Echthausen, the large estate owned by the Baron von Lilien at Echthausen, ca. 1870.[160] This well-ordered estate provided impressive results that were convincing evidence to farmers: Half of Echthausen's 40 acres of Wagnerian pastures fattened 88 head of cattle.[161]

His institutional position made Wagner into a hybrid of improver, scientist, and extension agent. He owned no land, but observed nature and improvers' trials; he developed universal claims by observation in place and chemical analysis; he identified as an improver and spoke like one; his job was generating profits on the farms of a whole region by convincing them to use innovation in place. In decisive contrast to scientists, removed from environmental and economic pressures, Wagner produced innovation on working farms with landowners' help. As it not only appealed to improvers' want for increased yields but also to their drive for social status as early adapters, this strategy was largely

[160] Alexander Duncker, ed., *Die Ländlichen Wohnsitze, Schlösser Und Residenzen Der Ritterschaftlichen Grundbesitzer in Der Preussischen Monarchie : Nebst Den Königlichen Familien-, Haus-Fideicommiss-Schatull-Gütern in Naturgetreuen, Künstlerisch Ausgeführten, Farbigen Darstellungen; Nebst Begleitendem Text*, vol. 12 (Berlin: Verlag von Alexander Duncker, 1871), 666, digital image courtesy of Zentral- und Landesbibliothek Berlin, 2006. URL: http://nbn-resolving.de/urn:nbn:de:kobv:109-1-7689260.
[161] Wagner, *Ausdauernder Gemengefutterbau*, 24.

successful with improvers. Wagner did not need go-betweens to shield an elevated status in the agrarian-industrial knowledge society. He approached improvers at eye level. What was more, Wagner included improvers in a distributed process of innovation in place. This was an improver knowledge system at odds with that of scientists. Where scientists had to be innovators above improvers, Wagner was an innovator among improvers.

## **Bridging the distance: Improvers talking to improvers in Maine and the Sauerland**

Improvers talked to each other a lot, but rarely over the garden fence. Their experiments lay in their daily work and that workday usually rolled on before these men could run to their neighbors to let them witness what exactly they had thought up. Results were a little bit easier. Prize oxen or dollars in hand were easier to show but still required a story to go with them. So, improvers found ways to tell stories of their failed or successful, but always fateful, experiments in a believable fashion.

Improvers commonly relied on the same conventions in making their stories credible. That is why the following Maine and Sauerland examples can be analyzed together. The discussion that followed L. L. Lucas' lecture in Paris, Maine, presented above, shows the same strategies of bridging the distance between improvers as a lecture by Wilhelm Wagner. Recorded in the LZWL, Wagner's lecture addressed an annual meeting of the district Arnsberg agricultural society, held in Siegen on September 23, 1879. The requirements for speakers' credibility also find evidence in both regions. Improvers in the Sauerland and in Maine shared not just knowledge systems but also communication strategies when addressing other improvers.

Improvers developed their own form of what historians of science have called virtual witnessing. As analyzed by historian Emily Pawley for writers in American antebellum agricultural journals, improvers poured a prolix amount of detail on the reader to provide the impression of actually having being present at the described event.[162] In the Maine discussion, South Paris improver Ziba Thayer took his listeners along through his hypotheses, trials, failures, and successes in finding a better hay equivalent

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[162] Pawley, *Nature of the Future*, 67-69. For a concise summary of this strategy that also finds it in the repertoire of nineteenth century bureaucrats, see Becker and Clark.

for corn meal. After several carefully explained feeding trials to figure out a sufficient and cost-saving combination of hay and corn meal, Thayer "hunted up what the books had to say about it."[163] When he found a report that lined up with his own experience, he presented his hay equivalent for corn meal as innovation in place: sixty-four pounds of corn equal to one hundred pounds of good hay. In the Sauerland lecture, Wagner detailed one of his experiments in a similar way. He began with his hypothesis that his selected vetches and clovers could dissolve minerals out of solid rock. Then he described in detail his process of experimentation and observation. He "placed smoothly sanded, round discs of limestone, graywacke and basalt into baskets of ½ bushel in volume, filled them with soil, sowed partly with seed of the wild fodder plants, partly with red clover seed."[164] After two years, he found his wild plants had eroded the rock more than the red clover. Then he linked this "root force" (*Wurzelkraft*) to the wild plants' observed habitat in rock crevices, on gravel, and even railroad banks, and described a litmus paper test to argue for the particularly strong acid excretion of these roots. Both Thayer and Wagner painted a scene. They took the audience along through their thought process, describing their trials and their measurements in sequence to present their engaging narrative as more credible.

Improvers also had a style of narrative that resembled strategies historians of science have attributed to scientists. Drawing on historian Emily Pawley again, in this "naked writing style," improvers stuck to "facts" rather than attempt explanations as if to suggest nature spoke for itself.[165] Thayer simply "found out" that his initial trials had failed. It seems that the correct "fact" in the end, confirmed by the authority of printed experts, explained why his previous hay equivalents had been wrong. In the story of his experiment, he had asked questions of nature and it answered. Wagner did the same but ventured his own conclusion from his carefully described evidence. He "believed" that he "should assume" that the

[163] Goodale, *Report Maine Board of Agriculture* 1872, 159.
[164] "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 362. Original: "legte glattgeschliffene, runde Scheiben von Kalk, Grauwacke und Basalt in Körbe von ½ Scheffel Inhalt, füllte sie mit Erde, besäete sie theils mit dem Samen der wilden Futterpflanzen, theils mit Rothkleesamen."
[165] Pawley, *Nature of the Future*, 67-69. See also Becker and Clark, "Introduction."

"peculiar acids"[166] excreted by the roots dissolved minerals from solid rock to use as plant food. His choice of words illustrated how out of the ordinary his attempt at explanation was in comparison to his frequent references to "nature" or God as the "master of creation."[167] Both speakers hid the considerable amount of labor, measurement, and observation over a long period of time that went into their simple narrative of "facts." Similar to scientists, improvers aimed to produce credibility by presenting nature as based on unfailing laws and facts that it revealed on its own if man was just skillful enough in asking.

Finally, improvers also brought real witnesses into their account. Even though he had brought his own experience and that of published experts into alignment, Thayer's audience at his local farmers' club did not believe him. He set up his narrative for the key evidence establishing his credibility: the conversion of the neighbors. He provided his neighborhood critics with visual evidence. Was the correct equivalent ten, fifteen, or twenty bushels of meal to a ton of hay? Thayer put three piles of meal according to these propositions before his neighbors, with the expected success. "When they came to see the different messes as actually weighed out they all came over to my way of thinking."[168] In reality, a minority of four men at the Paris meeting refused to agree with him, but Thayer neglected this little detail to increase the credibility of his report.[169] Wagner presented not the conversion of neighbors but simply a list of eight collaborating improvers from different towns across the Sauerland and the neighboring mountainous Siegerland. They had reported their impressive hay harvests from Wagnerian meadows in weight. Wagner's perspective was regional, so he abbreviated the conversion stories of the specifically named improvers to their results in weight so he could scale up his evidence.[170] Improvers simulated visual evidence for the audience of their reports and witnesses fulfilled a key function in this narrative.[171]

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[166] "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 362. Original: "glaubte […] eigenthümliche Säuren […] annehmen zu sollen."
[167] Ibid, 361. Original: "Herr der Schöpfung."
[168] Goodale, *Report Maine Board of Agriculture 1872*, 159.
[169] Ibid; "Farmers' Club—Paris," in *Oxford Democrat*, Dec 5, 1871, 4.
[170] "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 362.
[171] For this strategy in antebellum journals in the United States, see Pawley, *Nature of the Future*, 70. For the prime analysis of this strategy as employed by scientists, see Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis* 79, no. 3 (1988): 373–404.

Communicating innovation in place relied on situating the evidence in place. This also allowed the movement of this knowledge. After Thayer, the next discussant in Paris, Maine, was James A. Lawrence of Bucksport on the central Maine coast, who had traveled 150 miles to the meeting. This seventy-two-year-old improver, "not bred a farmer," had been short of hay like other Maine farmers and struggled to bring his herd, half Durham and half Ayrshire, through the winter. Then he listed his specific rations for the different ages of cows as well as the timothy and red top composition of his hay – no clover, no weeds – the time when it was cut, and its quality of curing: "bright, handsome and aromatic."[172] A specific ration or manner of feeding was useless unless placed in its context of climate, plant species, animal breeds, farm practices, and markets. In the Siegen lecture, Wagner also placed his evidence. The eight improver results had all been achieved on mountainous fields of low-value tax class 4 to 6 on graywacke bedrock. Expanding the evidence to financial matters, Wagner stated that "pastor Vollmer of Netphen produced from 150 rods of this fodder 60 marks annual rent while the same area as common mixed grass yielded only 15 marks."[173] Describing the local environmental and economic conditions of trials was essential to allow improver audiences to evaluate the evidence. Improvers did not claim innovation in place was universal, but it was still moveable. Placing innovation into local conditions, improvers with enough skill could adapt the described parameters to their own farm.

To increase the credibility and moveability of innovation in place, improvers also pushed standardized reporting of evidence. At the Paris meeting, discussion leaders encouraged speakers to include all the evidence leaders deemed relevant. Warren Percival of Vassalboro in Central Maine took on this role. He asked Thayer right away about factors that threaded through discussions of this topic at the time: "Did you feed the meal wet or dry? […] Did you cut the hay [rather than leave it as mowed]? […] Did you give the cows all they would eat of hay and meal?"[174] Percival had set the agenda with his

[172] Goodale, *Report Maine Board of Agriculture 1872*, 160.
[173] "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 362. Original: "Herr Pastor Vollmer zu Netphen erzielte von 150 Ruthen dieses Futters 60 Mark jährliche Pachtrente, während die gleiche Fläche als gewöhnliches Misch-Grasland nur 15 Mark einbrachte."
[174] Goodale, *Report Maine Board of Agriculture 1872*, 159.

questions and the audience followed suit. Immediately following Lawrence's testimony, other audience members asked him the same questions. At the Siegen meeting, Wagner revealed what he saw as ideal reporting as well as his struggles with promoting it. He introduced the data of the reporting improvers as hay harvested per morgen (ca. 0.63 acres), but one improver had used the cut grass as green fodder and another had only planted 80 square rods (ca. 0.28 acres). Another had reported only one of their cuttings. Wagner strove for a standard in reporting which his improver collaborators still had to learn.[175] Improvement leaders encouraged fellow improvers to use standards of reporting to make placed evidence as comparable as possible.

Regulation like this relied on improvers accepting the status of their leaders. While officers of agricultural associations were elected by their members, improvement leaders generally had to demonstrate their economic, farming, and political prowess. Warren Percival, the discussion leader in Paris, Maine, was a notable breeder of Shorthorns, selling purebred animals throughout New England. Giving lectures at several meetings of the Maine Board of Agriculture in the early 1870s, he had been elected as a board member by the state agricultural association in 1872 only to become president of the board for a single year in 1873. Also, he had served as senator in the Maine legislature in the early 1860s.[176] In the Sauerland, Wagner relied on his official position with the district Arnsberg agricultural association for his status as leader of improvers. He held much-lauded lectures all over the Sauerland in which he spoke as an improver among equals. Wagner began one of his brochures with the words: "We farmers of the present."[177] His identification was not influenced by the fact he had retired from active farming for health reasons. The economic success of those who used his fodder cultivation stood in for his own lack of farming. Leaders of improvement had economic success in farming, held official positions in

[175] "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 362.
[176] Henry D. Kingsbury and Simeon L. Deyo, *Illustrated History of Kennebec County, Maine; 1625-1799-1892* (New York: H.W. Blake & co., 1892), 84, 89, 205-206; Stephen L. Goodale, *Twelfth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1867*, (Augusta: Stevens & Sayward, 1867), 175-177.
[177] Wagner, *Ausdauernder Gemengefutterbau*, 3. Original: "Wir Landwirthe der Gegenwart."

improver institutions, commanded up-to-date knowledge of contentious topics, and showcased rhetorical skill.

Their elevated position among improvers allowed leaders to promote shared emotions and values which made improvers into reliable producers and reporters of evidence. At the Paris meeting, Warren Percival exemplified this in his ensuing evening lecture. He contrasted the antithesis of an improver, Mr. A, with the ideal improver, Mr. B. While Mr. A's buildings, tools, lands, fences, crops, and livestock were in a neglected and deteriorating state, those of Mr. B showed his orderliness, forethought, efficiency, neighborliness, and appreciation of improvement. Mr. A had no books but tobacco, alcohol, and card games instead, so his children were "ignorant, awkward, impudent, dissipated, and dishonest"[178] and appreciated neither science nor God. Mr. B was teacher and role model to his children. They read classic and modern books and thus found beauty in art, science, and nature. They "combined theory and practice"[179] in their knowledge of all elements of the farm. Improvers were expected to have the "moral courage to advocate truth against falsehood."[180] Wagner's close collaborator in Serkenrode, vicar Johannes Dornseiffer, spun similar values in an 1879 article series in a local newspaper. He encouraged initiative to read agricultural journals and books to learn the natural sciences as well as economics. Record keeping was a key ingredient to rational planning and profitable farm practice. "Is [a farmer] not able to do so, he is working in the dark, then his fate is sealed: he is and remains a self-torturer."[181] Improvers would step out of tradition despite the influence of their conservative neighbors. Fearing God and self-help went together, as Dornseiffer reminded his readers at the end of all he wrote: "Help yourself then God will continue to help."[182] Improvers wove a close web of values that constituted improvement as

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[178] Goodale, *Report Maine Board of Agriculture 1872*, 168.
[179] Ibid, 169.
[180] Ibid, 169-170. Conspicuously, farm women appeared only once in Percival's description of the ideal improver, as having "practical knowledge of the duties of her sphere as a farmer's wife," while the domain of men were "the principles of agriculture."
[181] Johannes Dornseiffer, "Vom Bauernstande: Plaudereien für die Winterabende," in *Sauerländisches Volksblatt*, December 3, 1879, 1. Original: "Ist er hierzu nicht fähig, wirthschaftet er in's Blaue hinein, dann ist sein Schicksal besigelt: er ist und bleibt ein Quäler."
[182] Ibid. Original: "Hilf dir selbst, so wird Gott weiter helfen." See also Dornseiffer's articles under the same title in *Sauerländisches Volksblatt*, November 12, November 19, and November 29, 1879.

much as agricultural innovation itself. This organized system of moral obligation also drew sharp lines around improver membership.[183]

Improvers told each other stories. These stories needed evidence and improvers did their best to take their audience along to witness their experiments. Where scientists found ways to convey results bereft of human and nature, improvers and their farms stood front and center in their reports. They were not simply applying methods and knowledge, as scientists simplified their task. Every farm was new terrain for every piece of new knowledge. Improvers were always innovating in place. They did not need to universally resolve the differences between the unique evidence produced by others' trials. Rather, they only needed to know enough of their conditions to determine if and how they might adapt innovation by other improvers to their own farm. They accepted the resulting stratification of the improver hierarchy along the lines of proficiency in understanding, communicating, and using knowledge. The ways in which they tried new methods and talked to each other about them reassured improvers that, at least, they still stood higher than those farmers who could not try and talk like them.

## Elevating our brother farmer: Improvers talking to farmers in Maine

> We all know the sturdy, honest, hard-working farmer is hard to reach. The scales of indifference and conservatism so completely envelop him that he is almost impervious to new ideas, however forcibly they may be projected against him. How shall we approach him?[184]

Ziba Alden Gilbert, vice president of the Maine Board of Agriculture in 1871, had hit the nail on the head in his lecture that year. His question troubled the board meetings and public audiences through the early 1870s, including in Paris. Complaining about backward farmers was one way improvers reassured each other of their own elevated status. But that alone would not do. Farmers needed to see the light so that farming as a whole could thrive. That would allow improvers to present themselves as the leaders they wanted to be. Maine improvers developed ways to teach farmers how to teach themselves.

[183] In a marvelous study of improver farmhouses and farm buildings in New England, historian Thomas Hubka elaborated on these shared improver values. Hubka, *Big House, Little House, Back House, Barn*.
[184] Goodale, *Report Maine Board of Agriculture 1871*, 140.

For Maine improvers, the prime knowledge infrastructure to reach farmers were farmers' clubs. These clubs had existed in some towns and neighborhoods for decades already, but in the early 1870s they caught the attention of improvers on the state level. Smaller than agricultural associations that covered a whole county and attracted improvers, these clubs extended to farmers in the same neighborhood or town, beyond the reach of the agricultural associations. That is why the Maine Board of Agriculture at the 1872 meeting in Paris voted to require county agricultural associations to use a quarter of their state funding to promote farmers' clubs. After the lectures and discussions of the third day, the board expended the entire fourth day of its meeting on reports and discussions on these smallest assemblies of those practicing agriculture. And according to Stephen L. Goodale, the secretary of the Maine Board of Agriculture in 1872, this fourth day mirrored discussions of the two previous years, which is why the following presents evidence from these three years.[185]

Improvers had to integrate the meetings of farmers' clubs into the lives of farmers as much as possible. Meetings had to blend with the seasons and workdays of the farm just as much as with the social lives of those who lived there. Improvers at the board meetings in the early 1870s reported in detail their strategies to make meetings of farmers' clubs attractive to farmers. They usually met every week or every other week only during the winter months at town meeting houses, at the one-room schoolhouses existing in most neighborhoods, and at farmers' homes. Meeting schedules could be adapted for holidays or even the lunar calendar so the moon could shine a light home after the meeting. Saturday evenings were popular times. They gave the opportunity to make the meeting not just a discussion of agricultural matters, but a social occasion where farm families could "pass round the apples and cider, and have a good time generally."[186] Improvers frequently encouraged other organizers of farmers' clubs to invite farm women as well. Improvement mattered to them too. But more importantly to the male improvers discussing these plans, they found that farm wives motivated their husbands to attend and they made

[185] Goodale, *Report Maine Board of Agriculture 1872*, 5-7, 171-172.
[186] Stephen L. Goodale, *Fifteenth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1870*, (Augusta: Sprague, Owen & Nash, 1871), 398.

meetings more orderly in their discussions. Bringing farm daughters drew out farm sons who would otherwise not attend solely to discuss farming matters with the old folks. D. H. Thing, the president of the board in 1871, summarized the key to successful farmers' clubs well when he said: "there are some men who must have the gospel carried to them; we cannot get them out to hear it."[187] In knowledge infrastructure, improvers met farmers where they were, but only to bring them to where they should be.[188]

To improvers, farmers' clubs were the means to extend their established knowledge infrastructure into the farm neighborhood. Improvers organizing farmers' clubs largely reproduced elements of agricultural associations and fairs. Some clubs introduced friendly competition for honorary premiums to encourage improvement among farmers. Others started town exhibitions modelled upon the exhibitions of agricultural associations at county fairs. In all clubs, improvers reproduced the meeting structure of agricultural associations and even the board of agriculture. Meetings began with a lecture and continued with a discussion. Even if not all farmers attended the club meetings, improvers surmised, the discussions spread into conversations with neighbors. Occasionally, farmers' club organizers would invite speakers from elsewhere, especially members from the state board of agriculture. They were supposed to carry knowledge communicated at those meetings to the farmers. Similarly, improvers encouraged the promotion of agricultural journals and the creation of club libraries as the means to move improver knowledge to farmers. In the opposite direction, farmers' clubs should ideally have a secretary record the discussions at the meetings and along with the scripts of lectures submit them to local newspapers or agricultural journals. Improvers made farmers' clubs an extension to their knowledge infrastructure that ideally communicated knowledge in both directions.[189]

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[187] Goodale, *Report Maine Board of Agriculture 1871*, 146.
[188] Goodale, *Report Maine Board of Agriculture 1870*, 396-407; Goodale, *Report Maine Board of Agriculture 1871*, 137-153; Goodale, *Report Maine Board of Agriculture 1872*, 171-172. Other historians of science have analyzed the importance of sociability to knowledge communication, see Anne Secord, "Science in the Pub: Artisan Botanists in Early Nineteenth-Century Lancashire," *History of Science* 32, no. 3 (September 1, 1994): 269–315.
[189] Ibid. Naturally, farmers were also invited to the winter and spring public board meetings. The board began to hold these in different farming towns throughout the state in 1870 to allow more farmers to attend. Samuel Lane Boardman, *Stephen Lincoln Goodale: His Life-Work for Maine Agriculture: Memorial Address* ([S.l: s.n.], 1898), 16-18.

The strategy of improvers to enable this dialogue was training farmers to think, talk, and feel like improvers. To start with, improvers thought farmers should not just use their hands but also their minds to produce knowledge. Never mind that, of course, farmers had always been thinking and had made their own little experiments, of which improvers were surprised to hear. But now, farmers should make purposeful and systematic experiments in the style of improvers. As E.G. Phelps from South Paris reported, their club had "arranged to try experiments in fertilizing, and other ways."[190] Together with the improvers organizing farmers' clubs, vice-president of the board Gilbert argued, farmers would acquire the "mental culture" of improver experimenting, promoting "a keener perception, a closer observation, a more accurate knowledge of the different farm operations."[191] Improvers taught farmers how to innovate in place like improvers so that the knowledge improvers communicated to farmers would fall onto fertile ground.

For that to happen, farmers had to understand improvers. So, improvers adapted the knowledge infrastructure to farmer settings to allow them to learn the conventions of improver communication. Improvers wanted to draw out the knowledge of all farmers in discussions with other farmers. However, as a Mr. Moore reported for the remote western Maine town of Anson, "farmers who can sit down by their firesides and tell how to raise a calf, a lamb, a colt, or an acre of corn, with perfect ease, if you get them into a club and ask them to speak to twenty or thirty people, they do not feel at home, and decline to say anything."[192] Improvers came up with several strategies to encourage farmers to speak. Some assigned individual members to prepare short lectures; others posed direct questions of members in discussion; and others still provoked answers by making exaggerated statements. Improvers tried to approach farmers' fireside conversations by prioritizing local, familiar speakers, breaking up larger groups into smaller committees, and encouraging a conversational style of communication. Finally, improvers started club libraries and promoted agricultural journal subscriptions to encourage reading

[190] Goodale, *Report Maine Board of Agriculture 1870*, 399.
[191] Goodale, *Report Maine Board of Agriculture 1871*, 138-139.
[192] Ibid, 14.

habits, provide examples to emulate, and give farmers confirmation of their own ideas in print. Farmers should learn improver conventions and skills of speaking in public, writing coherent lectures, and abiding by appropriate rules of discussion. As one recipient of this farmers' club course in improver communication assured improvers: "if we have neglected in former years to discipline ourselves to speak like professional men I trust we shall do so no longer."[193] Improvers dove down to the level of farmers only to lift them up to a level required to understand and express knowledge like improvers.[194]

To complete farmers' conversion to improver ways, farmers were supposed to adopt improver values. Only this would turn them into reliable makers and reporters of knowledge as well as progressive and worthy members of the farming community. Improvers tried to imbue in farmers their own curiosity to learn more about the facts and laws of nature. They should understand the principles underlying their own craft rather than what improvers decried as following old routines blindly. Gilbert described the ideal farmers' club in these terms. Coming together with their neighbors in a social and inquisitive fashion at the clubs encouraged a feeling of community among those families tilling the soil. "The association with the fellow members of the club creates a healthy rivalry in matters of rural taste and rural adornments, and neatness, thrift and enterprise are stamped on all the premises."[195] The orderliness, efficiency, and bourgeois decoration of farmhouses and grounds became the evidence for the conversion of farmers to the higher moral ground of improvers.[196]

In this threefold education effort to think, talk, and feel like improvers, visual evidence was key. Improvers argued that actually witnessing the evidence was paramount for farmers. Witnessing evidence through communication alone, as improvers found convincing, would not do. When Ziba Thayer presented his experiments to determine the hay equivalent of corn meal to the Paris farmers' club, it was

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[193] Ibid, 144.

[194] Goodale, *Report Maine Board of Agriculture 1870*, 396-407; Goodale, *Report Maine Board of Agriculture 1871*, 137-153; "Farmers‘ Club," in *Oxford Democrat*, Dec 2, 1870, 2.

[195] Goodale, *Report Maine Board of Agriculture 1871*, 139.

[196] Hubka, *Big House, Little House, Back House, Barn*. Compare also the global rise of the bourgeoisie in the nineteenth century, see Christof Dejung, David Motadel, and Jürgen Osterhammel, *The Global Bourgeoisie: The Rise of the Middle Classes in the Age of Empire*, 2020.

the actual piles of hay and of corn meal he presented that "smashed into flinders"[197] the previously assumed hay value. The attending farmers inspected the piles and could see first-hand what the referenced weights of hay and corn meal looked like. Apparently, they all had different images in their head of what hay and corn weighed out looked like and, as improvers described it, only the visual evidence could bring most of them into agreement. One attending farmer stated, "that it was hard meeting facts such as Mr. Thayer had stated, supported by demonstration."[198] And improvers knew that this effect of demonstration would multiply the effect of farmers' clubs. As summarized in the board report of 1872, farmers would benefit "second hand" if they "see something of the improvements as put into practice."[199] Elegant and orderly farmhouses as well as prized livestock and crops bespoke the prosperity of their owners. They showed quite palpably that the methods and morals of improvers translated into economic success. Integrating farmers and their most convincing evidence into the knowledge system of improvers promised to spread the improvement message into countless farm neighborhoods, far beyond the direct reach of improvers.

A central characteristic of improvers ran as an undercurrent through all of their efforts: They divided farmers into progressives and lost causes. While farmers not attending farmers' club meetings might still benefit from the knowledge discussed there, it was the attendees that were the future of farming. Improvers habitually described those farmers listening to them and following their prescriptions as "intelligent" farmers. By contrast, farmers who rejected improvers and their ideas were the irrational and backward farmers to complain about. As the board report for 1872 summarized, "their well directed [sic!] enthusiasm may leaven the duller ones with progressive ideas."[200] Improvers had to win over a critical mass of farmers but they had no illusions of converting all of them.

Improvers wanted to integrate willing and able farmers into their knowledge system as a reliable source and destination of agricultural innovation in place. Most importantly, farmers would become

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[197] "Farmers' Club—Paris," in *Oxford Democrat*, November 28, 1871, 2.
[198] "Farmers' Club—Paris," in *Oxford Democrat*, Dec 5, 1871, 4.
[199] Goodale, *Report Maine Board of Agriculture 1872*, 172.
[200] Ibid, 171.

multipliers of improver knowledge communication and production. This required teaching farmers improver knowledge conventions. Maine improvers identified the farmers' club as the most promising institution to achieve this goal because improvers extended it as much as possible into the lives of farmers. Gilbert called them the "primary schools of agriculture."[201] Improvers were to be the teachers and farmers their students, learning their elementary lessons in innovation in place on their own farms and, every once in a while, providing their teachers with little nuggets of new "facts." Farmers as the prime target of improver innovation also became another source of agricultural knowledge to improvers.

**Meeting farmers were they are: Improvers talking to farmers in the Sauerland**

Similar to Maine improvers, Sauerland improvers had developed a knowledge infrastructure that reached into farm neighborhoods. Instead of farmers' clubs, Sauerland improvers had local agricultural associations (*landwirtschaftliche Lokalvereine*) as extensions of the hierarchical structure from national to county. These usually included several nearby towns rather than just one or even just one neighborhood. As a result, their membership was larger than farmers' clubs, at least on paper. Members came together only a handful of times per year at most, but since the location of meetings alternated between villages often at a distance, association leaders and local members came to these meetings. Their annual fair drew larger crowds, member or no member, despite the distance between villages. The improvers attending carried improvement messages back with them into their respective neighborhoods. Unlike farmers' clubs in Maine, their conversations with neighbors remained without institutional structure and without historical record. In addition, associations provided access to regional agricultural journals. When one copy per member exceeded the funds of the Serkenrode association, it voted to lay out copies in local pubs, have neighbors share copies, or have local improvers read them out loud at announced times and places. Notices and articles in general newspapers and the longer annual reports sent to every member added channels to local improver messaging. In Germany as in the United States, improvers made sure

[201] Goodale, *Report Maine Board of Agriculture 1871*, 140.

improvement knowledge traveled as closely as possible to farmers' doorsteps, but Sauerland improvers recorded the response of farmers less than some of their Maine counterparts.[202]

Sauerland improvers largely used the same communication strategies to reach farmers as their fellow improvers in Maine. In the case of Serkenrode, the activities of local Vicar Johannes Dornseiffer attest to the long-standing function of local priests in European improvement on a town scale.[203] As select priests had done since the eighteenth century across Europe, Dornseiffer employed his local upbringing, his education, and his elevated social status to translate improver knowledge to farmers in simple and brief messages.[204] On the one hand, he addressed farmers with understanding.

> It must be done differently! The traditional shall be disposed of, the much-loved changed, the new put in its stead! Certainly, a difficult enterprise. Yet, it is imperative to break much-loved habits, to dispose of distrust, to bring about the required understanding, and overcome financial difficulties. And still it must be, there is no other way.[205]

On the other, Dornseiffer spoke down to farmers authoritatively, in the confessional and from the pulpit. In one of his sermons, Dornseiffer reported that he had seen "a farmer had thrown his quitch on the path," but that he did "not want to see that again!" Dornseiffer admonished "you must plow the quitch under so that after their decomposition they nourish the soil with nutrients."[206] Dornseiffer spoke the language of

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[202] For agricultural associations in Westphalia, see Frese; Behr, "Das Landwirtschaftliche Vereinswesen Westfalens im 19. Jahrhundert;" Reif. For the Serkenrode local agricultural association, see Minute books of the Landwirtschaftlicher Lokalverein Serkenrode, in private possession of Heinrich Schmidt in Fehrenbracht, January 6, 1879; December 10, 1879; October 21, 1880; July 8, 1883; October 26, 1884; August 30, 1885; Amtmann Kayser to Landrat Hammer, March 1 and 2, 1882, in *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 410, "Landwirtschaftlicher Kreisverein I," 301, 303.

[203] Jones; Marcus Popplow, "Economizing Agricultural Resources in the German Economic Enlightenment;" Pelzer, "Landwirtschaftliche Vereine als Wissensagenturen." There is at least one similar case in nineteenth-century Maine where the Catholic priest of a predominantly Irish-American farming community, Rev. Thomas J. Nelligan of Whitefield, took a role in agricultural improvement, see Michael J. O'Brien, "The Early Irish in Maine," *The Journal of the American-Irish Historical Society* 10 (1911): 166-168.

[204] For newspaper notices, Dornseiffer advised fellow improvers that "one accomplishes more with a succinctly composed program than as if we announced the content of our lectures in academic breadth." See, Johannes Dornseiffer to Landrath Federath, September 20, 1884, LAV NRW W, Kreis Brilon – Landratsamt, Folder 1296, 46.

[205] *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883* (Paderborn: Bonifacius, 1883), 4. Original: "Es muß anders gemacht werden! Das Althergebrachte soll beseitigt, Liebgewordenes geändert, Neues an seine Stelle gesetzt werden! Gewiß ein schwieriges Unternehmen. Gilt es doch, liebgewordene Gewohnheiten zu durchbrechen, Mißtrauen zu beseitigen, das nötige Verständnis herbeizuführen, und finanzielle Schwierigkeiten zu überwinden. Und dennoch muss es sein, es geht nicht anders."

[206] Andreas Oberdorf, "Hilf dir selbst, dann hilft dir Gott," in *Landwirtschaftliches Wochenblatt* 20, 2015, 98. Original: „Ich ging dieser Tage über den Berg nach Salwey. Da hat ein Bauer seine Ackerquecken auf den Weg

farmers and understood their precarious situation but much like other improvement leaders across the Sauerland, he spoke down to farmers with the supposed authority of someone who knew better than they.

Dornseiffer added virtual and visual evidence to his arguments. When Dornseiffer introduced his argument for Wagner's method of fodder cultivation in a Serkenrode agricultural association annual report, he asked rhetorically of the past system of grains agriculture: "What good is it if we do not profit from it?"[207] Only to follow with an enumeration of Sauerland statistics – environmental advantages for fodder cultivation, percentages of land uses, the livestock to population ratio – and the specific measures necessary to turn agriculture around – more livestock, better meadow irrigation, correct cultivation of Wagner's fodder. On several occasions, Dornseiffer supported these measures with descriptions of the crops of local early adapters and painstaking calculations of the potential profits for local farmers should they use Wagner's method. Finally, Dornseiffer also presented firsthand visual evidence for Wagner's method in a small experimental plot in his own garden.[208]

Sauerland improvers harbored the same divisive mindset as their Maine counterparts. This was also the case in the Serkenrode agricultural association. Its leadership in the 1880s described members as small farmers while excluding even smaller farmers. A temporary shift in this outlook made this tendency apparent. New leadership in 1890 proposed to halve the membership dues for those farmers paying less than 5 Marks in annual land tax.[209] To the leadership around Dornseiffer, poor farmers were the subject of paternalistic charity who needed agricultural education. The association's winter school under Dornseiffer's leadership provided a waiver of tuition for those families unable to pay. Yet, its annual reports did not address poor farmers as the agents of change in agriculture as in Dornseiffer's 1884 discussion of the recent phenomenal potato harvest of great importance to poor farmers.

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geworfen. Ja es läuft sich schön weich darüber, aber ich möchte das nicht noch einmal sehen! Die quecken müsst ihr unterpflügen, damit sie nach ihrer Zersetzung den Boden mit Nährstoffen bereichern!" Other translations for quitch, meaning the plant genus of Elymus, are couch grass, wheatgrass, or wild rye.

[207] *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883* (Paderborn: Bonifacius, 1883), 5. Original: "Was nützt es, wenn wir nichts dabei profitieren?"

[208] Ibid; Quiter, 114-117; *Mescheder Zeitung*, July 11, 1879. Most likely, he was co-author of "Unsere Ziele," in *Mescheder Zeitung*, July 26, 1881.

[209] Minute books Serkenrode, September 28, 1890.

> There are households where potatoes are eaten five times a day: in the morning with coffee, at 10 o'clock with coffee, of course for lunch, in the afternoon at 4 with coffee and in the evening with coffee. Nothing but potatoes and coffee, if it really is coffee! That much in confidence; I only ask not to tell on me! – thus, it should be clear that such people are still very much in need of instruction so that they are capable of expanding their intellectual and economic circles.[210]

Dornseiffer invited association members into the circle of enlightened improvers, chuckling at the woes of the poor. At the same time, he reminded them and the agencies funding agricultural improvement of their responsibility to charity.

Convincing farmers to join improvers and use Wagner's method, however, was a completely different animal than teaching them how to use it. His print instructions for using his method remained ineffective in teaching tacit skills because they lacked demonstration and they were short, general, and tucked away at the end of lengthy, promotional essays.[211] Unlike Maine improvers, Wagner and his collaborators began to build infrastructure for institutional instruction. In 1880, Wagner added farm visits to his lecture circuit. The district agricultural association gave him three months out of the year to instruct farmers and work with them on their own farms to adapt his method.[212] Following the example of associations in the Rhine province, the agricultural associations in Serkenrode, county Meschede, and in nearby Elspe, county Olpe, founded the first agricultural winter schools in Westphalia. The winter sessions of these schools were consciously adapted to the winter lull in farmers' work seasons so that their sons could attend the school. In addition to the next generation, the agricultural teachers at these

[210] *Vierter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1883-1884* (Paderborn: Bonifacius, 1884), 16. Original: "…besonders wenn ich dem Leser im Vertrauen die Mitteilung mache, daß es Haushaltungen gibt, wo fünfmal im Tage Kartoffel gegessen werden: morgens früh zum Kaffee, um 10 Uhr zum Kaffee, mittags selbstverständlich, nachmittags um 4 Uhr zum Kaffee und abends zum Kaffee. Nichts wie Kartoffel und Kaffee, wenn es wirklich Kaffee ist! Soviel im Vertrauen; nur bitte ich, mich nicht zu verraten! – also es wird auch einleuchten, daß solche Leute noch sehr der Belehrung bedürftig sind, damit sie ihren Ideen- und Wirtschaftskreis zu erweitern imstande sind."

[211] Wagner, "Der Futterbau im Sauerland." See also, Wagner, *Ausdauernder Gemengefutterbau*. On the history of knowledge and manuals, see Kerstin von der Krone, Mark R. Stoneman, eds., *Learning by the Book: Manuals and Handbooks in the History of Knowledge*, preconference blog series, May-June 2018, https://historyofknowledge.net/lbtb/.

[212] Der Vorstand der Landeskultur-Gesellschaft, "Jahresbericht der Landeskultur-Gesellschaft für den Reg.-Bezirk Arnsberg," in *LZWL*, April 1, 1881, 101-111.

schools advised their students' parents on their own farms the rest of the year.[213] Instruction happened on site and hands on, but by trained personnel, not "second hand" as in Maine. Wagner and Sauerland improvers met farmers where they were, on their farms, but improvers did not trust farmers' teaching abilities.

Rather than bringing farmers up to improver knowledge production, as Maine improvers proposed, Wagner and winter school teachers brought innovation in place down to farmers. They did not try to win over farmers by telling them to adapt innovations on their own with improver methods. Sauerland improvers had already adapted this innovation to Sauerland environmental and economic conditions as an institutional service and farmers should simply follow improver instructions. Improvers narrowed the parameters in which farmers should adapt Wagner's method to their farm. And this method was the only viable solution for the survival of Sauerland agriculture.[214] When farmers "allowed themselves modifications on their own account"[215] in their use of Wagner's method, such as using less of the expensive seed, these were not improver experiments to adapt the method to individual means. They were farmer mistakes that led to failure that could only hurt the promotion of the Wagnerian farming revolution. Improvers chastised farmers if they behaved like improvers. Anticipating extension in its top-

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[213] *Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1880/1881* (Arnsberg: F. W. Becker & Comp, 1881); Fritz Söbbeler, Landwirtschaftsschule Fretter – Eslohe – Meschede: Einige Daten und Fakten zu ihrer Geschichte und Entwicklung von der Gründung bis zur Gegenwart, (Meschede: Verein ehemaliger Landwirtschaftsschüler und – schülerinnen Meschede und Landwirtschaftsschule/Höhere Landbauschule Meschede, 1996); *Erster Jahres-Bericht der landwirthschaftlichen Winterschule zu Elspe. Winter-Semester 1880/81*, (Olpe: Th. Mietens, 1881); *Fünfundzwanzigster Jahresbericht der zweisemestrigen landwirtschaftlichen Winterschule zu Elspe über das Schuljahr 1904/05 (*Olpe: F. X. Ruegenberg, 1905).

[214] Consider, for example, Dornseiffer's appeal in his third annual report for the Serkenrode agricultural association: "More fodder, more cattle, better animal care and husbandry, refinement of our local breed, excellent milk cows and – – creameries!!" Original: "Mehr Futter, mehr Vieh, bessere Pfege und Haltung des Viehs, Veredelung unseres Landschlages, vorzügliche Milchkühe, und -- -- Molkereien!!" *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883*, 6-7.

[215] "Jahresbericht über den Zustand der Landescultur in der Provinz Westfalen 1879," in *LZWL* May 7, 1880, 153-155; Der Vorstand der Landeskultur-Gesellschaft, "Jahresbericht der Landeskultur-Gesellschaft für den Reg.-Bezirk Arnsberg," in *LZWL*, April 1, 1881, 106-107; Der Vorstand der Landeskultur-Gesellschaft, "Jahresbericht der Landeskultur-Gesellschaft für den Reg.-Bezirk Arnsberg," in *LZWL*, April 1, 1881, 107. Original: "auf eigene Faust sich Abänderungen erlaubt."

down instruction, Sauerland improvers argued that farmers would only reap the benefits of innovation if they ceded innovation in place to improvers.[216]

Sauerland and Maine improvers developed very similar strategies to reach farmers. However, with different farm density and different knowledge infrastructure to match, Sauerland improvers cast their strategies of educating farmers in a different light. The vision of Maine improvers to teach farmers how to innovate in place themselves made sense given that they had nowhere near the resources or personnel to send experts to every far-flung but small farm neighborhood across the state. In the Sauerland, improvers had institutionalized their efforts to educate farmers earlier because farm neighborhoods were denser and in closer proximity to each other. As a result, the strategies to reach farmers were the same as in Maine but the goal was a different one. Innovation in place was a service improver institutions provided to farmers.

## Extending both hands: Maine improvers collaborate with scientists and farmers

Over the next decade, both Maine farmers and improvers seemed to graduate from the primary school of agriculture, as Gilbert had called it. Farmers' clubs continued and were joined by granges all over the state. In the mid to late 1870s, the Patrons of Husbandry rapidly gained a substantial following, relied less on state funding, but in its knowledge negotiations functioned similarly to farmers' clubs, if putting on the formality of a secret order. Leaders of granges and agricultural associations followed the establishment of agricultural science in Maine closely. Much discussed in the 1860s, the Maine State College of Agriculture and the Mechanic Arts had made great strides since began operations in the central Maine town of Orono in 1868. Collaborating closely with the Maine State Board of Agriculture as the former highest authority on agricultural science, the college had won over the state legislature and many farmers to support an agricultural experiment station. Established in 1885, the station marked the institutional cementation of agricultural science as an integral part of farming in Maine. So, in the 1880s,

[216] Also note the increase in official expert lectures as top-down instruction that Pelzer has found for the Lüneburg region beginning in the 1880s. Marten Pelzer, "'Was die Schule für das heranwachsende Geschlecht ist,'" 55-56.

improvers began to connect improver and scientist institutions as sources of agricultural knowledge. Improvers in Maine joined forces with scientists to institutionalize improvement and education.[217]

In the last decades of the nineteenth century, improvers and scientists developed what would become extension. Scientists at agricultural colleges and experiment stations had to extend their expertise to the improvers and farmers of the state paying their salaries. In the United States, scientists had held lectures for farmer organizations since the late eighteenth century. Yet, only in the middle of the nineteenth century did scientists in several states begin traveling to smaller, less established meetings of farmers, early farmers' clubs. The 1870s and 1880s in other New England states saw improvers, especially in the grange, challenge scientists for lacking worthwhile contributions to farming. In the 1890s, scientists at the Maine State College resolved the issue by collaborating with improvers in developing early extension efforts.[218]

The farmers' institute was the prime institution where Maine improvers and scientists developed the ways extension would work as a central function of agricultural colleges. Improvers organized special meetings of farmers' clubs and invited agricultural scientists to hold lectures next to other improvers and farmers. Farmers' institutes reproduced the lectures and discussions of the traveling biannual meetings of the Maine Board of Agriculture in the early 1870s but with a smaller audience, in more remote locations, and with more frequency. In 1881, a farmers' institute had been held in every county of the state and their number would grow from there.[219] In Maine, this was the first widespread engagement of agricultural scientists with farmers. These farmers' institutes exhibit the strategies of integrating improver and

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[217] Reznick; Stanley Russell Howe, *A Fair Field and No Favor: A Concise History of the Maine State Grange* (Augusta: Maine State Grange, 1994); Samuel Carleton Guptill, "The Grange in Maine from 1874-1940" (1973); Rexford Booth Sherman, "The Grange in Maine and New Hampshire, 1870-1940" (1972); David C. Smith, *The First Century*; Boardman, *Stephen Lincoln Goodale,* 15-19; David C. Smith, *The Maine Agricultural Experiment Station*.

[218] Alfred Charles True, *A History of Agricultural Extension Work in the United States, 1785-1923,* Miscellaneous Publication / United States Department of Agriculture ;No. 15 (Washington, D.C.: U.S. Dept. of Agriculture, 1928); Sorber.

[219] Ziba Alden Gilbert, *Twenty-Fifth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1881*, (Augusta: Sprague & Son, 1882), 3.

scientist knowledge systems into a knowledge system of extension that would take root in in several institutions of the late nineteenth and early twentieth century.[220]

**At the farmers' institute: Extension before extension**

Three people stood in front of the farmers of the Penobscot County Farmers' Club assembled at the Orrington Grange Hall on December 29, 1885. They were the highest order personnel of improvement and science to be found in Maine. Ziba Alden Gilbert had become an even more notable improver since the early 1870s, with tenures as president of the state pomological society, trustee of the Maine State College, and now long-standing secretary of the Maine State Board of Agriculture and newly president of the Maine Experiment Station board.[221] Walter Balentine had graduated from the Maine State College program in agriculture in 1874, had studied at Wesleyan university with Wilbur Olin Atwater and at Halle university and experiment station with Julius Kühn, whose ranges and averages of chemical feed components Armsby had included in his fundamental textbook on scientific feeding in 1880. In the same year, Balentine began his tenure as professor of agriculture at the Maine State College.[222] Gilbert M. Gowell was the former president of the Maine State Board of Agriculture who was now superintendent of the College Farm, possibly the most up-to-date farm in the state.[223] They combined the best that improvement and science had to offer. On this occasion, they gave the morning lectures at a well-attended farmers' club meeting which provided entertainment for all, including a choir performance. The club had chosen the topics of the three lectures to be given that day, including cattle feeding, and the president of

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[220] Day, *Farming in Maine, 1860-1940*; Ralph Ashton Corbett, *50 Years of Extension Work in Maine*, Maine Extension Bulletin 496 (Orono, ME: Cooperative Extension Service, 1962); True, *A History of Agricultural Extension Work*; Marcus, *Agricultural Science and the Quest for Legitimacy*.
[221] Samuel Lane Boardman, *Agricultural Bibliography of Maine*, 36-37; Samuel L. Boardman, *Annual Report of the Maine Fertilizer Control and Agricultural Experiment Station, 1885-6*, (Augusta: Sprague & Son, 1886).
[222] *Annual Reports of the Trustees, President, Farm Superintendent and Treasurer of the State College of Agriculture and the Mechanic Arts, Orono, Maine, 1880*, (Augusta: Sprague & Son: 1880) 5; Smith, *The Maine Agricultural Experiment Station*, 6-7. For the work of Julius Kühn, see e.g. F. Wohltmann and Paul Holdefleiss, *Julius Kühn, Sein Leben Und Wirken. Festschrift Zum 80. Geburtstag Am 23. Oktober 1905* (Berlin: P. Parey, 1905).
[223] Gilbert, *Report Maine Board of Agriculture 1881*; Smith, *The Maine Agricultural Experiment Station*.

the Orrington farmers' club led the meeting. This farmers' institute combined the expertise of improvers and scientists with the sociability of farmers, the blueprint of extension knowledge infrastructure.[224]

Gilbert reminded his farmer audience of the expectations he had for extension events. "We understand fully as well as you that we must discuss those topics intelligently." Extension invited farmers in to join the ranks of progressive farming and benefit from it. At the same time, it enforced the conventions improvers and scientists wanted farmers to follow. So did Gilbert. "We have always found that these meetings draw together a class of intelligent, thoughtful people, well read on all farm topics."[225] The reverse conclusion was that those irrational farmers not attending did not belong to this elevated group. Extension subscribed to the same division between cooperative and unwilling or unable farmers.

In their shared lecture, the three speakers carefully introduced science as part of the improver knowledge system. As representative of their elected agricultural association leaders, Gilbert addressed farmer criticisms and fears of science head on. Farmers could not rely on science too much yet. Still, it was the only aid farmers had. Gilbert translated the "correct application of science to the business" of farming into the only good business practice for farming. "Scientific farming means, in good homely English, good farming. No one can feed a steer to a rapid growth, no one can secure bountiful returns from a cow, unless it is done strictly in conformity with scientific principles."[226] He skillfully combined scientists' singular claim to truth with the economic goals of improvers. If farmers wanted more profit, they should use science. If they already made a profit, they were already using science. The laws of nature applied everywhere all the time whether farmers understood them or not. The respected improver normalized science as already living among the livestock, fields, and dollars of the farm.

Continuing the translation of science into farmer horizons, the scientist among the speakers integrated both farmer and scientist experience and language. Balentine echoed Gilbert's warning of relying on science alone before delving into the science of feeding. Balentine managed to explain

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[224] Ziba Alden Gilbert, *Twenty-Ninth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1885*, (Augusta: Sprague & Son, 1886), 69.
[225] Ibid, 70.
[226] Ibid, 72.

scientific feeding as he had learned it from Atwater and Kühn in plain words and simple sentences fitting on two pages. He began with a common observation known to farmers: fifteen pounds of oat straw produced entirely different results than fifteen pounds of oats when fed to the same animal. Chemical analysis of feed could explain why. Feeds consisted of different components which he simplified to "protein or albuminoids […] carbohydrates, also fats and the ash of the plant."[227] For the best results in feeding for milk or fattening, the feed should have the right proportions of each component for that purpose. Feeding only with oat straw through the winter, as "very many of you have noticed," would result in an animal "falling off in the fat and in the flesh, while the animal grows weak, and comes out, as you say, 'spring poor.'"[228] Finally, Balentine translated all of scientists' experiments at German experiment stations into one specific ideal ration for dairy cows. Comparing it to feeding practices of Maine farmers in the past, he arrived at a very simple conclusion: feed more protein. The key to extension was combining the language and observations of scientists and farmers into translations of scientific research that were specific to place, general in scope, and easy to understand. They had to be flexible yet firm on the singular claim to truth.

In the third step, extension had to demonstrate how science fit in with the rest of the farm operation. Gowell, the most practical improver present, explained what factors beyond science impacted his management of the ideal college farm. Individual dairy cows in the college herd required different rations, so Gowell specified a range of ideal rations not in chemical components but in weights of feeds. In addition to their "herds-grass, red top or Alsike clover"[229] mixed hay and 1 ½ pounds of bran, he fed corn meal and cotton meal at a maximum of 2 ¼ and a minimum of 1 ½ each. This ration was ideal not just because of its contents in albuminoids and carbohydrates but also because it induced the animals to eat more in total than if feeding hay alone. Finally, Gowell specified the exact prices he paid for these three concentrated feeds and wondered aloud whether he should replace cotton-seed meal with corn meal,

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[227] Ibid, 74.
[228] Ibid.
[229] Ibid, 76.

depending on the shifts in market prices. This farming improver married scientist and improver explanations, nutrition and palatability, and added specific instructions, communicated in improver conventions and adapted to farmer abilities and Maine markets. He set the boundaries in which farmers could develop feeding solutions on their farm. Extension brought science and improvement home to the Maine farm.

All three speakers had one strategy in common: they gave farmers the power to experiment and produce proof on their own. Balentine echoed Gilbert's warnings of relying on science too much: "There is no scientific man living who can come here and tell you, if you have not good common sense and practical knowledge of the subject, how to feed cattle successfully."[230] Only together could scientist and improver expertise create better results in the hands of farmers. Balentine instructed them to observe the health, appetite, and growth of their animals for the results of feeding. If these were lacking, "you know there is something scientifically wrong about it; you prove it by practice."[231] Gilbert added his own experiments to determine ideal rations for his cows. Not only did the feed requirements for different production purposes differ, but the needs of each individual animal also differed. "One of my cows is fleshy, and she needs a different ration from another at the other end of the row that is in poor condition."[232] Scientists and improvers respected each other's areas of expertise in extension. Delegating adaptation of scientific principles and innovating in place became one and the same thing: the farmer experiment. In this strategic move, giving farmers the power but also the responsibility to determine their own ideal rations served a dual purpose. Farmers were supposed to stop expecting the impossible, one-size-fits-all answers from scientists. At the same time, farmers should accept the responsibility to learn scientist and improver methods to develop their own answers within the parameters defined by extension.

These were the strategies that improvers and scientists used to develop extension as their combined effort. In the late nineteenth and early twentieth century, in Maine as in the nation, supported

[230] Ibid, 73.
[231] Ibid, 75.
[232] Ibid, 76.

by improvers and led by scientists, agricultural colleges began to train extension agents. They were more than just the educated improvers lecturing at associations and advocating to the government. Extension agents combined the characteristics of scientists and improvers into one-man professional advisers with authoritative messages. By and large, they had grown up on farms or in farming communities where they would also return after their training at the agricultural college. They combined experience farming with scientific understanding and the knowledge of how farmers in their hometowns talked and what evidence they found credible. Extension agents became the familiar face that farmers could depend on for sound advice if the old ways were no longer good enough. They were improvers imbued with the ability to resolve debates into authoritative instruction. Extension agents became the qualified personnel to reach all willing and able farmers.[233]

## Working with everyone else: Sauerland improvers challenge scientists

Where Maine improvers and scientists collaborated, Sauerland improvers quarreled with German scientists. Wagner's fodder cultivation and the budding infrastructure of farmer instruction had been a direct response to the inadequate advice of scientists to Sauerland improvers. The knowledge systems and the knowledge infrastructure of improvers and scientists clashed. Sauerland improvers collaborated with market and state agents to establish Wagner's game-changing innovation as the saving grace of Sauerland agriculture. This choice of collaborators aimed to bypass scientists. They had contributed little to Sauerland improvement in the past so improvers did not see them as a viable collaborator. However, Sauerland improvers found the task of collaborating with farmers, state agents, and market agents intricately interconnected with scientists' support.

### Convincing material supporters: Sauerland improvers collaborating with market agents

For his fodder cultivation, Wagner introduced uncommon plant species that were not grown commercially. Even during the development of his seed mix, Wagner had trouble finding larger amounts

[233] Day, *Farming in Maine, 1860-1940*; Marcus, *Agricultural Science and the Quest for Legitimacy*; True, *A History of Agricultural Extension Work*; Sorber; Laurie M. Carlson, *William J. Spillman and the Birth of Agricultural Economics*, Missouri Biography Series (Columbia: University of Missouri Press, 2005).

of specific plants' seeds. He inquired with seed stores large and small across Europe and even contacted German consulates abroad only to acquire just a few handfuls of seed of bird vetch (*vicia cracca*) and bush vetch (*vicia sepium*) from a Paris botanical garden. So, Wagner opted to breed these plants himself. In 1879, he and several Sauerland improvers collaborated with county officials to instruct elementary school teachers to have their students collect the seeds in the wild. Still, Wagner struggled for several years to make the seeds of these plant species and the meadow pea (*Lathyrus pratensis*) germinate reliably. For earlier trial fields, Wagner had been forced to substitute the intended but unavailable perennial species for the suboptimal but available annuals, defeating the long-term cost-cutting purpose of his method. In other cases, seed stores delivered seeds for species that looked like what he ordered but were really different species not valuable for his seed mix.[234] In short, Wagner not only had trouble breeding the plants for his own seed mix but also struggled to convince seedsmen to produce the correct seed mix at scale. It remained a scarce and expensive resource.[235]

In 1879, Wagner was at the helm of negotiating arrangements with seedsmen to solve these difficulties. He enrolled his employer, the district agricultural association, to contract with several seed stores outside the Sauerland to grow individual species out of the mix and send the seed to one seed store in Darmstadt to assemble the final product. The rationale behind this arrangement aimed at seed stores' bottom line. To provide the volume of seed Wagner foresaw, it was uneconomical and risky for one seed store to grow every single species of Wagner's mix. Integrating each new fodder plant out of the mix into the selective mass production of several seed stores opened up the benefits of economies of scale. This was a novel and still expensive product. Should it have the success Wagner foresaw, the profit potential for the exclusive producers was enormous.[236]

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[234] Scientist Friedrich Nobbe of the Tharandt experiment station, pioneer in seed testing, had complained in 1875 already about seedsmen sending children to collect wild seed in the forest. Friedrich Nobbe, "Wider Den Handel Mit Wald-Grassamen Für Die Wiesen-Kultur," *Landwirtschaftliche Jahrbücher* 5 (1876): 1035–64.
[235] Wagner, *Ausdauernder Gemengefutterbau*; "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 361-365; LAV NRW W, K 333, Folder 1784 "Einführung des sogenannten Wagner'schen Futterbaus."
[236] Freiherr Edmund von Hövel to Landrat Markus Hammer, October 30, 1881, in *LAV NRW W,* K 333 / Kreis Meschede, Landratsamt, Nr. 410, "Landwirtschaftlicher Kreisverein I," 229.

What was more, Wagner and the district association proposed a marketing deal to the advantage of seedsmen and farmers. The district association required that the final seed mix be tested for correct plant species, ratios, and germination rate by one of the few agricultural scientists in the district, Dr. Martin Schenck at the Siegen *Wiesenbauschule*, a landscape construction school. This approach had first been used by experiment stations across Germany in battling fertilizer fraud. It was soon expanded to seeds and concentrated feeds. In return, the association solicited orders by farmers and marketed the seed mix as genuine Wagner's seed mix, guaranteed by the association. In 1881, they even developed a trademark symbol to mark their seed mix against untested products sold under the same name. Protection against fraud was in the spirit of improvers, market agents, and farmers alike. Seed stores only had to produce and deliver the seed correctly, the association did the rest. Improvers understood the economics of seed production, respected seedsmen's economic and growing expertise, and enrolled the expertise of improvers and scientists to meet their needs.[237]

To increase farmers' trust in the product, Wagner and the district association also arranged the distribution of the seed mix. The district agricultural associations and the Meschede county association organized distribution of pre-ordered seed and seed sales through four designated seed sellers evenly spread around the Sauerland, in Berleburg, Lippstadt, Siegen, and Meschede. Not only did these stores print advertising of the certified product of their own, they provided personal accountability close-by. The association did not simply send the final product via mail order from the distant Darmstadt seed store, but it integrated the seed mix as much as possible into the economic landscape of the Sauerland. These seedsmen were Sauerländer themselves selling a product certified by the official agricultural authority for the Sauerland. Improvers went out of their way to meet farmers' expectations when connecting them to market agents.[238]

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[237] Ibid; Minute books Serkenrode March 21, 1881; *Landwirthschaftliche Zeitung Märkisch Sauerland*, March 1, 1879, 12; December 1, 1879, 48; *Mescheder Zeitung*, December 9, 1879; March 15, 1881

[238] Ibid. For accountability of local stores, compare Ira Spieker, *Ein Dorf und sein Laden: Warenangebot, Konsumgewohnheiten und soziale Beziehungen um die Jahrhundertwende* (Münster [u.a.]: Waxmann, 2000).

Finally, the district association solicited farmers' orders as joint orders to reduce the price of Wagner's seed mix. County and local associations soon joined in. In county Meschede, the Serkenrode association had compared offers and organized delivery of fertilizer and seed since 1866 and established a specific cooperative association (*Consum-Verein*) for this purpose and other cooperative purchasing in 1880.[239] Wagner himself had actively supported this strategy when he worked with them in 1879.[240] This strategy caught on. The more associations cooperated, the more savings they would garner. During the 1880s all over the Sauerland and Westphalia agricultural associations joined together in ordering agricultural inputs, finally ordering Westphalia wide. The district association fit Wagner's seed mix into this trend. Convincing as many farmers as possible to estimate their demand for Wagner's seed mix several months in advance was key to negotiating supply and price with seedsmen. The result were savings for farmers which lowered the economic barriers for establishing Wagner's fodder cultivation in the practice of Sauerland farmers.[241]

Improvers connected farmers and market agents by providing benefits to both. This win-win situation even became a triple win for improvers as it cemented their position at the center of the agrarian-industrial knowledge system. Improvers understood, respected, and worked hard to meet many of the needs of farmers and market agents. This was easier when each group's vision of their own role in the knowledge system matched the vision of their role by others. Market agents supported innovation by supplying the material inputs, and farmers used methods proven to benefit them. Under the right conditions, improvers could skillfully negotiate agreement between them.

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[239] Minute books Serkenrode, February 8, 1866, March 16, 1880; "Landwirthschaftl. Local-Verein Serkenrode," in *MZ*, March 12, 1880.

[240] Minute books Serkenrode December 10, 1879.

[241] Another strategy that contributed to the decreasing the impact of high seed cost was the establishment of rural credit cooperatives. In addition to the larger Westphalian credit institution, the Landschaft, established by Wilhelm von Laer, agricultural associations all over Westphalia as well as in county Meschede and township Serkenrode established smaller rural credit cooperatives after the Raiffeisen model. See, Maria Blömer, *Die Entwicklung des Agrarkredits in der preussischen Provinz Westfalen im 19. Jahrhundert* (Frankfurt am Main: Fritz Knapp Verlag, 1990); Raimund J Quiter, *Johannes Dornseiffer: ein Priesterleben im Sauerland an der Schwelle der modernen Zeit, 1837-1914* (Siegen: Verlag Höpner & Göttert, 1997), 128-158; Friedrich Schütte, *Westfalen in Amerika: Von Boeing, Bruns und Boas bis Ney, Niebuhr und Wewer*, (Münster: Landwirtschaftsverlag Münster, 2005), 174-181. In Maine and all over the United States, the Patrons of Husbandry, or the Grange, also engaged in cooperative purchasing of farm inputs. See e.g., Boardman, *Report Maine Board of Agriculture 1876*, 94-97; Reznick.

**Convincing deciders: Sauerland improvers collaborating with state agents**

Farmers lacked money to buy Wagner's seed. State agents wanted to expand the agricultural economy. These were the connection points improvers identified for Wagner's fodder cultivation. The Prussian state provided funds to support promising innovations and its agricultural ministry administered these through the hierarchical structure of the agricultural associations. Improvers only needed to write a convincing application and submit it through the proper bureaucratic channels. They hoped that increased funds to support farmers trying Wagner's method would decrease farmers' distrust of innovation and thus increase their ability and willingness to try it. What was more, improvers argued, state funding would turn Wagner's method into a credible innovation officially endorsed by the highest power on agricultural knowledge, the Prussian agricultural ministry.[242]

Access to state funding went through the state bureaucracy, so a personal and collaborative relationship with the responsible state agent was paramount. The leaders of the the Serkenrode, Eslohe, and Fredeburg agricultural associations began their application for state funding for Wagner's method by contacting the county executive (*Landrat*) for Meschede county. Two of the leaders were town bailiffs (*Amtmann*) and they used their experience and existing relationship with the county office to establish this contact. The county executive Markus Hammer had taken his post only in 1878 and came from outside the Sauerland. He was eager to collaborate with local bailiffs to improve the agricultural economy and gladly offered his bureaucratic expertise. In writing and in person, he advised the applicants to detail Wagner's method and provide supporting evidence of its viability as "in the case of such grants, the administration first wants exact insight into the ways the funds will be used."[243] These Sauerland improvers were successful in enrolling their state agent's bureaucratic expertise as well as his personal

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[242] Jonathan Harwood analyzed how upper-level agricultural associations developed strategies to further their own interests within the larger Prussian state policies on agriculture in late-nineteenth-century Germany, see Jonathan Harwood, "Research and Extension in Political Context: Rural Unrest and the Origins of the Prussian Chamber of Agriculture," in *The State and Rural Societies: Policy and Education in Europe, 1750-2000,* ed. Nadine Vivier (Turnhout: Brepols, 2008), 135–58.
[243] Landrat Markus Hammer to Amtmann Räper in Fredeburg, March 2, 1879, in LAV NRW W, K 333, Folder 1784 "Einführung des sogenannten Wagner'schen Futterbaus." Original: "Bei derartigen Bewilligungen wollen die Behörden vorher genaue Einsicht in die Art u. Weise der Verwendung der betr: Fonds haben."

endorsement up the bureaucratic flagpole. From this reliable source, they learned the communicative conventions required by state agents.[244]

Improvers enrolling state agent support had to demonstrate that their goals aligned with those of the state. With much detail and trial evidence, the applicants argued that Wagner's method would revolutionize agriculture not just to the benefit of poor farmers relying on the charitable support of their sovereign. This revolution would contribute to policy goals. It would increase domestic agricultural production of sought-after products like milk, butter, and meat, while plentiful hay production would also make forest pasture superfluous and remedy the decried forest devastations on Sauerland hilltops. Once the forest was removed from the farm nutrient cycle, it could be managed rationally and increase timber production for the booming German construction industry, an enterprise already well underway in state-managed forests. Improvers argued that supporting Wagner's method was an investment with ample returns for the economy and a shining example of intelligent policy.[245]

Next, the specific means to establish innovation among farmers and the underlying moral economy had to fit current state funding conventions. State funding would be handed out as premiums for exemplary results, which was a long-standing policy from the agricultural ministry down to local associations.[246] With this commitment to premiums as a method of rewarding farmers' efforts in

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[244] LAV NRW W, K 333, Folder 1784 "Einführung des sogenannten Wagner'schen Futterbaus." This application was the beginning of a long-lasting give-and-take relationship with county executive Hammer who became the president of the county agricultural association in 1880. Through him, Wagner and his collaborators in Meschede county effected the collection of Wagner's seeds, tried to influence political appointments, and were forced to cede some independence of local associations. The Serkenrode association made Hammer an honorary member and frequently invited him to attend the winter school's final exam. The association leadership also used this strategy to secure a good relationship with other influential players in the regional agrarian-industrial knowledge society, such as Wilhelm Gosker, principal at the agricultural school (*Ackerbauschule*) in Riesenrodt, and the president of the district agricultural association, Baron Edmund von Hövel. Minute books Serkenrode; *Jahresberichte Winterschule zu Fretter*; "Serkenrode," *MZ*, July 11, 1879; Minute books Serkenrode, February 8, 1866; May 25, 1879.

[245] Amtmann Kayser to Landrat Markus Hammer, March 24, 1879, in LAV NRW W, K 333, Folder 1784 "Einführung des sogenannten Wagner'schen Futterbaus;" Gabriel, Mues; Selter. See also, Harwood, "Research and Extension."

[246] Premiums had been part of Westphalian agricultural improvement strategies at least since the 1830s and the provincial government had provided funds for premiums since at least 1835, see Fritz Dieckmann and Gisbert Strotdrees, *Münster, Zentrum der Landwirtschaft: gestern und heute* (Münster-Hiltrup: Landwirtschaftsverlag, 1993), 25. In 1880, following controversial debates, the agricultural ministry advised by the Agricultural State Commission officially reaffirmed its commitment to the method of funding premiums for exemplary cattle, if in

improvement, Sauerland improvers also demonstrated that they agreed with state agents' condemnation of backward farmers. President of the Serkenrode association, bailiff Kayser, emphasized that only those farmers "who can show a truly worthwhile crop as a result of correct creation of fodder fields" should receive funding, "not those who, without further thought and without following the sufficiently known requirements, spent their money on seed but cannot exhibit any successes."[247] Lazy, backward, and irrational farmers should not be saved in favor of upstanding, industrious, and obedient improving farmers. A judging committee of association members would ensure that. Of course, this meant that the funds would go to association members. And to state agents and improvers alike, this was as it should be. It was expected that the application was mainly self-serving. State agents and improvers encouraged competition between farmers and understood that exclusion was part of improvement.[248]

The Sauerland improvers cast themselves as the accepted leaders of agricultural improvement in their region. After all, that was their job in the state-funded agricultural association hierarchy. The applicants made sure to point out they were at the helm of a united cause, representing all intelligent farmers and improvers of the region. They all agreed with their leaders that Wagner's method would revolutionize Sauerland agriculture. That is why they had already ordered 2400 Reichsmark worth of Wagner's seed, as Serkenrode president Kayser pointed out. He then went to great lengths to demonstrate that his association was an exemplar of improvement: they ordered increasingly more artificial fertilizer, the membership of the association had increased to 250, and the association held subscriptions of two

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combination with other measures. *Landwirtschaftliche Jahrbücher* 9, Supplement 1, 8-30, 214-230; Frhr. Von Hövel, A. W. Bömer, "Landes-Cultur-Gesellschaft für den Regierungsbezirk Arnsberg," *LZWL*, October 15, 1880, 343-345.

[247] Kayser to Hammer, March 24, 1879. Original: "…welche in Folge richtiger Anlage von Futterfeldern einen wirklich lohnenden Ertrag derselben nachweisen können; nicht aber diejenigen, welche ohne weiteres Nachdenken und ohne Beachtung der genügend bekannten Erfordernisse ihr Geld für Samen ausgegeben haben, ohne Erfolge davon aufweisen zu können."

[248] Minute books Serkenrode, October 21, 1880; Gabriel, Mues; Kayser to Hammer, March 24, 1879; Vorstand des landwirth. Kreis-Vereins Meschede an Landrath Hammer, May 28, 1879. The county association also received these funds earmarked for premiums but since it was already October it did not send anyone to look at the fields, even though they stipulated that size alone should not be the deciding factor for the winner. They increased three of their premiums because these farmers had been especially "industrious." Minutes of Vorstandsversammlung des landwirtschaftlichen Lokalvereins Meschede-Eversberg, October 23, 1880, in *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 410, "Landwirtschaftlicher Kreisverein I," 28-29. Original: "fleißig." Such self-serving arrangements have been reported for agricultural associations in other countries, such as Canada, see Wynn.

regional agricultural journals for each member. With this evidence, Sauerland improvers sought to prove their progressive mindset and capability.

Finally, Sauerland improvers presented themselves as the only experts for agricultural improvement in their region, versed in theory and practice alike. State agents expected to fund experts only. The application for funding was carefully orchestrated from the mosaic of expertise local improvers could enroll, including a large-scale farmer and bailiff, a hammer mill owner, and a pharmacist. They argued that current low cattle prices and improved creamery technology allowed a Sauerland "dairy production guided by scientific principles."[249] The increased prices paid by the recently established cooperative creamery would incentivize farmers to intensify hay production, improve manure, and thus maintain cereal production on less area. In improver's terms, the applicants presented Wagner's method as the only key to saving Sauerland farming. The reasons for Wagner's success could be explained scientifically. For the thin Sauerland soils on top of potash-rich grauwacke formations, the key ability of Wagner's uncommon "potash plants" was "to absorb their required alkalis and alkaline earths directly out of insoluble rock. This has been demonstrated beyond doubt at least for limestone, granite and osteolite [calcium phosphate] by the 1864 experiments made by Sachs (Hoffmeister's physiological botany IV pag. 189ff.)."[250] The application cited scientific literature, understood the experiments therein, and then applied them to Sauerland farming conditions in a whole list of observations of farmers' fields. Sauerland improvers argued that they were scientist and improver in one and thus had singular authority on the subject of Sauerland farming.

Their synergy bore fruit. Sauerland improvers had matched state agent conventions in enrolled advocates, aligned goals, current methods, appropriate values, improvement efforts, accepted leadership, and expert knowledge. The funding came at a price, though. The Sauerland improvers reproduced their

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[249] Gabriel, Mues. Original: "nach wissenschaftlichen Grundsätzen geleiteten Gewinnung der Milchprodukte."
[250] Gabriel, Mues. Original: "ferner haben die Wurzeln vieler Pflanzen das Vermögen, die ihnen nothwendigen Alkalien und alkalischen Erden aus unlöslichem Gestein direkt aufzunehmen, wenigstens ist dies für Kalkstein, Granit und Osteolith? (Phosphorsäurenkalk) durch die 1864 von Sachs angestellten Versuche zweifellos dargethan (Hoffmeisters physiologische Botanik IV pag. 189 ff.)."

claim to scientific expertise in the press and scientists took note. In line with their model for the agrarian-industrial knowledge system, scientists kept watch over improver knowledge translation and Sauerland improvers did not meet their approval. To scientists, these accroaching improvers assumed the position of innovator that was reserved for scientists. A full-on controversy ensued, up the agricultural association scales to the agricultural ministry, from the Sauerland to Berlin.

**Antagonized technicians: Sauerland improvers challenging scientists**

In just a few months, the disagreement over Wagner's fodder cultivation brought out the fault lines between Sauerland improvers and scientists. In the summer of 1879, Wagner's employer, the district Arnsberg agricultural association, was at the helm of promoting his method and it asked the agricultural experiment station in Münster for an evaluation. Funded by the provincial agricultural association of Westphalia, the Münster station had two assistants fulfill improver expectations and confirm by chemical analysis that Wagner's hay was as at least as nutritious as conventional hay plants. In the mind of Sauerland improvers, the job of scientists ended there. However, the report by the Münster scientists went on to attack the expertise and explanations of Wagner and his collaborators lest they gave farmers erroneous ideas about how nature worked. Scientists and improvers outside the Sauerland reproduced and added to this initial scathing critique throughout the following debate. It climaxed at the February 5, 1880 meeting of the Prussian State Agricultural Commission (*Landesökonomiekollegium*), the expert body advising the Prussian agricultural ministry. Wagner's ideas and terminology were at best outdated, or proven to be wrong, the critics argued; Wagner's ideas were certainly not new. Scientists policed the boundaries of science as the only credible source of agricultural innovation. Sauerland improvers protested. Out of soil rich with diverging knowledge production, infrastructures, and communicative conventions grew a power struggle over the nature and creators of innovation.[251]

Wagner had not produced a universal method that negated place. His supporters contended that the specific seed mix for the Sauerland should travel to similar regions. Awareness of regional conditions

[251] Dr. v. d. Becke, Dr. C. Krauch, "Zur Kenntniß des Wagner'schen Futterbaues," in *LZWL*, September 5, 1879, 311-315; *Landwirthschaftliche Jahrbücher* 9, Supp. 1, 204-214.

was a hallmark of improver innovation in place. Wagner's method had convinced the director of the Poppelsdorf agricultural academy, Prof. Dr. Friedrich Dünkelberg, because he had traveled to the Sauerland himself to meet Wagner. And it was Dünkelberg who translated Wagner's method to the Commission suggesting that the agricultural ministry should pay Wagner to write and publish a brochure on his innovation. Essentially, he argued that this itinerant teacher without academic credentials should be elevated to the status of innovator among scientists. This was too much for the eminent German expert on seed research, Prof. Dr. Friedrich Nobbe. He had started the first seed testing station at the agricultural experiment station at Tharandt in 1869. To him, questions on particular applications of scientific principles were beneath this expert body. "I could name an inexhaustible abundance of such questions e.g. from the Thuringia region, but I want to spare you."[252] Wagner's fodder cultivation was a dime a dozen. To scientists, the particular was infinite, only the universal was singular and thus worthy to be called innovation.[253]

Wagner had not communicated his method in the conventional media of scientists. As a result, most of their criticisms were founded on incomplete information. In several newspapers and farm journals, Dornseiffer contrasted each criticism raised by the Münster scientists with a variety of citations by Wagner and his collaborators to the point of ridicule. Wagner had already provided all the clarifications in the two Sauerland agricultural journals, the Berleburger *Organ* and *Landwirthschaftliche Zeitung Märkisch Sauerland*, as well as in a brochure by Wagner and an Eslohe agricultural association annual report. With Sauerland farmers as his audience, Wagner had published in media by and large not available outside the region. By contrast, the Münster scientists had cited a book on grass seed mixes published in Leipzig in 1873 unknown to Dornseiffer.[254] Their report was the only credible evidence to scientists. In the February meeting of the Prussian State Agricultural Commission, Friedrich Nobbe only

[252] *Landwirthschaftliche Jahrbücher* 9, Supp. 1, 209. Original: "Ich könnte Ihnen z.B. aus der Thüringer Gegend eine unerschöpfliche Fülle von derartigen Fragen geben, aber ich will sie damit verschonen."
[253] *Landwirthschaftliche Jahrbücher* 9, Supp. 1, 204-214.
[254] Dornseiffer, "Zur Kritik des Wagner'schen Futterbaues."

referenced the Münster report, not the opposing publications.[255] An eminent journal for agricultural chemistry only summarized the scathing Münster critique in a short notice, reproducing it as uncontested scientific fact.[256] For Sauerland improvers, a single book in the ocean of too many books was meaningless if nobody demonstrated its usefulness on Sauerland fields. For most scientists, credible scientific contributions were not scattered across obscure regional farm journals.

Wagner and Sauerland improvers did not adhere to the professional jargon agreed upon by scientists. From the several offending terms in the debate, the term "root force" (*Wurzelkraft*) was by far the most contentious.[257] Scientists identified "root force" as a poorly chosen term, reminiscent of "life force" (*Lebenskraft*), the key concept of vitalism. By the 1840s, Liebig's findings in organic chemistry had moved agricultural science away from the idea of a vital force that drove organic processes. The Münster scientists made clear that "no scientifically educated person talks of life force anymore"[258] and that "less educated farmers"[259] might be misled by the term to believe in overturned principles. Nobbe ridiculed the term as "absurd," "magical," and "mystical."[260] These scientists understood what improvers actually meant with "root force:" the ability to solve nutrients out of the soil and, by the excretion of an as yet unidentified acid, even rock. Yet, they were not going to elevate this farmer talk to the level of scientifically accurate terminology.

Finally, Wagner's explanations for the stunning success of his method distorted fundamental scientific principles. What had been translated to scientists of Wagner's method seemed to suggest that the mix and selection of plants were the sole reasons for its success. Both the Münster scientists and

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[255] *Landwirthschaftliche Jahrbücher* 9, Supp. 1, 211.
[256] "Zur Kenntniss Des Wagner'schen Futterbaues," *Biedermann's Zentralblatt Für Agrikulturchemie Und Rationellen Landwirtschaftsbetrieb* 8 (1879): 950.
[257] The other much-discussed term was "wild children of nature" (wilde Kinder der Natur) to describe the uncultivated plants in Wagner's seed mix. Scientists misunderstood this term and Wagner's explanations to mean that wild seeds were more efficient in this case than cultivated seed. Instead, Wagner had argued that these wild seeds should be cultivated and bred to be introduced as new cultivated plants. But the collection of wild seeds itself hit too close to home for Nobbe who had been campaigning against collection of wild seed as fraud for years. Nobbe; *Landwirthschaftliche Jahrbücher* 9, Supp. 1, 209-212; Wagner, *Ausdauernder Gemengefutterbau*.
[258] Becke, Krauch, 313. Original: "redet kein wissenschaftlich gebildeter Mensch mehr von der Lebenskraft."
[259] Becke, Krauch, 315. Original: "Weniger gebildete Landwirte."
[260] *Landwirthschaftliche Jahrbücher* 9, Supp. 1, 210.

Nobbe thought the idea was impossible that an excessive number of different grasses and legumes, especially including wild ones, would thrive growing together. In the light of Darwin's survival of the fittest, the strong would choke out the weak. Nobbe believed this to be true for plants as for people, in keeping with his ideas about a racial hierarchy. Nobbe clarified that should you combine "wild children of nature" with "highly developed, strongly rooting cultivated plants, then the former will *perish* and will be able to prevail in the struggle for life as little as the Iroquois and Delaware in their struggle with the Anglo-Saxon race!"[261] Rather than the selection of plants, scientists posited that the reason for the unheard-of crops was Wagner's promotion of fertilizing hay fields. The proper application of Liebig's balance between soil supply and plant demand was providing required nutrients in readily soluable form in the shape of fertilizer. Plants dissolving minerals out of rock were an unnecessary complication of a simple solution. The economic straits of Sauerland farmers did not matter to agricultural best practice, according to scientists. It only mattered that Wagner, this supposed innovator, bent the laws of nature into dangerous distortions not in line with what scientists had agreed upon.[262]

With diametrically opposed visions of their functions in the agrarian-industrial knowledge society, Sauerland improvers were not able to win over scientists to support Wagner's fodder cultivation. To Wagner, the case was clear. The Münster assistants refused to do their job. It was unknown how exactly the roots of these legumes managed to dissolve nutrients out of rock, and scientists should "study this eminently chemical question rather than turn it into a laughing matter."[263] Behavior as evidenced in their report pointed to the "dangers that may arise when bookmen leave their actual field and intrude into agricultural practice."[264] Wagner and his collaborators spoke the language of improvers to build trust

[261] Ibid, 211. Emphasis in original. Original: "Und ich fürchte, wenn Sie eine ganze Zahl dieser wilden Kinder der Natur in Verbindung bringen mit hoch entwickelten starkwurzelnden Kulturpflanzen, so werden die ersteren […] *untergehen* und werden sich im Kampf ums Dasein mit dieser ebenso wenig behaupten können wie die Irokesen und Delawaren im Kampf mit der angelsächsischen Raçe!" Compare to how Emily Pawley's integrates the racism of the time into her analysis of antebellum improver knowledge production, see Pawley, *Nature of the Future*.
[262] Becke, Krauch.
[263] "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 364. "Diese eminent chemische Frage eingehend studierten, anstatt sie ins Lächerliche zu ziehen."
[264] Ibid. Original: "Gefahren, die entstehen können, wenn Stubengelehrte ihr eigentliches Gebiet verlassen und in die landw. Praxis übergreifen."

among users, not scientists. So, they addressed their factual corrections of scientists' criticisms at farmers. Factually, several of the attacks were baseless and easily corrected: Wagner had never mentioned vitalism, the wild legumes were not new but long-known, though previously unutilized, their seed was not to be collected in the wild but bred into cultivated plants, and the more than 100 positive reports from Sauerland farmers outweighed two assistants' observations of an incorrectly planted field. Even in their response to scientist critique, Sauerland improvers aimed to marginalize scientists. But the facts of Sauerland improvers had nothing to do with it. Scientists had long won advisory positions to the highest state authority on Prussian agriculture and had established much knowledge infrastructure in the image of their knowledge system. Sauerland improvers could not generate enough support to dislodge scientists in their power position within the state beyond the Sauerland. And scientists held that improvers could not innovate, but only "apply" innovation in principles.

Wagner's method also inherently did not match the agricultural futures imagined across the agrarian-industrial knowledge society. As Moser and Auderset have argued, the dominant vision of the future of farming after the mid-nineteenth century was industrial farming. Producing a variety of uncommon seeds at scale rather than seeds for monocultures did not fit industrial production and economies of scale. The dominant industrial mindset of the time sought discrete, standardized inputs out of the lithosphere, rather than variable interconnections in the biosphere. Farms working like factories required mineral fertilizer, not careful management of ecosystems. As improver, Wagner argued for observing farm organisms. He saw the expression of a natural law in natural meadows. Unlike monocultures, natural meadows did not know clover sickness or freezing out. Improvers had witnessed firsthand the productive temporal dynamic between Wagner's plant species that gave every cutting a different composition. Yet its potential was invisible to industrial mindsets and single sample chemical analysis. To Wagner, bad agricultural conditions should lead the way into the future because they punished every misstep against natural limits with failure. Good conditions only promoted soil exploitation and unsustainable, yet capital-intensive agricultural practices. However, the agrarian-industrial knowledge society at large took good farming conditions as their standard. In their minds, industrial agriculture worked well without negotiating agriculture with nature anew in every place.[265]

**House of Cards: Collapse and Reintegration of Sauerland Improvement**

The resounding refusal by scientists reverberated through the Sauerland agrarian-industrial knowledge society. The acreage of new Wagnerian fields planted per year decreased sharply after the controversy. This is precisely what Wagner and his collaborators had been afraid of. As much as Sauerland improvers had tried to discredit scientists as "latin farmers,"[266] the doubt they had sown took root. The result was decreasing demand for the seed Wagner and the district agricultural association had labored so hard to get seedsmen to grow. Combined with persistent difficulty in making Wagner's wild legumes sprout reliably for seed production, lack of demand in the Sauerland and across the empire made expansion of seed production unthinkable.[267] The lack of seed for Wagner's wild legumes had caused the less than ideal early meadows that in turn had contributed to scientists' damning misconceptions in the first place. So, Wagner's seed mix remained expensive, further curtailing farmer buy-in, which had been hampered by their difficulties to learn Wagner's method to begin with. Finally, the combination of scientist, market agent, and farmer rejection of Wagner's method went together with waning state funding, drying up after 1881.[268] Like dominoes, all actor groups within the agrarian-industrial knowledge society withdrew their support. By 1885, the provincial agricultural association reported that "the enthusiasm with which Wagner's fodder cultivation had been accepted and tried at the time has in many

265 Wagner, *Ausdauernder Gemengefutterbau*; Auderset and Moser; Moser and Varley, "The state and agricultural modernization in the nineteenth and twentieth centuries in Europe."
266 Johannes Dornseiffer, "Vom Bauernstande: Plaudereien für die Winterabende," in *SVB,* November 29, 1879. Original: "lateinische Bauern."
267 Wagner, *Ausdauernder Gemengefutterbau*, 11. Even in the reports of the select trials of Wagner's method as far away as Vienna complained of the wrong plant species contained in the mix they had purchased. See J. Zink, A. Kohlert, "Ueber Wagnerschen Futterbau," in *Biedermann's Zentralblatt für Agrikulturchemie und rationellen Landwirtschaftsbetrieb*, 13, August 1884, 550.
268 LAV NRW W, K 333, Folder 1784 "Einführung des sogenannten Wagner'schen Futterbaus;" Frhr. Von Hövel, "Jahresbericht der Landeskultur-Gesellschaft für den Reg.-Bezirk Arnsberg," in *LZWL*, April 1, 1881, 113; Frhr. Von Hövel, A. W. Bömer, "Jahresbericht der Landeskultur-Gesellschaft für den Regierungs-Bezirk Arnsberg pro 1881," in *LZWL*, April 7, 1882, 120.

places followed a contempt that, in our opinion, goes too far."[269] Towards the end of the decade, it dropped from association reports and journals entirely.[270] By trying to marginalize scientists, Sauerland improvers failed in their function as knowledge agency.

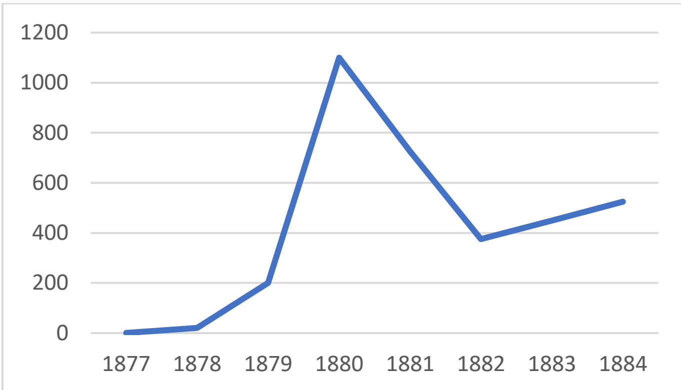


Figure 13: New plantings of Wagnerian hay fields in hectare, 1877-1884.[271]

The collapsing Wagnerian house of cards showcased a long-standing difficulty of improvers. As Marten Pelzer as shown for agricultural associations in the Lüneburg region, improvers had used personal instruction on farms to help farmers use improver innovations at least since the early nineteenth century. Apart from greater political representation and access to state support, agricultural associations organized to institutionalize farmer instruction in the shape of itinerant teachers and winter schools. The episode around Wagner's fodder cultivation showcases that scaling up professional improver instruction required an instructional and knowledge infrastructure which improvers alone could not provide. In 1885, the

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[269] *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1885*, 69. Original: "Auf die Begeisterung, mit der man seinerzeit den Wagner'schen Futterbau aufgenommen und versucht hat, ist vielerorts eine u. E. allzu weit gehende Geringschätzung gefolgt…"

[270] Several textbooks on the cultivation of fodder plants first published in the 1880s included Wagner's method in an encyclopedic manner. With their subsequent editions and resulting inclusion in a major encyclopedia, Wagner's method appeared in print at least as late as 1911, but by this time it had become a dead record. Eduard Birnbaum and Paul Gisevuis, *Pflanzenbau*, 8th ed. (Berlin: Paul Parey, 1911); Bernhard Römer and Gustav Böhme, *Grundriß der landwirtschaftlichen Pflanzenbaulehre: ein Leitfaden für den Unterricht an landwirtschaftlichen Lehr-Anstalten und zum Selbstunterricht*, 5th ed. (Leipzig: Karl Scholtze, 1895); J. Lehrke, *Mischung und Ansaat der Grassämereien sowie Pflege und Ertrag der Graskulturen: ein Handbuch für Land- und Forstwirte Bau- und Kultur-Ingenieure, sowie für Verwaltungsbeamte* (Breslau: Wilh. Gottl. Korn, 1888); "Futterbau," in *Meyers Großes Konversations-Lexikon. Ein Nachschlagewerk Des Allgemeinen Wissens* (Leipzig and Wien: Bibliographisches Institut, 1907).

[271] Data taken from: *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1884*, 52-53.

Eslohe association reported that farmers had made many mistakes in the previous year as "the correct planting of a fodder field is truly difficult."[272] Planting Wagner's hay fields was very different from planting common fodder plants like red clover. Farmers had to change the seed amount, density, and depth, the degree of working the soil and the tools for doing so, and the time of harvest for the top layer crop and the hay. A few winter school teachers and Wagner instructing improvers to teach their neighbors second hand a very difficult method rather than ways to innovate in place was an untenable approach. Sauerland farmer instruction was an improvers' game of telephone rather than a primary school of agriculture teaching how to innovate in place like in Maine. To reach the Sauerland goal of innovation in place as service, instruction faced distortion of knowledge as an obstacle. The solutions included foolproof innovations, more comprehensive instruction, and extension that allowed farmers to innovate in place. All of these required negotiating agreement with farmers, state agents, market agents, and scientists.[273]

Sauerland improvement reintegrated into the synergy of the agrarian-industrial knowledge society. Scientists had not dismissed Wagner altogether. In line with their knowledge system, scientists took Wagner's method as the expression of an agricultural problem that required research. As a result, Nobbe experimented with wild legumes as cultivated fodder plants and even collaborated with Wagner, who changed his tone from challenge to deference.[274] However, this did not last long. Without sustained support or a dependable knowledge infrastructure of their own, Wagner's method disappeared along with its supporters. Wagner retired in 1888 and his leading supporters had withdrawn from agricultural association work by the 1890s. The Serkenrode winter school, the first of its kind in Westphalia, competed more and more with other winter schools sprouting all over the province and empire. Dropping enrollment in the late 1880s encouraged a change in location to Eslohe and in sponsorship to the county.

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[272] *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1884*, 53. Original: „…die richtige Anlage eines Futterfeldes wirklich schwierig ist."
[273] Compare to Frank Uekötter's analysis of the relationship between the simplicity and the acceptance of innovations in farming, see Frank Uekötter, "Virtuelle Böden."
[274] Wagner, *Ausdauernder Gemengefutterbau*.

What had begun as Serkenrode improvers helping themselves turned into an extension of the state-funded and scientist-controlled knowledge infrastructure of extension. Serkenrode improvers had controlled the curriculum and had deliberately included Wagner's method but with state sponsorship came standardized curricula and standardized teacher training. In return, however, an increasingly dense network of winter schools took over the role of instructing farmers young and old in lectures, in person, and on farms. Extension agents translated lessons by scientists to farmers with an improver sensibility for innovation in place. The challenge to scientists had resulted in an expansion of extension. Improvers could not champion innovation in place as superior to scientist principles but they gained the knowledge infrastructure they desired.

## **Conclusions**

> Practice will have to render the final verdict after the different results have been compared and traced to their true value. This process, however, cannot go without the help of science at all, and so we hope that the current resentment will not last.[275]

> Science and practice must go hand-in-hand. Happily, the prejudice of the farmer against science in his calling is fast dying out; and the scientific investigator cordially welcomes the practical information of the most accurate farmers, and bases his deductions largely upon the facts which they have established.[276]

Agreement was paramount to a change in agricultural knowledge and practice. And rhetorical strategies were key in negotiating agreement between improvers and scientists, and their combined efforts to persuade farmers. The first quote was the attempt to smooth over the conflict over Wagner's fodder cultivation by the editor of the Westphalian provincial farm journal. Wilhelm von Laer moderated the controversy in the pages of his journal and reminded improvers and scientists of the extent of their expertise but also their mutual dependence.[277] The second quote is from an improver-authored textbook

[275] "Anmerkung der Redaction," in *LZWL*, October 17, 1879, 365. Original: "Das End-Urtheil wird die Praxis zu fällen haben, nachdem die verschiedenartigen Resultate verglichen und auf ihren wahren Werth zurückgeführt sind. Dabei aber ist die Hülfe der Wissenschaft gar nicht zu entbehren, und wir hoffen daher, daß die augenblicklich herrschende Verstimmung nicht von Dauer sein wird."

[276] Elliott W. Stewart, *Feeding Animals: A Practical Work upon the Laws of Animal Growth, Specially Applied to the Rearing and Feeding of Horses, Cattle, Dairy Cows, Sheep and Swine.* (Lake View: published by the author, 1883), 16-17

[277] Von Laer was also the final voice in the decisive meeting of the Prussian State Agricultural Commission. He

that accompanied Armsby's *Manual of Cattle Feeding* in classes at the Maine State College in the late 1880s and 1890s. Elliot W. Stewart made clear the relationship to scientists which improvers agreed upon and passed on to extension agents and school-taught improvers of the future.[278] Both in Maine and the Sauerland, improvers and scientists negotiated the boundaries of their expertise and eventually respected them. Whether through collaboration or conflict, they integrated the other into their own knowledge system without changing it. To improvers, scientists remained just one source of agricultural innovation, but improvers would not question their universal principles (to their face). To scientists, improvers remained intermediaries to reach farmers, but scientists replaced them with extension agents to diminish the knowledge distortion improvers could cause. Lip service accommodated opposite perspectives on the agrarian-industrial knowledge society.

The resulting agreement was called extension. Whether in the shape of a growing network of winter school teachers throughout the German Empire or a federal extension service with agents in every United States county, extension was based on formally trained instructors translating science to farmers. They became the official connection points to science. Improvers did less and less translation themselves but supported extension agents by lending them credibility. Together, they divided farming communities into professional farmers and lost causes. Extension agents aimed to get as close as possible to farmers and their farms to help them adapt standardized college lessons to their particular farms directly. Extension replaced the idea of educating farmers to innovate in place with trained service personnel marrying principles and place in collaboration with farmers. No more rogue educators distorting agricultural science. No more erudite scientists misunderstanding improvers and place. In the minds of improvers and scientists, their collaboration provided everything farmers needed to become what they should be. The agrarian-industrial knowledge society united behind extension as the future of farming.

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firmly subscribed to the compromise with scientists in the shape of extension and believed in the "objective" knowledge of scientists that improvers like Wagner and his supporters could not contend with. *Landwirthschaftliche Jahrbücher* 9, Supp. 1, 214.

[278] For more on this textbook, see Justus Hillebrand, "But Can the Farm Travel?"

# CHAPTER 4

## INNOVATION IN THINGS

> According to my now seven years of experience, I can claim that the inspection arrangements made by the local provincial agricultural association have come to beneficial successes; they have brought even the less educated farmer to the point that he no longer buys his wares from any peddler. Also, which is most important, he has learned to make certain demands on these wares. In this way, at least the initial cases of downright fraud and cheating have been reduced to a minimum.[279]

This is what market agents were up against: Scientists rallying farmers to keep makers and sellers of fertilizer, seeds, and feed on the straight and narrow. In the 1870s, even though market agents supplied the material inputs to farm innovations, they were outsiders of the agrarian-industrial knowledge society. The cry of “fraud!” reverberated through the ranks of scientists and improvers as soon as market agents did not align with their new standards. As Dr. Joseph König, director of the Münster experiment station, saw it, his own inspections (noted above) persuaded “less educated farmers” to bring market agents into the fold of nutritional contents and feeding standards. As it would turn out, the behavior of the mass of farmers would in fact tip the scales in the negotiations between market agents and the rest of the agrarian-industrial knowledge society. This popular vote, however, would not always favor the innovations scientists had hoped for.

In the second half of the nineteenth century in the United States as in Germany, the two solutions to intensify feeding exemplified a larger historical shift from agrarian to industrial food and feed production. Scientists agreed that purchasing factory-processed feedstuffs was the best solution to intensify livestock agriculture. They were easily accessible and chemical analysis revealed very clearly that these industrial byproduct feeds were nutritionally superior to farm-grown feed crops. Wary of hard-to-know feeds and increased capital investments, however, many improvers and especially farmers leaned

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[279] Joseph König, *Chemische Und Technische Untersuchungen Der Landwirthschaftlichen Versuchsstation Münster in Den Jahren 1871-1878* (Münster: Theissing’sche Buchhandlung, 1878), VIII. Original: “Nach meinem nunmehr 7jährigen Erfahrungen kann ich behaupten, dass die vom hiesigen landw. Provinzial-Verein getroffenen Control-Einrichtungen von segensreichen Erfolgen gewesen sind; sie haben auch den weniger gebildeten Landwirth durchweg dahin gebracht, dass er nicht mehr von jedem beliebigen Hausirer seine Waaren einkauft, sowie, dass er, was das Wichtigste ist, gelernt hat, gewisse Bedingungen an dieselben zu stellen. Auf diese Weise sind wenigstens die anfänglich groben Betrügereien und Uebervortheilungen auf ein Minimum reducirt.”

towards raising feed crops. Farmers trusted what they had grown, whereas industrial byproduct feeds came from an unfamiliar and untrustworthy world of factories. And when new feed products did not perform as promised, distrust of industrial processing culminated in accusations of fraud. As historian Benjamin R. Cohen has aptly put it for the case of food: “In the history of foods and farms, the move to industrial modernity was a move from trust in knowledge embodied by agrarian life to trust sanctioned by scientifically verified analytical knowledge.”[280]

Both solutions relied on purchasing material farm inputs. Even though farmers could grow their own seed, the concerted push by improvers and scientists for cultivated plant varieties and a scaled up specialized seed economy required at least some purchase of seed from market agents. Just as scientists’ innovations in principles of soil chemistry in the early nineteenth century had promoted a growing and quickly changing fertilizer market, their lessons in animal nutrition contributed to the development of a feed market. Together with expanding industrialization, the mindset to go with it, and the increasing demand for dairy and meat products from growing cities, the agrarian-industrial knowledge society saw potential in scaling up feed production and use. The intensification of agriculture in the late nineteenth century would depend on industrially processed farm inputs. That is why market agents became such great concerns for scientists and improvers. And that is also why market agents held power in negotiating their place in the agrarian-industrial knowledge society.

I define market agents as all people who made, bought, sold, or transported agricultural inputs or outputs.[281] Historical actors could shift between the roles of market agent and farmer or improver more easily than to the role of scientist. Market agents’ inherent self-interest generally disqualified them from the ranks of scientists, although there were notable exceptions. The most prominent example was Justus Liebig and his failed business venture in patent fertilizers.[282] Seedsmen, breeders, or builders of

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[280] Benjamin R. Cohen, *Pure Adulteration: Cheating on Nature in the Age of Manufactured Food* (Chicago ; London: The University of Chicago Press, 2019), 17. For this shift in Germany, see Uwe Spiekermann, *Künstliche Kost: Ernährung in Deutschland, 1840 bis heute* (Göttingen: Vandenhoeck & Ruprecht, 2018).
[281] With its focus on feed, this chapter highlights farm inputs over outputs, which are treated in the next chapter.
[282] Uekötter, *Die Wahrheit ist auf dem Feld*, 148, 159-160.

machinery functioned the same way as producers of fertilizer and feed manufacturers or merchants and shippers when it came to their knowledge production and communication. They all made non-human organisms or materials that farmers needed to intensify agricultural production. Market agents as a group bought raw materials, made different things out of them by processing, recombination, or simply transport, and then sold these new products. These functions could be handled by one or be shared between various market agents. Alone or in collaboration, market agent innovations came in the shape of new things.[283]

Market agent power over farming innovations thus relied on new material farm inputs rather than principles or local adaptations. This was their niche within the agrarian-industrial knowledge society. Not only did all other innovations rely on their material supplies but market agents were able to pack these innovations into tangible objects. Feeding experiments, chemical analysis, and resulting data tables were rather ethereal in comparison. Innovations in things approached the material demonstrations by improvers but had different dynamics of movement and communication. Some innovations in things relied on verbal communication and demonstration, but others worked with simple, written instructions. Some could work anywhere in the world, others remained bound to locality. The material things themselves could change when people moved them – they could spoil or break. The knowledge of them could distort even more, especially if knowledge and material traveled separately. Innovations in things were highly variable, depending on how their makers produced and marketed them. Market agents still had to negotiate knowledge production and communication with the rest of the agrarian-industrial knowledge society.

The following traces these negotiations through three innovations in things that promised to solve the feeding problem in the late nineteenth and early twentieth century. First, the flat pea, or *Lathyrus silvestris*, shows the example of a failed innovation in things. Wilhelm Wagner, the Sauerland innovator

[283] What I define as market agents, others have described as capitalists, especially in approaches of the new history of capitalism and capitalism in action, see e.g. Sven Beckert and Christine Desan, eds., *American Capitalism: New Histories* (Columbia University Press, 2018). In agricultural history, Emily Pawley focused impressively on the knowledge production of American improvers even more broadly understood as capitalists in the early twentieth century, see Emily Pawley, *The Nature of the Future*.

in place from chapter 2, bred this unconventional fodder plant, marketed it as a global revolution in fodder production, but failed to negotiate agreement over its capabilities and value with the German and global agrarian-industrial knowledge society. Wagner's flat pea provides the negative case, in contrast to the successful negotiations behind feeding solutions that remain dominant to this day. Second, byproducts of the food industry became the innovation in things that improvers, scientists, state agents, and market agents could agree on. Industrial byproducts from the processing of tropical and subtropical oil crops were the most successful of the new feeds. German market agents had access to a larger variety of them from European colonial empires than their American counterparts, so I focus on the German case study in its global entanglements. Byproduct feeds were also the foundation for the third innovation in things: balanced ration feeds. These were ready-mixed rations produced by feed manufacturers according to scientist principles. In a case study of the American mixed feed industry, I analyze how this new product allowed market agents to leverage farmer support to renegotiate their position within the agrarian-industrial knowledge society. Each case study showcases different aspects of the shared practices and strategies of market agent knowledge production, communication, movement, and negotiation.

## Wagner's flat pea: Imperfect negotiation of innovation in things

The story of Wilhelm Wagner as innovator was not over. The itinerant teacher of Westphalian district Arnsberg exemplified a common turn among improvers. He became a market agent, selling the farm inputs for his own innovation. He retired from his teaching position in 1888 and returned home to Württemberg where he started a seed business on his own estate in Kirchheim unter Teck. Wagner had moved on from the fodder cultivation that was so out of step with industrial production and scientist conventions. Experiments with wild legumes for his fodder cultivation in the early 1880s led to his next innovation: the flat pea (*Lathyrus silvestris*) as a new cultivated rough fodder plant. Whether in the US or in Germany, improvers frequently entered the business of supplying farm inputs, collaborating with or functioning as seedsmen or nurserymen, fertilizer or machinery salesmen.[284] The self-interest inherent to this role did not discredit them among improvers or even farmers, as long as they were providing useful innovation.[285]

Wagner produced his cultivated flat pea both within and outside the conventions of scientists. The problem Wagner intended to solve was the low germination rate of legume seeds due to their hard seed coat. The opponent to Wagner's fodder cultivation, Prof. Dr. Friedrich Nobbe, had published on this problem in 1876 (and it continued to vex agricultural scientists into the twentieth century). Around 1881, Nobbe told Wagner about his own experiments and resulting method to scarify the seed by beating them in a sack filled with seed and sand. Wagner used this advice to pursue the construction of a machine that would mechanize this process, a parallel enterprise to several experiment station scientists in the following years. Unlike his effort with his fodder cultivation, Wagner managed to negotiate collaboration with Nobbe. To Wagner, Nobbe was an expert technician solving a pressing problem in his realm of seed expertise. To Nobbe, Wagner was an improver setting the problem for science to solve and pass down innovation. The key was identifying a problem that seemed as of yet unresolved to scientists rather than convincing them a previous solution needed reconsideration.[286]

Market agents had to shape their products to fit scientist conventions yet still provide something new and useful. Wagner negotiated a compromise within the abilities of his flat pea. It fit both scientists' industrial mindset yet also stayed true to Wagner's concerns over soil exhaustion, bad farming conditions, and poor farmers. *Lathyrus silvestris* was to be cultivated in monoculture like all other common rough fodder plants, not as part of careful ecosystem management as his fodder cultivation. Its seed was a

[284] On the Maine side, consider e.g. Stephen L. Goodale, secretary of the Maine Board of Agriculture from 1856 to 1872, trustee of the Maine State College from 1870 to 1873, but also general manager and chemist in a fertilizer company and president of a bank, see Samuel Lane Boardman, *Agricultural Bibliography of Maine,* 37.
[285] *Jahres-Bericht der Landeskultur-Gesellschaft für den Regierungsbezirk Arnsberg 1886.* (Lüdenscheid: Ed. Horn Jr., 1887), 12-13;
[286] Wagner, *Ausdauernder Gemengefutterbau*; W. Wagner, "Lathyrus silvestris, eine ausdauernde Futterpflanze für den Sandboden," in *Deutsche Landwirtschaftliche Presse,* February 15, 1888, 73-75; Friedrich Nobbe, *Handbuch Der Samenkunde. Physiologisch-Statistische Untersuchungen Über Den Wirthschaftlichen Gebrauchswerth Der Land- Und Forstwirthschaftlichen, Sowie Gärtnerischen Saatwaaren.* (Berlin: Wiegandt, Hempel & Parey, 1876); Adalbert von Jarzymowski, "Über Die Hartschaligkeit von Leguminosensamen und Ihre Beseitigung." (Friedrichs-Universität Halle-Wittenberg, 1905.

standardized, uniform farm input that could be mass-produced. *Lathyrus* hay or straw came from one or two cuttings of the same plant regrowing, fitting conventions of sampling for chemical analysis. There was no laborious effort of adaption to particular conditions, as Wagner's flat pea would thrive in any poor, dry soil, even on railroad embankments. Just like the key legumes in his fodder cultivation, the flat pea solubilized nutrients from solid rock. Thus, it did not exhaust the soil because it cracked wide open a whole new source of nutrients formerly hidden and unreachable. At the same time, his flat pea produced plentiful protein-rich fodder for cattle, horses, and pigs, and did not require any tending or fertilizer in its continuous growth period of at least 17 but supposedly more than 50 years. *Lathyrus silvestris* improved upon the advantages of Wagner's fodder cultivation by requiring even less labor and purchased fodder especially in agriculturally challenging environments. Wagner still had poor farmers in mind, but now he would use the logics of industrial agriculture and scientist conventions to the advantage of his innovation. This made for a promising product to bring on the market.[287]

Wagner collaborated with improvers and scientists, yet he produced neither innovation in place nor in principles. The district agricultural association, as improver representative paid, his salary during development in the mid-1880s. This was essentially state funding for an agricultural research agenda set by improvers. This fit the model for innovation set by scientists. Unlike with his fodder cultivation, however, Wagner did not collaborate with practicing improvers during development. He repeatedly replanted selections of his flat pea in his own pots and trial fields, not on improver fields.[288] This kind of knowledge production resembled scientist conventions; still, Wagner was an itinerant teacher without scientific credentials or association with a scientific institution.[289] Wagner then deviated even more from scientist convention by becoming a commercial seedsman. Rather than merely acknowledging self-

[287] *Jahres-Bericht der Landeskultur-Gesellschaft für den Regierungsbezirk Arnsberg 1886*, 12-13; H Lingl, *Lathyrus silvestris, ihr Bau und ihre Ernährung: Ein volkswirthschaftliche Studie.* (Augsburg: K.B. Hofbuchdr. Gebr. Reichel, 1892); Franz Mayerhofer, *Praktische Anleitung zum Anbau der neuen Futterpflanze, Lathyrus silvestris Wagneri* (München: H. Kutzner, 1894); Max Schönfeld, *"Lathyrus silvestris", ihr Anbau und ihr Wert als landwirtschaftliche Kulturpflanze* (Halle a.S.: Druck von C.A. Kaemmerer, 1895).
[288] *Jahres-Bericht der Landeskultur-Gesellschaft für den Regierungsbezirk Arnsberg 1886*, 12-13.
[289] He did receive the title of professor in Sweden in 1889, but this had no discernable effect on his standing within the agrarian-industrial knowledge society. See "Kleine Mittheilungen," *LZWL*, March 1, 1889, 75.

interest as no impediment to innovation like improvers, market agents personified this value. Wagner as many market agents used some scientist conventions but leaned into their misgivings against commercial self-interest. This was the production of innovation in things between improvers and scientists in a seed shell.

Wagner's flat pea was not a new principle or idea, but a novel organism. Wagner had turned a wild plant into a cultivated plant with provable characteristics that, had in their combination, not been known before; and it addressed agricultural problems acknowledged by scientists. This made innovation in things credible to scientists. Yet, producing novel farm inputs largely lay outside scientific practice. Their disinterestedness could not be tainted by producing a commercial product. Their promoted expertise was discovering the natural laws that determined how plant breeding worked so the principles drawn from their research could be used for the good of mankind. They had to leave the actual production of new things to others: market agents. With the flat pea, Wagner was no longer a quack improver who bungled scientific knowledge production and claimed it as innovation. He presented innovation in the shape of an organism that had come into being through legitimate use of natural laws to solve legitimate problems. Whether it actually did, scientists argued, was subject to their approval and regulation.

Market agents like Wagner had to negotiate agreement with scientists if they did not want to suffer their condemnation. As with fertilizer, seed, and feed, the specter of commercial fraud motivated scientists at agricultural experiment stations and beyond to research Wagner's flat pea.[290] Was this plant truly useful to farmers and did it behave as promised? The basis of a scientific test required discounting all proof delivered by the market agent because their blatant self-interest made them suspect. For decades, agricultural scientists including Friedrich Nobbe had reported on fraudulent sellers of what scientists

[290] This included rather prompt experimental plantings in 1888 at the experiment stations in Regenwalde, Dahme, and Königsberg, see "Jahresbericht über das agrikultur-chemische Versuchswesen in Preussen für das Jahr 1888," *Landwirtschaftliche Jahrbücher* 18, supplement 1 (1889), 9, 19, 23. See also Mathias Huss, "Über Quellungsunfähigkeit von Leguminosensamen Und Mittel Zu Deren Abhile" (Friedrichs-Universität Halle-Wittenberg, 1890).

began to see as adulterated or mislabeled products.[291] Chemical analysis as well as cultivation and feeding experiments were the only means that could convince scientists to agree on the characteristics of the flat pea. Scientists found it thrived on bad, dry soils and its protein content as green fodder or as hay generally surpassed red clover.[292] Beyond these results, scientists disregarded Wagner's claims of the new characteristics of his breed, *Lathyrus silvestris wagneri*, because they did not match the experimental evidence. In his 1890 Halle dissertation on legumes' hard seed coat, agricultural scientist Mathias Huss summarized the objections raised by several experiment reports. Wagner claimed to have found and bred out the bitter substance gentianin, which made flat pea unpalatable to cattle, when feeding experiments had found cattle and horses eating regular *Lathyrus* hay readily. Wagner claimed to have bred his flat pea to have a softer seed coat for more reliable germination. Experimental plantings had found this soft seed coat did not need scarification to sprout, but subsequent generations of the plant lost this characteristic. Wagner's variety was unstable – a problem which Wagner admitted in response but asked scientists to help him solve. Even before the rediscovery of Mendel's laws of heredity, scientist handbooks on plant breeding judged the practice of repeated replanting into better soil (Wagner's process) to be inferior to crossbreeding and selection in the production of new plant varieties.[293] Rather, Huss and agricultural scientists after him agreed, mechanical scarification by machines or later chemical treatment was the most reliable solution. Agricultural scientists' evaluation was split. They generally acknowledged the flat pea was a valuable addition to the canon of rough fodder plants. However, they never acknowledged

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291 Nobbe, "Wider Den Handel Mit Wald-Grassamen Für Die Wiesen-Kultur." Most experiment station reports found at least a few products, producers, or sellers, which did not meet their approval. Compare also Cohen, *Pure Adulteration.*

292 Schönfeld.

293 Henry Settegast, *Die Landwirthschaftlichen Sämereien Und Der Samenbau; Anleitung Für Landwirthe, Forstwirthe Und Gärtner Zur Werthschätzung Und Gewinnung Der Sämereien.* (Leipzig: T. O. Weigel (Tauchnitz), 1892), 103-140. On Wagner's practice, see Wagner "Lathyrus silvestris, eine ausdauernde Futterpflanze für den Sandboden;" Lingl, 1st ed. 6. 3rd ed, 10. Compare to common breeding practices by improvers, see Thomas Wieland, "Scientific Theory and Agricultural Practice: Plant Breeding in Germany from the Late 19th to the Early 20th Century," *Journal of the History of Biology* 39, no. 2 (July 1, 2006): 309–43; Jonathan Harwood, "Did Mendelism Transform Plant Breeding? Genetic Theory and Breeding Practice, 1900–1945," in *New Perspectives on the History of Life Sciences and Agriculture*, ed. Denise Phillips and Sharon Kingsland, Archimedes (Cham: Springer International Publishing, 2015), 345–70.

Wagner's flat pea as its own variety because elements of his knowledge production did not meet their standards.[294]

This was the enforced compromise between market agents and scientists. Innovation in things had to align with scientists' principles. All deviating claims were dismissed as malicious fraud. That is the service scientists had promised to improvers and their continued collaboration depended on it. Scientists also knew their promise to increase individual and national economies depended on the industrial production of farm inputs. Scientists needed market agents too, so they proposed a deal. If market agents agreed to cede regulatory authority over innovation in things to scientists, they would reap the benefits. They could then enroll scientists' approval into their own knowledge communication in the shape of marketing. If their product also performed as scientists predicted and convinced improvers, the approval of both theory and practice would propel market agents products. If they integrated into the knowledge systems of the agrarian-industrial knowledge society, its knowledge infrastructure would open up the global market. The flat pea met enough shared expectations to reach the global market, but not enough to stay there.[295]

**A global hype: How innovation in things could fail**

The promise of the flat pea certainly fit into the hopes of all actors of the agrarian-industrial knowledge society around the globe. The globalizing market put places and economies producing the same crops into competition, pushing for intensification of farming. This did not just mean that the agrarian-industrial knowledge society strove to produce more on less area. It also meant that improvers, state agents, scientists, and farmers looked for ways to expand the productive land base. In Germany as elsewhere, water regulation by controlled irrigation and drainage was one example of how wasteland was

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[294] Dr. Rudolf Ludloff, editor of the *LZWL* with an economics doctorate, put an asterisk on Wagner's breeding claims in an 1890 improver report pointing out that the author held all responsibility for the correctness of these claims. Fr. Kötter, "Zur Lathyrus-Kultur," *LZWL*, September 12, 1890, 307.
[295] Historians Thomas Wieland discussed a similar negotiation process for breeders of new cereal variteies, see Wieland.

to be turned into productive soil.[296] The flat pea promised a viable alternative. This plant would turn poor, dry, hillside fields into an abundant and sustainable source of livestock fodder. Its roots would not just use the nitrogen from the air as other legumes, they would tap into the entirely new nutrient base hidden in solid rock. The flat pea promised a revolution that was attractive to all in the global agrarian-industrial knowledge society battling dry soils.

Improvers, scientists, state agents, and farmers around the globe learned of this promising plant through their shared knowledge infrastructure. Farm journals in Germany and abroad reported on improver and scientist trials. This stir in the press caused German scientists to evaluate the trials which their colleagues in agricultural colleges and experiment stations abroad took note of. Market agents offered flat pea seeds in Germany and abroad to supply the growing demand. State agents ordered official trials. All of which caused more interest in the flat pea and thus more demand on the global market. The knowledge infrastructure of the agrarian-industrial knowledge society carried *Lathyrus silvestris* not only all over the German Empire but also across Europe to Ireland, England, France, Austria, Scandinavia, the Baltics, Hungary, Bulgaria, Romania, and Russia; to colonies in Algeria, East and South Africa; to British India, Persia, Japan, and Australia; to Argentina, Brazil, Canada and to all states of the United States. Even a Hawaiian newspaper reported on "the famous agricultural writer, Wagner" and his "wonderful shrub" that had "become almost a national plant in Germany."[297] But getting the farming world to know about the flat pea was not enough. Market agents had to convince all actors in the agrarian-industrial knowledge society this innovation in things could deliver on its promise.[298]

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[296] Compare Rita Gudermann, *Morastwelt und Paradies: Ökonomie und Ökologie in der Landwirtschaft am Beispiel der Meliorationen in Westfalen und Brandenburg (1830-1880)* (Paderborn: F. Schöningh, 2000).
[297] „Hunting in Germany," in *The Hawaiian Star*, September 7, 1897, 7.
[298] Mayerhofer; Lingl; Friedrich Winkler, "Zur Kultur Der Wald-Platterbse, Lathyrus Silvestris," *Biedermanns Central-Blatt Für Agrikulturchemie Und Rationellen Landwirtschafts-Betrieb* 23 (1894): 470–72; Friedrich Winkler, "Kultur Der Wald-Platterbse Lathyrus Sylvestris Wagneri," *Möller's Deutsche Gärtner-Zeitung*, May 1, 1894, 150–52; Fr. Kötter, "Zur Lathyrus-Kultur," in *LZWL*, September 12, 1890, 307 F. W. Dafert, *Relatorio Annual Do Instituto Agronomico Do Estado de S. Paulo (Brazil) Em Campinas 1894 e 1895* (S. Paulo: Typhographia de Compania Industrial., 1896); United States Department of Agriculture. Division of Botany, *The Flat Pea*, Circular 4, 1895.; Jared G. Smith, *Fodder and Forage Plants Exclusive of the Grasses*, revised, USDA Bulletin 2 (Washington: Government Printing Office, 1900), 38; Ellison A. Smyth, *A New Fodder Plant: Lathyrus Silvestris*, Bulletin 20, (Blacksburg, VA: Virginia Agricultural and Mechanical College, Agricultural Experiment Station, 1892).

Market agents' knowledge communication relied on the reputation of their product. Without evidence of its success from outside testers, who would believe the self-interested agent selling grand claims? Wagner enrolled improvers, scientists, and state agents as testers. In combination, they should provide credibility from all angles to convince consumers. Inspired by the rush of demand and surge in prices, Wagner founded his own seed company in Munich and collaborated with a specialist in marketing. Franz Mayerhofer wrote a brochure for Wagner's flat pea that combined the story of its "discovery," its wondrous characteristics, detailed instructions, and testimonials from all corners of the international agrarian-industrial knowledge society. He showed par excellence how market agents generally enrolled the expertise of others into their vision of the agrarian-industrial knowledge system.

The brochure opened with thick-lettered announcements of distinctions which Wagner's flat pea had won at international agricultural exhibitions in Prague, Kopenhagen, Munich, and Vienna. He listed twenty-nine farm journals and general newspapers reporting favorably on *Lathyrus silvestris Wagneri*. Also, Mayerhofer announced a separate publication of farmer testimonials detailing how Wagner's flat pea had saved them in the drought year of 1893. Finally, Mayerhofer included an image of the extensive roots of Wagneri, growing three to nine meters into the ground (see Figure 14). Fifteen years earlier, Wagner had dug out the root systems of the wild legumes of his fodder cultivation to show improvers their drought resistance. With an image, Mayerhofer now employed the same strategy. They both knew that, with improvers, seeing was believing. Consumers should have no doubt that this product was successful and delivered on all its claims.[299]

[299] Mayerhofer, 3, 15, 20-21. "General-Versammlung der Landes-Cultur-Gesellschaft für den Regierungs-Bezirk Arnsberg," in *LZWL*, October 17, 1879, 361-365.

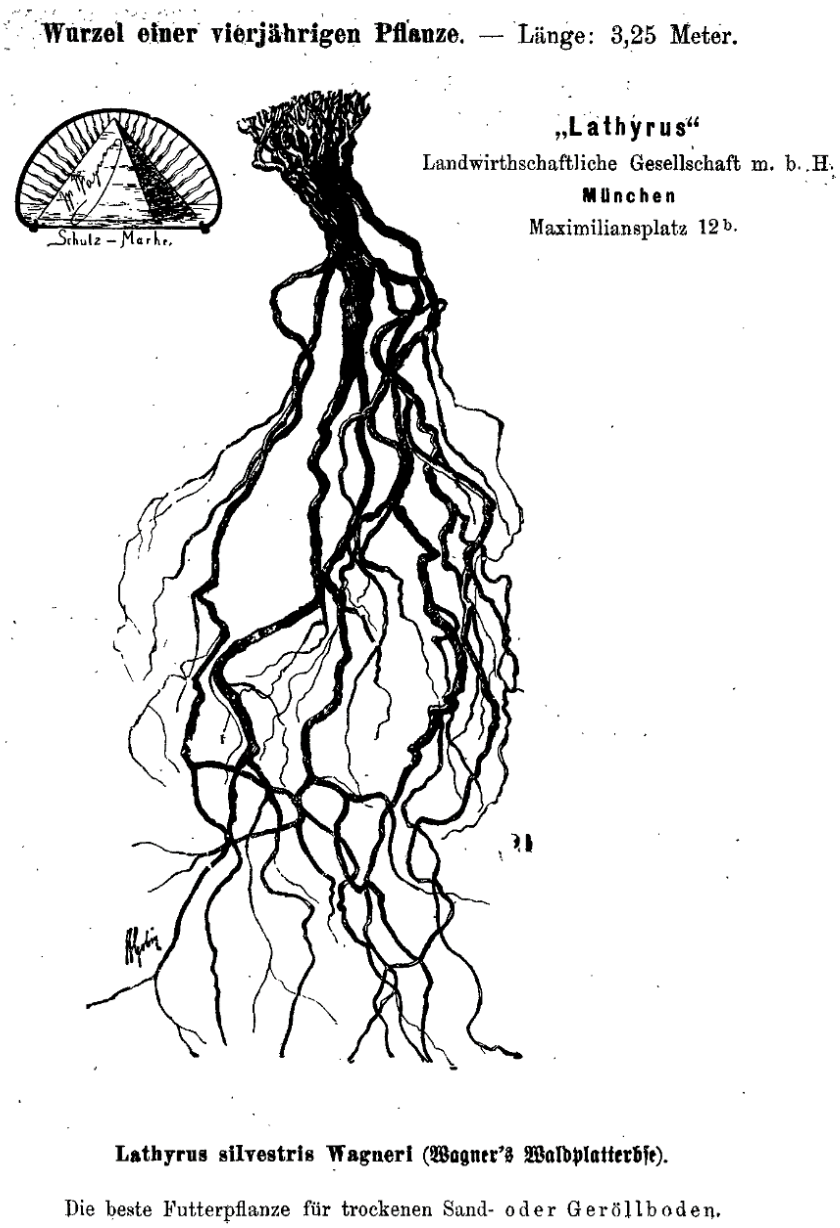


Figure 14: The image of the roots of Lathyrus silvestris Wagneri. It was used as visual evidence for its drought resistance. The captions read: “Root of a four-year-old plant. – length: 3.25 meters. “Lathyrus,” agricultural limited liability company, Munich, Maximiliansplatz 12b. Lathyrus silvestris Wagneri (Wagner’s flat pea). The best fodder plant for dry sand or rocky soil.”[300]

Mayerhofer also enrolled the highest order of state agents. This effort stood in stark contrast to Wagner’s previous strategy as itinerant teacher. Wagner had tried to win over state agents for his fodder

[300] Mayerhofer, 25. Digital image courtesy of Bayerische Staatsbibliothek, 2020. URL: http://daten.digitale-sammlungen.de/bsb00133237/image_31.

cultivation from the bottom-up through the bureaucratic hierarchy. Mayerhofer did the opposite. He sent letters and an economic study of Wagner's flat pea to the German emperor as well as royalty of Wurttemberg, Bavaria, Hohenzollern, Baden, Romania, and Bulgaria. Their replies allowed Mayerhofer to print their full titles in big letters above their expressions of interest for their regional and national economies. Some politely confirmed their interest whereas others ordered trial plantings. These orders then moved top-down in the state hierarchy. In Westphalia, a letter by the president of the province soon encouraged the provincial association to start field trials by farmers and promised funding. Enrolling state agents top-down not only provided marketing material from a macro-economic angle, it also promised more trial evidence.[301]

Finally, the brochure also pointed out the support of scientists. Mayerhofer listed the "major experts of all countries"[302] promoting the great advantages of Wagner's flat pea. These included scientists at several agricultural experiment stations, colleges, and schools in Germany, South Africa, and the United States. Select quotations of their reports confirmed the claims Mayerhofer made about the characteristics of Wagner' flat pea. A board member of an agricultural school in Stellenbosch, South Africa, confirmed that farmer trials had shown that "it is very well suited for poor, sandy, and stony soils in which alfalfa and other clovers could not be grown with success anymore," and that cattle had eaten it green or as hay "with great appetite."[303] The citation of Dr. Albert Stutzer, head of the Poppelsdorf experiment station confirmed that "the plant is extraordinarily rich in digestible nutrients."[304] Mayerhofer translated the lengthy and complex scientific analyses of Wagner's flat pea into digestible blurbs. He cultivated the impression that scientists stood united behind his product.

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[301] *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1893*, (Münster: Theissing'sche Buchdruckerei, 1894), 67-70; Mayerhofer, 16-17.
[302] Mayerhofer, 17. Original: "bedeutenden Fachmänner aller Länder."
[303] Ibid, 17-18. Original: "…sie für ärmliche, sandige und steinige Bodenarten, in denen Luzerne und andere Kleearten nicht mit Erfolg, mehr angepflanzt werden konnten, sehr geeignet ist. Die Ernte wurde theils grün, theils als Heu gefüttert und frass das Vieh in beiden Formen mit grosser Begierde."
[304] Mayerhofer, 18. Original: "die Pflanze ausserordentlich reich an verdaulichen Nährstoffen ist."

However, this market agent knowledge system relied on negotiating agreement with improvers, farmers, and scientists. Their evidence and approval had to be represented faithfully. Marketing language and content as well as the seed had to meet the various expectations from the rest of the agrarian-industrial knowledge society. Market agents had to fit their vision of the agrarian-industrial knowledge system into the visions of these groups. If they failed to do so, market agent promotion would backfire, discrediting their product rather than producing credibility. This was the case for Wagner's flat pea. After its global hype in the early 1890s came the ultimate bust. By the early 1900s, it had disappeared from the knowledge infrastructure of improvement and science, prompting one late-coming trial report to state that "one hears and reads so little of it that it seems as if currently the interest for this plant has fairly expired."[305] What had brought down this revolutionary innovation?

Most importantly, Wagner and Mayerhofer did not acknowledge the power of scientists over innovation in principles. Scientists had dismissed Wagner's breeding claims but Mayerhofer's brochure even expanded on them. He painted Wagner as the singular "inventor" who had not just discovered and ingeniously improved the flat pea, but had also used its growth on essentially nitrogen-free rocks to prove before any scientist that legumes took their nitrogen from the air. Also, Mayerhofer warned consumers not to buy any "half- or uncultivated"[306] seed for the danger it posed to animal health. Only Wagner's labor of more than thirty years improving the seed by a "cultivation method specific to him"[307] made it safe and reliable to use. Scientists' critique of Wagner's claims and breeding method had leveled the differences between Wagner's and any other improved flat pea. So, Mayerhofer excluded this critique and controversy in favor of scientists' chemical analysis, which placed the protein content of Wagner's flat pea as high as peanut cake. Mayerhofer fatefully demoted scientists to the status of mere technicians to produce Wagner's flat pea as a unique product in the marketplace.

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[305] G. Andrä, "Die Waldplatterbse (Lathyrus Silvestris), Ihr Anbau Und Ihre Verwertung Als Futter Für Milchvieh," *Landwirtschaftliche Jahrbücher* 31 (1902): 55. Original: "man hört und liest davon so wenig, dass es scheinen will, als wäre gegenwärtig das Interesse für diese Pflanze ziemlich erloschen."
[306] Mayerhofer, 20. Original: "halb- oder unveredelter Samen."
[307] Ibid, 3. Original: "ihm eigenthümliches Veredlungsverfahren."

Also, Mayerhofer's knowledge communication fell short of scientist expectations. Rather than using official scientist guarantees, he relied on a market strategy for producing credibility. Mayerhofer's "Lathyrus" company had the exclusive international sales and distribution rights for seeds and seedlings carrying the official "Lathyrus silvestris Wagneri" trademark. The signature of the inventor in the trademark logo guaranteed that the seed and seedlings were real and, as Mayerhofer repeated six times throughout, "highly cultivated."[308] Rather than using their conventions of knowledge communication, Mayerhofer leaned into the sensationalist language so suspect to scientists. An ad on the last pages of his brochure compressed in bold letters the take-aways on this "most excellent of all fodder plants" (see figure 15). It closed with the claim that "Lathyrus Wagneri as a fodder is, according to the evaluation of authorities, a discovery of equal economic significance as that of the potato."[309] Such hyperbole did not sit well with scientists. When an improver sent an inquiry about the value of Wagner's flat pea to the *LZWL* in 1894, its editor and secretary of the agricultural association of Westphalia, agricultural scientist Dr. Arthur Schleh, responded that "*Lathyrus Silvestris Wagneri* is an advertisement behind which stands definitely no real value."[310] Mayerhofer and Wagner's marketing strategy backfired. Their innovation was rejected as fraud.

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308 Ibid, 7, 19, 20. Original: "hochveredelt."

309 Ibid, 24. Original: "Lathyrus Wagneri ist als Futtermittel nach dem Urtheil von Autoritäten eine Entdeckung von gleich volkswirtschaftlicher Bedeutung wie die der Kartoffel."

310 "Fragen und Antworten," in *LZWL*, May 11, 175. Original: "*Lathyrus Silvestris Wagneri* ist eine Reklame, hinter der durchaus kein reeller Wert steckt." Schleh had received his doctorate in Leipzig in 1874 with a dissertation on the function of water in plants and water regulation in soils. Arthur Schleh, "Über die Bedeutung des Wassers in den Pflanzen und die Regulirung desselben in unsern Culturböden" (Leipzig, Universität Leipzig, 1875).


Figure 15: Ad for Lathyrus silvestris Wagneri. It showed the trademark label with Wagner's original signature in the top left and promised in bold letters that Wagner's flat pea "thrives on poorest soil [...] withstands every drought […] needs no maintenance […] contains 25-30% Protein […] is eaten with appetite by all livestock." Further description qualified or elaborated on these claims.[311]

[311] Mayerhofer, 24. Digital image courtesy of Bayerische Staatsbibliothek, 2020. URL: http://daten.digitale-sammlungen.de/bsb00133237/image_30.

What was worse, this disagreement with scientists created mixed messages. Wagner, Mayerhofer, and several other publications claimed that Wagner had bred out the bitter and, in fact, poisonous substances "Cytisin, Cathartin, and Gentianin."[312] Should consumers use other seed than Wagner's, they warned, their livestock would be harmed. Scientists dismissed these claims as mere advertising. Feeding experiments had not harmed animals, so they did not deem it necessary to analyze *Lathyrus* hay or green fodder for these poisons. Publications through the 1890s and 1900s in Germany and the United States reported diverging evaluations. Some reported livestock did not like to eat *Lathyrus* or was even harmed by it, whereas others detail scientifically documented feeding experiments without harm and without mention of poisons or injurious effects.[313] This disagreement sowed doubt among consumers. Improvers could not be sure whether Wagner's flat pea would revolutionize their farms or kill their livestock.

In fact, it remains impossible to know to this day. With such diverging experimental results and competing new fodder plants drawing attention, it took agricultural scientists well into the twentieth century to develop a better understanding of the poisonous qualities of the flat pea. A 1990 review of the existing research on the flat pea reported that it contains 2,4-diaminobutyric acid (PABA), a neurotoxic nonprotein amino acid that can kill animals. This toxin is more concentrated in the flat pea the riper it is. Mixing the hay with other feeds to limit the consumption per animal or using the green fodder for silage could keep down the levels of PABA to avoid detrimental effects on animal health. This explains some of the diverging results of trials that cut the flat pea at different times and fed in different forms. Researchers in the late nineteenth and early twentieth century did not document whether they purchased Wagner's or other seed. Scientists saw no difference, yet it remains unknown whether there truly was a difference. Wagner might have explained his breeding method in unconventional ways, leaving out his selection and

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[312] Lingl, 1st ed. 6; 3rd ed. 10; Mayerhofer, 3.

[313] For a good overview of contradictory trial results in Germany, see Emil Pott, *Handbuch Der Tierischen Ernährung Und Der Landwirtschaftlichen Futtermittel. Für Landwirte Und Zootechniker.*, 2nd ed., vol. 2 (Berlin: P. Parey, 1907), 116-119. For the United States, see United States Department of Agriculture. Division of Botany. See also, for example, Andrä; Gustav Hegi, *Illustrierte Flora von Mittel-Europa: Mit Besonderer Berücksichtigung von Deutschland, Österreich Und Der Schweiz. Zum Gebrauche in Den Schulen Und Zum Selbstunterricht*. Vol. 4, part 3. München: J. F. Lehmanns Verlag, 1907, 1601.

crossbreeding practices. He may have produced a new variety without the poisons, which could also explain some of the diverging trial results. Scientists might have distorted Wagner's breeding results out of existence. The only thing that we know for certain is that Wagner's potential variety of the flat pea no longer exists, if it ever did.[314]

Uncertainty over the safety and efficacy of the flat pea added to the obstacle of its complex and sensitive cultivation. Scientists were aware of this complexity, but it did not prompt them to discount the flat pea as a potential rough fodder solution. Improvers cared much more. To them, complexity translated to costs. Mayerhofer laid out the cultivation, harvest, and feeding method in twenty-six steps. It included planting the seed in good, old soil to grow seedlings before replanting these to poor, dry fields. This process relied on careful gardening skills as even slight damage to the seedlings killed them. After keeping the seedling plots free from weeds in the first year, the flat pea produced its first crop only in the third year. The careful seeding and replanting labor was costly. So was the lack of a crop in the first two years, no matter the fifty years following. Wagner tried to decrease these costs by selling not only seed but seedlings. Still, reports generally faulted the high cost of seed and seedlings. Select affluent improvers adapted Wagner's method to cut costs, as they did for scientist innovation in principles. Wagner's collaborator for fodder cultivation, the baron von Lilien in Echthausen, successfully experimented with growing cover crops with the flat pea to make up for its lack of a crop in the first two years. The baron of Wangenheim on the estate Weissenborn, near Freiberg in Saxony, developed a method using a seed drill that produced a crop in the second year already. Similar to his fodder cultivation, these innovations in place still proved very costly up-front as compared to other fodder plant cultivation and other solutions

[314] J. G. Foster, "Flatpea (Lathyrus Sylvestris L.): A New Forage Species? A Comprehensive Review." *Advances in Agronomy* 43 (January 1, 1990): 241–313. Another 1996 feeding trial with "Lathco" flat pea, the only flat pea cultivar in the US today, found it a potential rough fodder for challenging farming regions, see Joyce G. Foster et al., "Performance of Feeder Cattle Offered a Diet Containing Early-Bloom Stage Flatpea Silage," *Journal of Production Agriculture* 9, no. 3 (1996): 415–18. See also, Gerhard Flachowsky, et al., "Untersuchungen Zu Inhaltsstoffen Und Zum Futterwert Der Waldplatterbse (Lathyrus Sylvestris L.)." *Archiv Für Tierernährung* 32, no. 5/6 (1982): 393–99.

for using poor, sloping, far-away fields. Advice from the time for planting trees in such location developed into spruce monocultures that continue to cover the slopes of the Sauerland and other challenging farming regions to this day. Wagner's flat pea failed to meet the economic demands and farming abilities of improvers, especially as compared to competing innovations.[315]

Disagreements with scientists and improvers disrupted market agent knowledge movement abroad. Wagner did not have to rely on knowledge infrastructure to move cultivation of his flat pea to the United States. His brother Karl emigrated to Old Economy in Beaver County, Pennsylvania, and brought over in 1888 what might have been the first flat pea seed in the United States. Karl received the sole distribution rights for the United States as long as he drew seeds from Wilhelm's estate in Kirchheim. Karl might have adapted the cultivation method to his new environment in Old Economy, but he stuck with his brother's method of transplanting seedlings. In their personal relation, there was no contest over where the seed came from or how to grow it successfully. Still, despite exhibitions in Pittsburgh and one documented big sale of seedlings to Louisiana for levee protection, Karl Wagner could not establish Wagner's flat pea as a widespread fodder solution in the United States.[316]

Scientists at agricultural experiment stations could not rely on the credibility of family relationships. American experiment stations began cultivation trials and feeding experiments in the early 1890s. However, few of them list the origin of their seed. In 1893, Oscar Clute, director of the Michigan experiment station, stated that there was no seed to be purchased in the United States and he had ordered seed from London, England, giving no further insight whether this seed had come from Wagner's estate in Kirchheim. He received actual flat pea seed, unlike other American buyers falling victim to seed fraud.[317] For more information on the flat pea, Clute did not turn to his seed merchant, but German publications and colleagues in Germany. He began his cultivation experiments on dry, sandy soil, and

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[315] Mayerhofer; Andrä; Heinemann, "Die Lathyruspflanzen in Echthausen," in *LZWL*, Dec 24, 1897, 445-446. Winkler, "Kultur der Wald-Platterbse Lathyrus sylvestris Wagneri." For the rise of forestry in the Sauerland, see Selter.
[316] Victor E. Wagner, "The Wagner Pea," in *American Bee Journal*, 18 (December 1943), 457.
[317] "Fragen und Antworten," *LZWL*, September 13, 1895, 329.

only gradually arrived at Wagner's method of transplanting seedlings from good soil.[318] This might have been inspired by conflicting messages from his German sources but probably also addressed concerns over adaptation to American contexts. As his colleague Frank Lamson-Scribner, the national expert on the study of grasses at the United States Department of Agriculture, put it in a bulletin on the flat pea in 1899:

> In a country so rich in forage plants as the United States, and especially where the methods practiced are so different from what they are in European countries, this manner of [Wagner's] procedure is not likely to be followed. More economical and expeditious methods must be sought.[319]

American scientists were concerned with adapting the flat pea to the farmers, environment, and economy of the United States. In their own efforts, several experiment stations produced the same conflicting evaluations of the flat pea as their German counterparts, disagreeing especially about cultivation success and palatability. As compared to other rough fodder plants, this difficulty in knowing and adapting the flat pea soon disqualified it from the canon of promising American fodder plants.[320]

Market agents relied on scientists and improvers in their knowledge communication and resulting knowledge movement. Direct personal relationships were able to move innovation in things faithfully because they relied on personal trust and first-hand instruction and evidence. Market agents could do without scientists and improvers. However, moving innovation in things at scale relied on a wider, decentralized, and impersonal knowledge infrastructure as well as market networks. Communication through countless publications from farm journals to scientist reports could only be credible if the majority of communicators agreed upon the message. Complex and hard to know innovation in things made this difficult. Further, unregulated competition in the marketplace allowed sellers to claim different materials as the same innovative thing. Similar to factory-processed foods, doubts about authenticity

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[318] O. Clute, F. B. Mumford, and O. Palmer, *Two Plants for Sandy Land.*, Bulletin / Michigan Agricultural Experiment Station 91 (Lansing: Michigan Agricultural Experiment Station, State Agricultural College, 1893), 9-13.
[319] F. Lamson-Scribner, *The Flat Pea*, United States Department of Agriculture, Division of Agrostology, Circular 11, 1899., 4. For more on the accomplished standing of Lamson-Scribner, see James W. Hilty and Paul D. Peterson Jr. "Frank Lamson-Scribner: Botanist and Pioneer Plant Pathologist in the United States." *Annual Review of Phytopathology* 35, no. 1 (September 1, 1997): 17–26.
[320] For a summary of these experiments as of 1899, see F. Lamson-Scribner.

discredited new products to consumers.[321] Finally, the separation of the innovative thing from the knowledge about it exacerbated disagreement. Stable innovation in things relied on agreement between all actors of the agrarian-industrial knowledge society in their knowledge systems, unified and clear communication through the society's knowledge infrastructure, and a strong linkage between material innovative thing and the knowledge about it. The simpler an innovation in things was to use, the likelier it was to achieve these three requirements.

## Industrial byproduct feeds: Successful negotiation of innovation in things

1893 was a year of agricultural crisis in many parts of Europe. A severe drought withered much of the rough fodder crop on the fields. The German agricultural ministry scrambled to provide relief to affected farmers to prevent a collapse of the livestock, meat, and dairy market. In circulars sent through the hierarchy of agricultural associations, state agents urged farmers not to sell their cattle because widespread sales would severely decrease prices and severely increase the price to buy cattle in the years to come. Market collapse was good for nobody. Instead, state agents communicated advice to farmers of how to feed their cattle through this crisis. The choice of advice demonstrated which innovations the agrarian-industrial knowledge society could agree on. State agents, improvers, scientists, and market agents agreed on fast-growing fodder plants and industrial byproduct feeds. The former was a true emergency measure to cram rough fodder yields into the last months of the season. The latter were well-established best practice for decades among improvers and scientists. Byproducts of industrial food production included oil cakes and meals from various nuts and seeds, brewery or distillery slumps, cereal bran, and sugar beet residue. Without alternatives, they reckoned, necessity would push farmers to start purchasing industrial byproduct feeds.[322]

[321] Benjamin Cohen describes the "era of adulteration" for food masterfully, see Cohen.
[322] LAW K 333 / Kreis Meschede, Landratsamt, Nr. 2245, "Die durch die anhaltende Dürre im Jahre 1893 entstandene Viehfutternot;" *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1893*, (Münster: Theissing'sche Buchdruckerei, 1894), 37-50; Karl Römer, *Die Kraftfuttermittel*, vol. 54, Des Landmanns Winterabende (Stuttgart: Eugen Ulmer, 1895); L. Hannemann, *Ursprung Und Wert Der Kraftfuttermittel Des Handels.* (Bern: K. J. Myß, 1894).

This crisis year demonstrated successful collaboration throughout the agrarian-industrial knowledge society. European empires' colonial economies supplied the crops for the feeds richest in protein and fat, such as peanut, oil palm kernel, or coconut meal or cake. The German state provided special railroad shipping rates to sellers of domestic and colonial industrial byproduct feeds. Scientists at agricultural experiment stations throughout Germany collaborated with market agents by setting standards for chemically determined minimum protein and fat contents. The agricultural ministry and associations tasked winter school teachers with adapting scientists' feeding standards and the offerings of the feed market into advice for farmers in their teaching districts. Agricultural associations on all levels solicited orders for industrial byproduct feeds from farmers and pooled them for better rates and more reliable nutrient guarantees. What had been impossible for Wagner's flat pea, worked for industrial byproduct feeds: all actor groups of the agrarian-industrial knowledge society collaborated in the knowledge production and communication of industrial byproduct feeds from tropical and subtropical oil crops as reliable innovations in things.[323]

**Colonial farming, industrial processing: Innovations in things across space and time**

Market agents' knowledge production for industrial byproduct feeds was biological prospecting. It involved developing colonial agricultural economies, transporting raw materials, and processing them into new commercial products. This global production chain was only possible through close collaboration among market agents, state agents, scientists, and improvers. Whereas many agricultural inputs for the intensification of European agriculture relied on extracting energy from other places in the shape of raw materials, and from other times in the shape of fossil fuels or mineral deposits, industrial byproduct feeds were born out of both. Wagner's flat pea had failed to convince farmers because of its initial costly investment in money and labor, and its uncertain benefits. By comparison, industrial byproduct feeds were cheap, easy to use, and standardized. Improvers had tried to acclimatize colonial

[323] *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 2245, „Die durch die anhaltende Dürre im Jahre 1893 entstandene Viehfutternoth." See also *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1893*, 37-50.

plants in Europe since the eighteenth century but had found their limits in tropical plants. The agrarian-industrial knowledge society in the late nineteenth century imported tropical crops for industrial processing instead. Colonized farmers and environments as well as fossil-fueled industries paid the bill rather than European farmers. Market agents were the key actors in developing this constellation of innovation in things. [324]

In Germany, the market for industrial byproduct feeds began developing in the mid-nineteenth century. Farmers who brewed, distilled, or milled had used byproducts or refuse for feed in the past. In the nineteenth century, however, these trades turned into specialized industries that produced much larger volumes of food byproducts. Farmers around cities incorporated these familiar materials for their feeding practices, spawning the idea of a wider market. As compared to growing feed crops, such as tubers or cereals that fetched a price fit for human food, byproducts of the food and beverage industries were cheap, easy, and still nutritious. Scientists and improvers argued if farmers sold food crops and bought byproduct feeds in exchange, they would come out ahead. Economies of scale processing crops through the use of fossil fuels undercut the price and labor of farm crop production yet increased the need for up-front capital. This generally drew support from those enamored with industrial solutions to biological problems. Market agents gained a new product out of byproducts that had previously been discarded as refuse. Scientists and improvers saw the nutritional and economic potential of industrial byproducts. And state agents supported improvements that generated multilateral support and promised intensification of agriculture. Only farmers had to be convinced to trust factory-processed feeds and be drawn further into market dependence and capital-intensive farming, something the crisis in 1893 accelerated.[325]

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[324] Marcus Popplow, "Economizing agricultural resources in the German economic enlightenment;" Hannemann, 3-4; Andrew Zimmerman, *Alabama in Africa Booker T. Washington, the German empire, and the globalization of the New South*, 2010, 1-19; Corey Ross, *Ecology and Power in the Age of Empire: Europe and the Transformation of the Tropical World*, 2019, 1-21.

[325] Artur Schmidt, "Die Entwicklung Der Deutschen Futtermittelindustrie" (Dissertation, Cologne, University of Cologne, 1929); König, *Chemische Und Technische Untersuchungen Der Landwirthschaftlichen Versuchsstation Münster in Den Jahren 1871-1878*, 29-44; Emil Schwarzkopf, "Entwicklung Der Deutschen Futtermittelversorgung." (Dissertation, Emsdetten, University of Cologne, 1936).

While cotton, sugar, coffee, or tea were already globally traded goods by the nineteenth century, oil crops in commercial volumes were new when they came to Europe in the mid-nineteenth century. They became a central innovation on the feed market. The principal innovators were trading companies in Hamburg and other port cities in northwest Germany. Their main drive for innovation in oils grew out of two factors. First, the supply of whale oil had become unreliable by the 1850s and the export of Russian tallow was interrupted and ultimately ceased because of the Crimean War (1853-1856). Second, demand for oil substitutes occurred at the same time as the official end of the Trans-Atlantic Slave Trade by 1807 and the difficulties of enforcing the ban until the 1860s. Market agents drove the search for African commodities to replace slaves. Vegetable oils from tropical crops were the answer. Palm oil, for example, was a welcome oil substitute for industries producing soap, lubricants, margarine, or explosives, and oil palms grew abundantly in sub-Saharan Africa. Peanut oil worked very similarly. As a result, Hamburg trading companies shifted their investments from the slave trade to establishing trading posts on the West African coast. Competing with British, French, and Dutch posts, Hamburg merchants traded weaponry, spirits, tobacco, and other products for various African commodities, including palm oil processed by African locals and eventually oil palm kernels. Oil mills in Hamburg and other European port cities processed these kernels into palm oil and sold processing byproducts as palm kernel cakes. The development of other tropical oil crops functioned similarly. Emil Wolff's 1874 textbook on scientific feeding took stock of the now commercially available cakes and meals derived from oil palm kernels, peanuts, coconuts, cottonseed, sesame, and candlenut. Tropical oil crop cakes and meals became a staple on the European feed market.[326]

[326] See Samuel Eleazar Wendt, "Hanseatic Merchants and the Procurement of Palm Oil and Rubber for Wilhelmine Germany's New Industries, 1850–1918," *European Review* 26, no. 3 (July 2018): 430–440. See also, Hermann. Schad, "Die geographische Verbreitung der Ölpalme (Elaeis Guineensis)" (Dissertation, Berlin, University of Giessen, 1914), 364-365. For the development of peanut exports, see Jan S Hogendorn, *Nigerian Groundnut Exports: Origins and Early Development* (Zaria; Zaria; Oxford: Ahmadu Bello University Press ; Oxford University Press, 1979). For the intensification of peanut agriculture for export in French Senegal, see Christophe Bonneuil, "Penetrating the Natives: Peanut Breeding, Peasants and the Colonial State in Senegal (1900-1950)1," *Science, Technology and Society* 4, no. 2 (September 1, 1999): 273–302. For Wolff's lists, see Emil Wolff, *Die landwirtschaftliche Fütterungslehre*, 319; Emil Wolff, *Die Rationelle Fütterung*, 220-221.

The development of these tropical oil crop economies relied on collaboration with state agents, scientists, and improvers. Since the 1860s, Hamburg trading companies had pushed for state protection of their commercial interests in Africa against attacks from local communities and against the competition from other Europeans. Only when Adolph Woermann, a large-scale Hamburg ship owner representing Hamburg traders, became German Chancellor Otto von Bismarck's trusted advisor in commercial interests in Africa, did Bismarck begin to consider following the example of other European empires and establish overseas colonies. With the Berlin conference in 1884-1885, the other imperial powers, most notably Britain, France, and the Netherlands, acknowledged German colonial claims. In the 1890s and 1900s, state and market agents worked hand in hand to establish German colonies in East Africa, Southwest Africa, Cameroon, Togo, and the South Pacific. With state protection of market agent interests and investment in railroads, telegraphs, and other tools of empire, German colonialists funded expeditions and surveys to identify profitable local crops or the potential to introduce new crops. The Colonial Economic Committee and the German Colonial Society represented the collaboration between market agents from industry, commerce, and banking, state agents in municipalities, scientists and engineers in various research institutions, and missionary societies. Prominent improvers joined expeditions and surveys, such as Dr. Rudolff Ludloff, secretary of the Westphalian agricultural society and editor of the LZWL. In 1890-1891, Ludloff traveled to German Southwest Africa to assess the agricultural potential of the region and published influential reports suggesting sheep farming. Along with broad sections of German society, the agrarian-industrial knowledge society was intricately involved in colonial expansion and the development of colonial farming.[327]

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[327] Wendt; Conrad Weidmann, *Deutsche Männer in Afrika. Lexicon der hervorragendsten deutschen Afrika-Forscher, Missionare, etc.* (Lübeck: B. Nöhring, 1894), 78; R. F Ludloff, *Nach Deutsch-Namaland, (Südwestafrika) Reisebriefe* (Coburg: Dietz'sche Hofbuchdruckerei, 1891); Dr. R. Ludloff, "Ein Schäfereiunternehmen für Damaraland," *Deutsche Kolonialzeitung*, August 22, 1891, 115-117. For the history of biological prospecting, see e.g. Londa L Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World.* (Cambridge: Harvard University Press, 2009); Richard Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens, and the Orgins of Environmentalism, 1600-1860*, Studies in Environment and History (Cambridge ; New York: Cambridge University Press, 1995).

The key economic ingredient in colonial agriculture was race. Race was not just part of the ideological framework for colonization. It also served to devalue the labor of nonwhite colonial farmers (as in the U.S. South). German colonial experts reasoned that the African farmers and laborers were biologically fit for labor in hot climates and they could be paid less than one fifth of what German farmers required.[328] Even so, colonizers still had to negotiate with the colonized. Negotiation included coercion and brute force to push monocultures, exclusive trade with European merchants, and the abandonment of traditional practices and economic arrangements. In 1904, for example, Samoan coconut farmers in German Samoa expanded traditional cooperatives to cut out German traders and the excessively low prices paid for copra, the white flesh of coconuts used for oil and feed as cake and meal. In response, the armed German colonial administration arrested cooperative leaders and ultimately extinguished the cooperative movement. Across German and other European colonial empires, racial labor categories made colonial economies profitable. Industrial byproduct feeds from tropical crops were thus not just available to German farmers, but affordable.[329]

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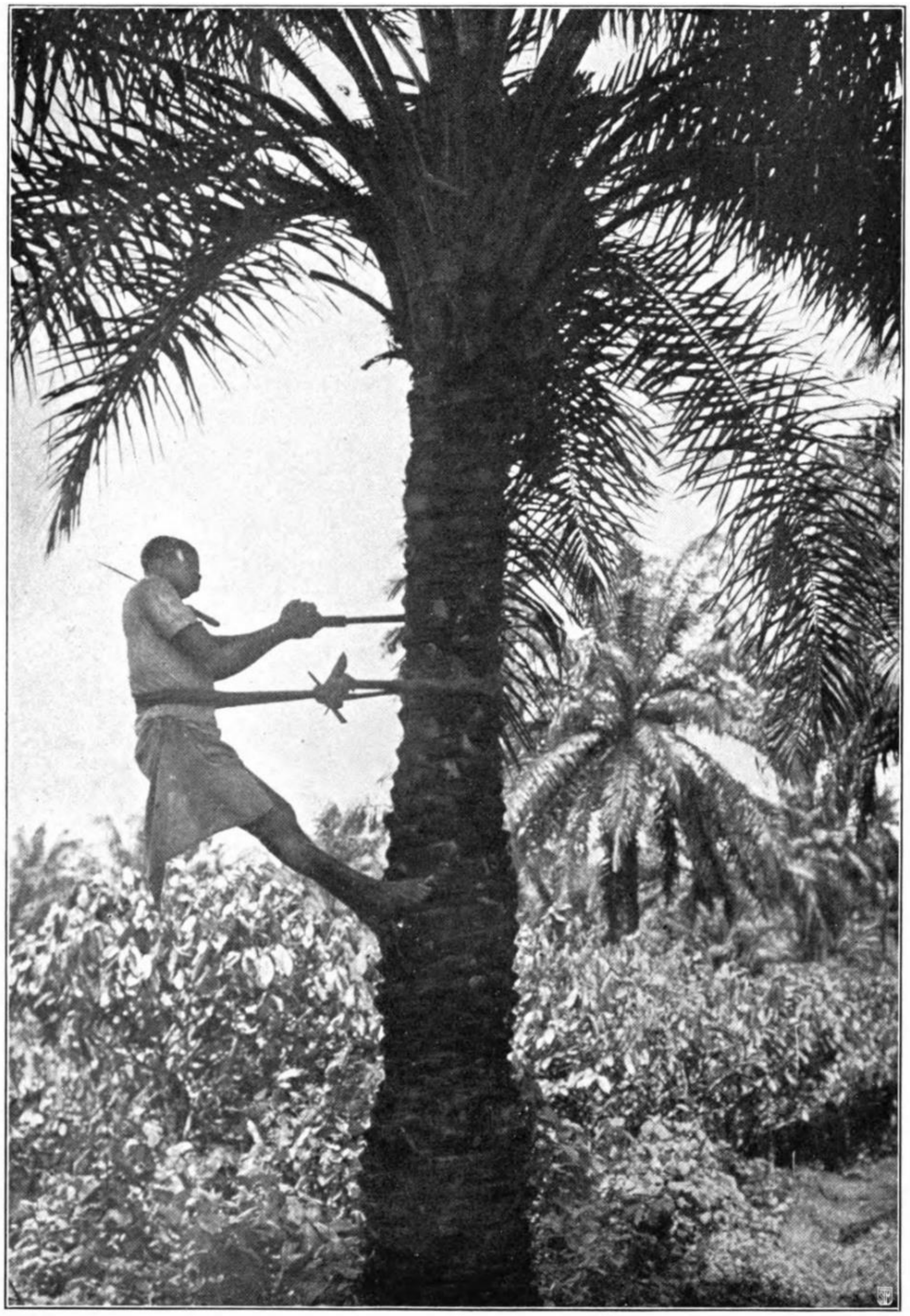
[328] Zimmerman, 4.

[329] Zimmerman; Holger Droessler, "Copra World: Coconuts, Plantations and Cooperatives in German Samoa," *The Journal of Pacific History* 53, no. 4 (October 2, 2018): 417–35; Ross; Ulrike Kirchberger and Brett M Bennett, *Environments of Empire: Networks and Agents of Ecological Change* (Chapel Hill: University of North Carolina Press, 2020). Compare also Beckert, *Empire of Cotton*.



2. Eingeborener bei der Ernte der Ölpalmenfrüchte in Kamerun.

Figure 16: "Native harvesting oil palm fruit in Cameroon." This was the second photo in a short photo series documenting palm oil production in the German colonies in Africa included in a report by a special oil commission of the German Colonial Society (*Deutsche Kolonialgesellschaft*) in 1913. The work of native farmers or laborers started the journey of palm oil and kernels to European consumers.[330]

[330] Deutsche Kolonialgesellschaft, *Verhandlungen der Ölrohstoff-Kommission des Kolonial-Wirtschaftlichen Kommitees E.V. wirtschaftlicher Ausschuss der Deutschen Kolonialgesellschaft*, 1, 1913, (Berlin), 18. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/hvd.hn74xa?urlappend=%3Bseq=23.

The other half of producing economically viable feed was transport and processing using fossil fuels. German trading companies bought tropical crops from local farmers or German planters in the colonies, or in ports of other European empires. Then they transported these goods to German harbors by steamship, notably to Hamburg and Bremen. Oil mills congregated in these port cities. For example, as the historian Samuel Eleazar Wendt has found, "by the 1890s, more than one third of all palm kernels imported to Europe were processed in the oil mills of Hamburg's neighbouring city Harburg."[331] Powered by fossil fuels, hydraulic oil presses and machines for chemical extraction were the principal means for industrial oil extraction and the concurrent production of oil cakes and meals. Innovations in chemical engineering were key for the development of the vegetable oil industry and thus also the industrial byproduct feed market. Directly from these plants or through middlemen, oil cakes and meals were shipped in bulk by train to consumers all over Germany, including Westphalia. Fossil fuels powered the movement and transformation of tropical oil crops from farmers in European colonies to farmers in western European metropoles and beyond.[332]

[331] Wendt, 431.
[332] Wendt; Adolph Emmerling, "Über Palmkernkuchen Und -Mehl," *Die Landwirtschaftlichen Versuchs-Stationen* 50 (1898): 5–63.

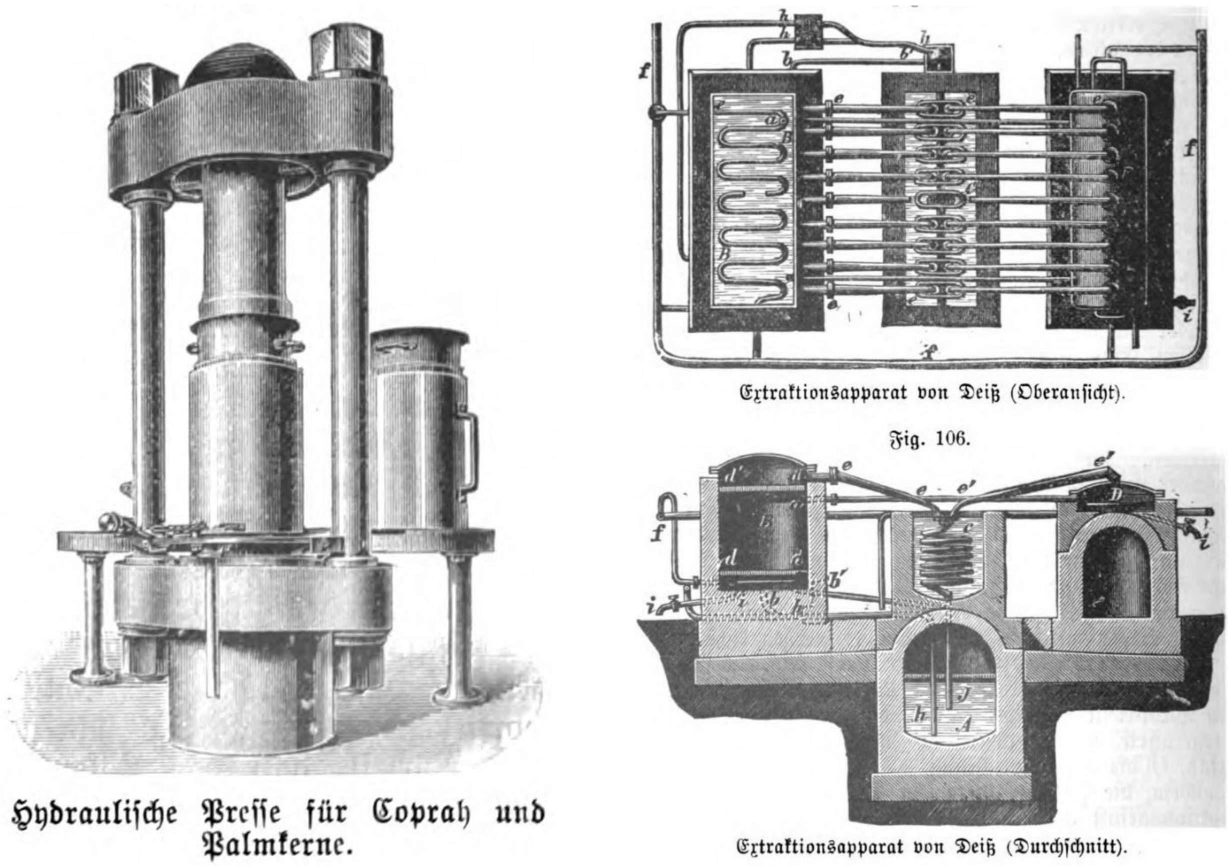



Figure 17: Hydraulic Oil Presses. A 1905 handbook on machines used in chemo-technical industries included images of hydraulic oil presses, here specifically for copra and oil palm kernels on the left, and machines for extracting oils using carbon disulfide or other solvents on the right.[333]

**Speak for me: Communicating innovations in things with scientists**

As with their multilateral knowledge production, the key to market agent knowledge communication was collaboration across the agrarian-industrial knowledge society. While negotiations for collaboration with individual actor groups were specific, they all boiled down to the same goal. Scientists, improvers, and state agents should validate market agent credibility and enable the movement of knowledge and material to consumers. Advertisements sent to Sauerland improvers in the feed crisis of 1893 demonstrated this market agent vision.

[333] Friedrich Weigand, *Die mechanischen Vorrichtungen der chemischtechnischen Betriebe*, (Wien: A. Hartleben, 1905), 183, 198. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/nyp.33433062727999?urlappend=%3Bseq=207; https://hdl.handle.net/2027/nyp.33433062727999?urlappend=%3Bseq=222.

Improvers were the first line in negotiating with market agents. Editors of agricultural journals sought advertisements for all things related to farming, from fertilizer to farm implements. There, market agents could market away, slapping snappy slogans next to pompous pictures and titillating texts telling consumers about the latest innovations. Improvers would invite market agents to show their wares at local fairs and city exhibition halls.[334] In the feed crisis of 1893, the provincial agricultural association of Westphalia solicited offers from feed sellers to organize joint purchasing across the province. They compiled these offers in a circular sent down to district, county, and local agricultural associations. This was a list of feed companies across Northwest Germany, their delivery terms, and the feeds they offered, including their protein and fat content as well as their price and origin. Consumers could find "best German linseed cake" and "prime Neuss rapeseed cake" next to "best German palm kernel cakes"[335] grown in German West Africa, "high prime white hair-free Rufisque peanut cakes" from French Senegal and "white round Ceylon-coconut cake"[336] from the British colony on Sri Lanka. German, Rufisque, and Ceylon became marks of quality. Whether in farm journals, fair exhibits, or price lists, improvers collaborated with market agents in translating innovations in things to a comparative display of quality and price. Similar to scientists' data tables, market agent price lists obscured technical details and colonial coercion alike. Market agents rewarded improver support with better transport rates for bulk orders as incentive for cooperative purchasing and promoting industrial byproduct feeds to wider farm audiences.

In their own advertisements, market agents cited improvers as warrantors of quality and credibility. As Mayerhofer had done for Wagner's flat pea, advertisers of industrial byproduct feeds listed positive feeding results by successful improvers. In the feed crisis of 1893, Sauerland improvers received

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[334] The Serkenrode local agricultural association noted several of these demonstrations, see Minute books Serkenrode.

[335] *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 2245. Original: "Beste deutsche Palmkernkuchen [...] beste deutsche Leinkuchen."

[336] *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 2245. Original: "Beste deutsche Leinkuchen […] Prima Neußer Rapskuchen […] Hochprima weiße haarfreie Rufisque-Erdnußkuchen […]weiße runde Ceylon-Cocoskuchen." For a history of rapeseed in German agriculture, see Sarah Waltenberger, *Deutschlands Ölfelder: Eine Stoffgeschichte der Kulturpflanze Raps (1897–2017), Deutschlands Ölfelder* (Brill Schöningh, 2020). For an overview of the peanut export industry in French Senegal, see Bonneuil; Hogendorn, 36-38.

a leaflet by the feed company Cölle & Gliemann in Hamburg. For their "high prime hair-free Rufisque peanut cakes of A1 extra quality,"[337] they described the technical details of removing the shell, brown skin, and nucleus of the peanuts, which explained the high protein and fat content. They also detailed the various feeding uses reported from "the largest estates of Germany which routinely fill their demand from us."[338] In their letterhead, these feed sellers printed the emblems of medals they had won from various agricultural associations, including the one of the most influential German agricultural association, the *Deutsche Landwirtschaftsgesellschaft*. Positive evaluations and large orders by improvers became marketing material. Market agents provided the explanations for quality, but the voice of improvers made them credible.[339]

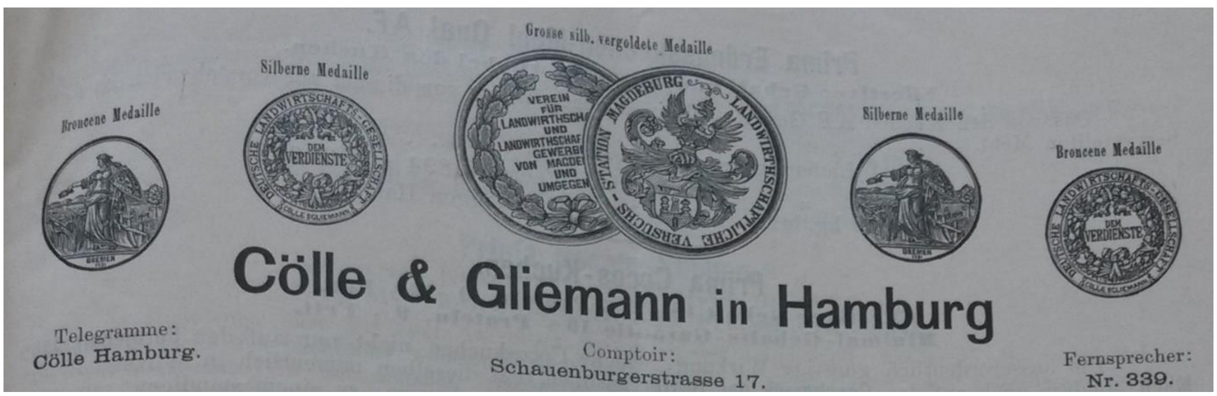


Figure 18: Letterhead by feed company Cölle & Gliemann of Hamburg. It displayed medals won for their products.[340]

Scientists also granted credibility but only after lengthy negotiations. The minimum protein and fat content market agents advertised were guarantees underwritten by agricultural experiment stations. As with fertilizers and seed, defrauded improvers and their agricultural associations tasked scientists at agricultural experiment stations all over Germany to regulate the quality of feed products on the market

337 *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 2245. Original: "Hochprima haarfreie Rufisque-Erdnusskuchen Qual. A1 extra,"
338 *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 2245. Original: "Zeugnisse der grössten Begüterungen Deutschlands, welche regelmäßig ihren Bedarf von uns entnehmen."
339 Agricultural machines worked similarly in advertising and organizing trials, see Pawley, *The Nature of the Future*, 81-102; Gordon M. Winder, *The American Reaper: Harvesting Networks and Technology, 1830-1910*, Modern Economic and Social History Series (Farnham, Surrey ; Burlington, VT: Ashgate, 2012).
340 *LAV NRW W,* K 333 / Kreis Meschede, Landratsamt, Nr. 2245.

by chemical analysis. Initially, improvers sent samples of feed for analysis to make sure they would not be cheated. Scientists, however, soon pushed market agents to agree to regular monitoring for mutual benefit. In Westphalia, the agricultural experiment station developed a model contract for feed merchants in 1876. Feed merchants would send in samples for every new batch of feed in their store, guarantee consumers pure, unadulterated, and properly named products, promise compensation for deficient products sold, pay a fee to the agricultural association for every zentner (ca. 50 kg) of feed sold, acknowledge the free experiment station analysis as the true nutritional content, and label every feed sack. Material thing and the knowledge about it would be physically attached to travel together. In return for these regulations against fraud, feed merchants would have the analyses of their feed published in the provincial farm journal and receive a discount on advertisements in that journal.[341] What went unmentioned in the contract was the enrollment of scientists' credibility. As in the case of Cölle and Gliemann in 1893, feed sellers could praise guaranteed nutritional content and digestibility and list regular inspections by experiment stations across Germany, including at Münster and Möckern.[342] In essence, if market agents played fair and acknowledged scientists' authority, scientists would certify market agents' claims.

This collaboration was possible mostly because sellers of industrial byproduct feeds did not challenge scientists' expertise. Whereas marketing of Wagner's flat pea had identified him as a sole inventor, producers of industrial byproduct feeds did not claim to be innovators in principles. They presented themselves as suppliers of materials that fit into the principles of scientific feeding. Market agent expertise was in transport and processing, using industrial technology that lay outside of the regulatory expertise of agricultural scientists. Hydraulic seed presses and chemical oil solvents were frequently included in scientist reports on industrial byproduct feeds. Yet unlike agricultural machines tested in machine testing stations, these technologies lay beyond scientists' disciplinary boundaries.

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[341] König, *Chemische Und Technische Untersuchungen Der Landwirthschaftlichen Versuchsstation Münster in Den Jahren 1871-1878,* 232-234. Also compare "Controle der Futtermittel," *LZWL* October 13, 1876, 346.
[342] *LAV NRW W,* K 333 / Kreis Meschede, Landratsamt, Nr. 2245.

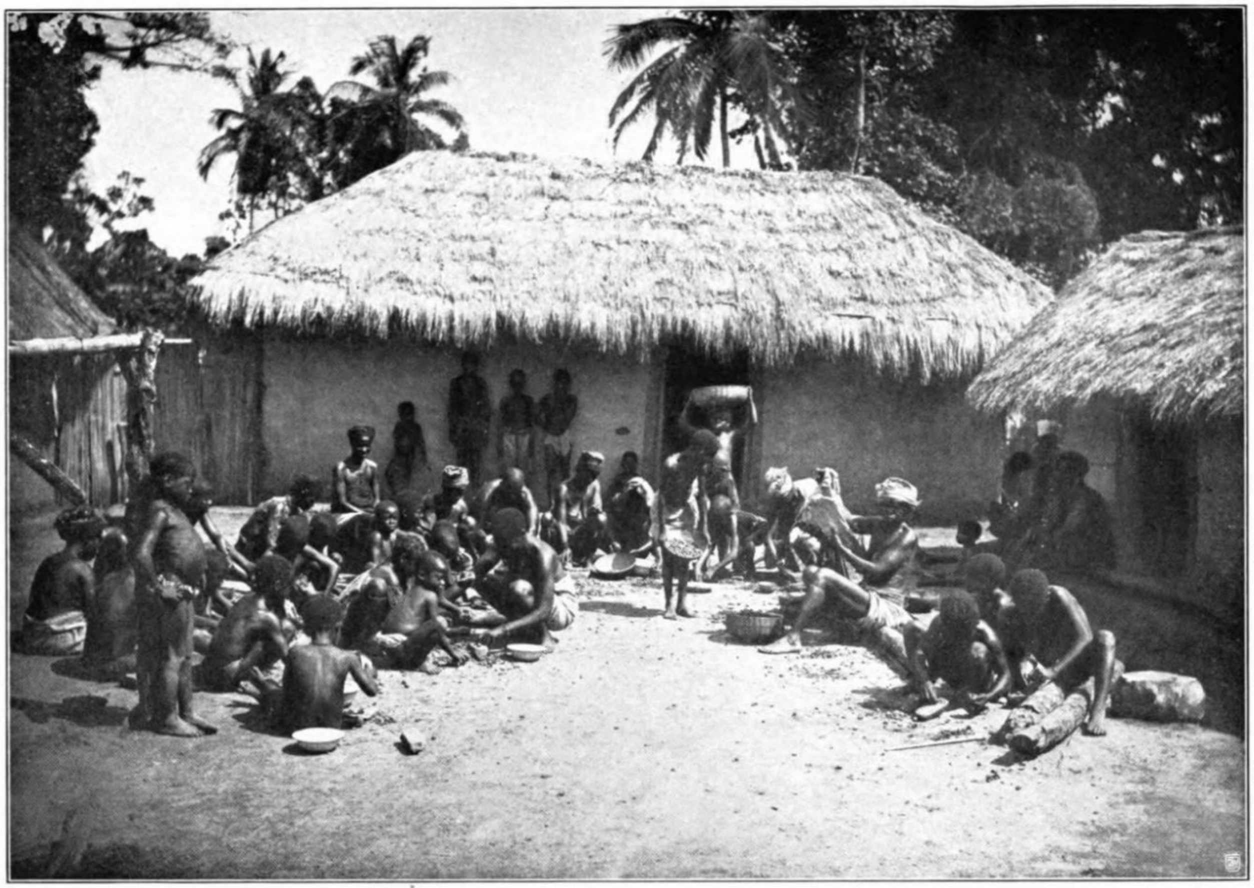
Market agents relied entirely on scientific feeding and the knowledge infrastructure of extension. Feed sellers did not supply complex instructions on how to use their feed, which had hampered Wagner's flat pea. The only information required from market agents was the nutritional content determined by scientists. Feed merchants did not intrude into the expertise of either scientists or improvers but agreed to play by their rules. It was a win-win-win situation.[343]

Improvers educated farmers about the characteristics of new industrial byproduct feeds. In the 1890s, several improvers devoted manuals to the use, characteristics, and origins of these new feeds so that farmers could tell the quality of previously unknown oil cakes and meals by their color, consistency, and smell.[344] Farmers should not let market agents get away with selling bad quality or spoiled products. Scientist regulations aimed at a more systemic effect. Frequently published in agricultural journals, their chemical analyses aimed to reveal fraudulent adulterations or mislabeling of feed products. On different levels, yet together, farmers, improvers, and scientists pushed market agents to improve the quality of their product. On the one side, this effort aimed to convert or bankrupt feed sellers who knowingly cheated their customers. On the other, the agrarian-industrial knowledge society pushed for better processing of feeds not just in European oil mills but also in the colonies.

Negotiating collaboration in knowledge communication led to regulatory feedback that traveled through the production chain back to colonized farmers. In 1898, the director of the Kiel agricultural experiment station, Adolph Emmerling, added to a series of studies on commercial feeds by the association of agricultural experiment station in the German Empire. In his detailed treatise, Emmerling urged market agents to improve the sorting and cleaning of oil palm kernels in oil mills, and to push African farmers to do more thorough work removing the adulterating hard kernel shells.[345] In the colonies, however, leaving part of the shell on saved labor and increased the weight of kernels. As historian Holger Droessler has found for Samoan farmers in German Samoa, adding sand or small stones

[343] Emmerling.
[344] Consider e.g. Römer, *Die Kraftfuttermittel*; Hannemann; Pott.
[345] Emmerling, 21.

to deliveries of copra was a way to shortweight European traders.[346] Adulterating crops for the oil and feed industry was a strategy of colonized farmers to resist the devaluation of their labor. In response, all of the agrarian-industrial-colonial knowledge society screamed fraud. As Emmerling had made clear, selling worthless shells in oil palm kernel meal was adulteration. Colonial domination and "civilizing" natives to "honest" business practices was an integral part of creating and maintaining innovations in things based on tropical crops.



**5. Aufknacken der Palmkerne durch Frauen und Kinder in Togo.**

Figure 19: "Cracking of palm kernels by women and children in Togo." The 1913 photo series in the report by the special oil commission of the German Colonial Society (*Deutsche Kolonialgesellschaft*) also covered the initial processing of palm kernels in German colonies in Africa. From the point of sale of tropical oil feed cakes and meals to European farmers, the powerful arm of the agrarian-industrial-colonial knowledge society reached back all the way into farm families in the colonies.[347]

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[346] Droessler, 426.

[347] Deutsche Kolonialgesellschaft, 24. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/hvd.hn74xa?urlappend=%3Bseq=35.

In 1893, Sauerland farmers were not convinced. The German industrial byproduct feed industry boomed. The oil cake and oil meal industry more than doubled its exports and imports between 1890 and 1900 and continued to grow from there.[348] Sauerland farmers stuck to their own means of production. The annual report of the provincial agricultural association summarized the reports from across the province: their measures in advising and supporting farmers had worked, but mostly because the feed crisis had turned out to be not as damaging as feared. Also, farmers had preferred the fast-growing, late-season fodder plants suggested to them, so that they could grow their own fodder after the summer drought rather than buy commercial feeds. The local agricultural association of Serkenrode placed merely one joint order for peanut meal in January 1894 but not subsequently.[349] At least in the Sauerland, market agents along with the rest of the agrarian-industrial knowledge society still had their work cut out for them.[350]

**Balanced ration feed: Market agent challenge to scientists**

Balanced ration feed was the pinnacle of innovations in feed, not to be surpassed for more than a century. In the United States, the terms balanced ration feeds, ready rations, compounded feeds, stock feed, and dairy feed all pointed to the same innovation in things.[351] Industrial feed manufacturers mixed the feed for consumers according to scientists' feeding standards. For market agents, it was the market niche that extension could not fill. The vast majority of farmers had little time or money to invest in the study of scientific feeding, even if it was brought to their doorstep. By contrast, balanced ration feeds made scientific feeding easy. Market agents combined industrial economies of scale, tropical and subtropical raw materials, and devalued black labor with scientist expertise and their own market knowledge into an innovation in things that convinced farmers and forced scientists to accept it.

[348] Exports increased from 49,646 tons in 1890 to 140,350 tons in 1900; imports from 219031 tons in 1890s to 499,615 tons in 1900. Full production statistics are available only in the late 1900s. See Schmidt, 30.
[349] Serkenrode minutebook, January 28, 1894.
[350] *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1893*, 37-50.
[351] For Germany, Artur Schmidt described these feeds as "ökonomisches Futter." See Schmidt, 73.

The production of concentrated feeds in the United States in the mid- and late-nineteenth century took a slightly different shape but principally functioned the same way as in Europe. The feed market similarly consisted of cereal and oil milling byproducts, but Midwest cereals and Southern cotton production meant bran, corn meal and especially cottonseed meal dominated the market.[352] Colonialism was just as central as industrial processing. Midwest grains grew on land stolen by settler colonialism and sullied with the blood and tears of native American tribes. Southern cotton agriculture, also planted on former Native lands, had traded slavery for sharecropping and Jim Crow laws. The use of race to devalue the labor of African Americans and violence to enforce it worked in the same way as in European colonies. Steam ships and railroads connected farmers to mills and consumers across North America. Grain and oil mills used fossil fuels to produce flour and vegetable oil as well as byproducts sold as feed. In the United States as in Europe, the agrarian-industrial knowledge society integrated sources of energy, nutrients, and labor from different times and places to intensify agriculture.[353]

American market agents developed balanced ration feeds in the early twentieth century, slightly earlier than their European counterparts. In the 1880s, many cereal mills in the Midwest dumped bran and other byproducts into rivers. Cottonseed mills in the South sold cottonseed meal as fertilizer. In the 1870s and 1880s, some cereal millers started to sell their byproducts as "mixed feed." The mixture was mainly determined by which byproducts millers wanted to get rid of. With increasing demand, this side business turned into the specialized feed industry in the late nineteenth century, particularly in Chicago with such large operations as American Linseed Oil Company and the American Cereal Company, one of the predecessors of the Quaker Oats Company. Their prime market for feed was the Northeast. Agricultural

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352 Some regions favored linseed meal, corn gluten feed, or brewer's grains, but they largely could not compare to the dominance of cottonseed meal in the United States in the late nineteenth and early twentieth century. See Alan L Olmstead and Paul W Rhode, *Creating Abundance: Biological Innovation and American Agricultural Development* (New York: Cambridge University Press, 2008), 270-283; Joshua MacFadyen, *Flax Americana: A History of the Fibre and Oil That Covered a Continent* (Montreal: McGill-Queen's University Press, 2018).
353 Lynette Boney Wrenn, *Cinderella of the New South: A History of the Cottonseed Industry: 1855-1955* (Knoxville: Univ. of Tennessee Press, 1995); Cohen, 111-142 as well as the accompanying maps of the cottonseed oil crushing mills at https://purefood.lafayette.edu/maps/cottonseed-production/; William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York: W.W. Norton, 1991); Zimmerman.

experiment stations took note and decried adulteration and mislabeling as fraud on the feed market. Only in the late 1890s did several Northeastern states pass legislation to turn scientific regulation of feeds into law, an example which other states followed in the next decades. Pushed to guarantee nutritional contents of feed, the feed manufacturers began to take note of "the balanced ration," as they called the result of scientific feeding. The earliest balanced ration feeds entered the market in the mid-1890s but production really only took off in the 1900s and 1910s. Feed manufacturers began their own experiments, hired agricultural scientists, and eventually even established their own experimental farms. What would later be called the research division of feed manufacturers was all part of the effort to produce ready-made, scientifically-founded feed.[354]

**The chemist for every feed bag: Putting scientist expertise into material innovations**

Balanced ration feeds and the innovators behind them disturbed the compromise between scientists and improvers. Scientists' feeding standards had been based on helping farmers economically. They tried to help farmers buy the best feed at the lowest price. To provide scientifically founded comparisons between feeds, scientists had developed methodologies to assign monetary value to nutrients and thus feeds. Through the 1880s and 1890s, these became a firm part of their translations to improvers and their training of extension agents. Based on chemical analysis, feeding experiments, and mathematics, agricultural scientists had ventured into the economy of farming.[355] Improvers took scientist recommendations on the feed market with a grain of salt, always sure of their expertise to adapt scientist prescriptions to their farm or even region. Balanced ration feeds offered improvers an alternative.

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[354] Larry Wherry, *The Golden Anniversary of Scientific Feeding.* (Milwaukee: Business Press, 1947). Consider the example of Otto Weiss in Wichita, Kansas, developing the first Alfalfa balanced ration feed in 1904, see "A Great Alfalfa Milling Plant," in *American Hay, Flour and Feed Journal* 22, No. 2 (January 1913), 53-54. His competitor, the M. C. Peters Mill Company experimented at the feed lots of the mill, see C. W. Wright, "The Alfalfa Milling Industry," in *Alfalfa in Kansas: Report of the Kansas State Board of Agriculture for the Quarter Ending June, 1916.*, vol. 138, Kansas. State Board of Agriculture. Report 35 (Topeka: Kansas State Printing Plant, 1916), 443. The Larrowe Milling Company in Detroit established its own research farm, even keeping its name when the company was taken over by General Mills in 1938. Larrowe Milling Company, *A Visit to Larro Research Farm.* (Detroit, Mich.: The Company, 19??).

[355] This was also true for the German side, where Münster experiment station director Joseph König was an early innovator in principles on developing monetary values of nutrients. Josef König, "Ueber die Geldwerthsberechnung der Futtermittel," in *Landwirthschaftliche Jahrbücher* 9 (1880), 805-836; Josef König "Was kosten augenblicklich die Nährstoffe in den Kraftfuttermitteln?" in *LZWL*, October 12, 1883, 329.

Disciplined by the feed laws scientists and improvers had lobbied for, feed manufacturers challenged scientists on their home turf: science.

This conflict came to a head in a meeting of the American Feed Manufacturers' Association on May 22, 1914. Founded in 1909, this association represented large-scale feed companies, mainly based in the Mid-West, and had grown to over a hundred members by 1914. These leaders of a vastly successful industry had assembled in Chicago for their sixth annual meeting. Other than discussing developments in feedstuffs grading, new regulations, and methods of production, these meetings also covered the relationship of feed manufacturers to agricultural scientists at experiment stations and colleges. Manufacturers had been disappointed with these scientists for years. Their advice in experiment station bulletins and farm journal articles discouraged improvers from using balanced ration feeds. Feed manufacturers had collaborated with scientists, improvers, and state agents in enforcing and lobbying for feed regulation as quality assurance and sound business practice. Yet, scientists still snubbed them, focusing on the few bad apples that manufacturers also wanted to keep from spoiling the bunch. At this meeting, however, the association had invited a scientist to answer to the concerns of feed manufacturers.[356]

[356] "Feed Manufacturers Hold Great Meeting," *Flour & Feed*, June 1914, 14-34.

AMERICAN FEED MANUFACTURERS IN SESSION, CHICAGO, MAY 21-22.

Figure 20: The crowd at the meeting of the American Feed Manufacturers' Association on May 21-22, 1914 in Chicago.[357]

Dr. Elmer Seth Savage climbed to the podium to address the assembled leaders of feed manufacturing. Having earned his doctorate in animal husbandry at Cornell University in 1911, Savage had just become a full professor there in 1913. He would go on to a successful career in agricultural science, publishing textbooks on animal feeding and contributing frequently to journals of cattle breeders.[358] He did well with improvers. But at this meeting, the twenty-nine-year-old was noticeably out of his depth addressing established industry professionals, most clearly his senior. These were not the improvers scientists usually addressed. Savage knew he needed a delicate strategy to convince this skeptical audience of his goals.

Savage invited feed manufacturers to collaborate for the benefit of improvers. He wanted to convince them of open formula feed labeling. Manufacturers were supposed to put their recipes on balanced ration feeds in addition to their chemical contents so agricultural scientists could compare the

[357] Ibid, 17. Digital Image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/uiug.30112064272146?urlappend=%3Bseq=17.

[358] Elmer Seth Savage, *Feeding Dairy Cattle*, 3rd and revised ed. (Syracuse, N. Y: Holstein-Friesian World, 1921); Cornell University and Office of the Dean of the University Faculty, "Savage, Elmer Seth," 1943, https://ecommons.cornell.edu/handle/1813/17857.

prices of balanced ration feeds with the prices of the ingredients that went into them. This was the basis of their economic recommendations to improvers and that is where scientists' loyalties lay.

Savage shaped his communication strategy along these lines. He knew he could not just ask manufacturers for even more transparency and regulation given their opposition to scientists' critique of their products. His colleagues had addressed previous trade meetings of feed manufacturers which had resulted in name calling in feed industry trade journals. "I hope that when I am through if I am to be called a 'bigoted theorist' that I will be told the reason today."[359] Savage invited discussion, as scientists were trained to educate students and improvers alike. To be sure, he led with humble assurances not to overstep his expertise as a teacher and simply "learn as much as possible of the business side of the great industry in which we are all so interested."[360] Little did he know that he was in for a schooling of his own.

PROF. ELMER S. SAVAGE. R. W. CHAPIN.

Figure 21: Portraits of Elmer S. Savage and Robert W. Chapin as printed with the report of the 1914 AFMA meeting.[361]

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[359] "Feed Manufacturers Hold Great Meeting," *Flour & Feed*, June 1914, 21.
[360] Ibid.
[361] Ibid, 25, 33. Digital Image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/uiug.30112064272146?urlappend=%3Bseq=25; https://hdl.handle.net/2027/uiug.30112064272146?urlappend=%3Bseq=33.

Savage presented scientists' presumed economic expertise to feed manufacturers. He demonstrated the method he taught students to compare feed prices. Savage combined tables of average nutrient contents with an average of twenty-five local feed prices which extension agents across the state of New York had sent him. In the audience, Robert W. Chapin protested. The owner of Chapin and Company in Hammond, Indiana, manufactured the "Unicorn Dairy Ration," the first balanced ration feed Savage criticized as too expensive in his demonstration. He criticized Savage's averages as "arbitrary prices" and explained that "the rates of freight vary $2 a ton from one end of New York state to the other. […] Some of these prices are in bulk and some in sacks; the sacks costing $2 a ton."[362] The variations in nutritional content which Savage averaged away also made a difference in dollars and cents. Chapin was well-versed in the most current nutritional tables as updated by Henry Prentiss Armsby and Oskar Kellner as well as published analyses by experiment station bulletins. He could correct Savage's tables on the spot using scientists' calculations. He also connected them to profit. Concentrated or by-product feeds' content varied up to 10%, which cost consumers up to $3 per ton. Scientist calculations made no sense in real markets. What was negligible or impractical variation to scientists made all the difference to market agents.

Savage maintained that the feed tables of average nutritional contents, perfected by scientists for more than half a century, were the best options available to scientists and their students. What else should they use?

> Mr. Chapin: Use the actual analysis. We don't use tables. We use facts.
> Mr. Savage: The farmers don't do that.
> Mr. Chapin: That is why the farmer can't mix his feeds as cheaply as we can.[363]

Here was their difference of perspective in a nutshell. Scientists knew how to help farm operators by using the tools of mathematical calculation. Feed manufacturers employed their own college-trained chemists who analyzed every carload of concentrated feed before mixing balanced ration feeds. There was a chemist behind every feed sack sold. As Chapin later claimed with some right, this resulted in four-

[362] Ibid, 22.
[363] Ibid, 22.

or five-times lower variation in the fat, fiber, and protein content of balanced ration feeds as compared to their ingredients. Scaled up chemical analysis also pushed farmers producing feed ingredients to strive for higher quality.[364] Through their combination of economies of scale and scientist expertise, feed manufacturers produced balanced rations much closer to the feeding standard suggested by scientists. And as Chapin ended a triumphant article on the conflict with Savage, a standard guarantee was "something no home-mixed ration based on a long distance (sic!) prescription can ever hope to do."[365]

The convenience of balanced ration feeds addressed a different target audience than what scientists had in mind. Savage had only the extension model in mind, either teaching students who would become official or unofficial extension agents, or teaching farmers himself as part of extension. He took the expertise and labor of mixing balanced rations at home for granted. It was part of scientists' strategy to uplift farmers to the better ways of improvement and scientific farming. Savage described to his feed manufacturer audience how he taught feed mixing to his students at Cornell. The whole exercise was over in only half an hour, hardly worth the "mixing fee" which manufacturers demanded. "What has the manufacturer of 'Unicorn' [feed] done for me that I can't do for myself?"[366] The answer came promptly from the secretary of the Larrowe Milling company in Detroit, Charles Staff. He pointed out the great convenience for farmers to be able to buy a ready-made sack of feed with guaranteed ideal content. They would not have to buy ingredients by the ton and mix them on the barn floor, not knowing exactly if they had in fact produced an ideal ration. "The manufacturer does a service for which he is entitled to be paid, but you expect that the farmer will do the work himself and not be paid anything for his labor."[367] Savage was comparing the price of flour to the price of bread, Staff argued. Feed manufacturers had the experience of farmers on their mind. Charging $3 more per ton in comparison to the feed ingredient prices was a steal for the convenience in labor, lower up-front expense, and easy access to expertise. One of Staff's colleagues drove this point home. J. W. Anderson of the Kornfalfa milling company in Kansas

[364] Wherry, 87-90.
[365] Robert W. Chapin, "Review of Savage Paper," *Flour & Feed*, June 1914, 13.
[366] "Feed Manufacturers Hold Great Meeting," *Flour & Feed*, June 1914, 22.
[367] Ibid.

City estimated that 97% of farmers did not know how to mix their own feed. Hard pressed to intensify livestock farming with little capital and little time to spare for education, these farmers were their target audience – not the few improvers and extension agents scientists got into touch with. Feed manufacturers were serving this audience more economically and expediently than scientists ever could.

The feed manufacturers emerged victorious, at this meeting and in the years to come. Savage surrendered before the barrage of questions from his more than capable audience. "I have suffered enough,"[368] he conceded. Still, he complimented the honesty of the members of the American Feed Manufacturers' Association and suggested they introduce a quality label marking the manufacturer's membership in this association as a sign of credibility. The audience then clarified their expectations for amicable collaboration. There needed to be an end to the bad press scientists gave feed manufacturers. And scientists should follow the example of the Massachusetts experiment station to experiment with balanced ration feeds to demonstrate their efficacy in feeding experiments rather than just chemical analysis. The president of the association and feed manufacturer of the Quaker Oats company in Chicago, George A. Chapman, put his finger on it. "The mixed feed or balanced ration business has come to stay."[369] These manufacturers argued that they deserved a place in the agrarian-industrial knowledge society because they applied scientist knowledge to provide a reliable, uniform product at a savings to farmers. Market competition kept them honest in the long run. Their chemical analysis at scale pushed raw material producers to meet higher standards. Scientists needed to accept them as valued members and communicate their contributions as such. In fact, the endorsement of scientists was key to the communication of knowledge by market agents, so it is no surprise feed manufacturers demanded just that in their negotiation for collaboration.

Scientists accepted begrudgingly. As a bulletin by the Massachusetts Experiment Station put it in 1919:

> The mixed feed business is a legitimate one, and has increased greatly of late years. Because of the large variety of by-products, it is probably a necessity. On the other hand,

[368] Ibid, 28.
[369] Ibid, 29.

> its tremendous growth has been greatly aided by the feeder, who evidently prefers to pay the extra cost of prepared feeds rather than to give the matter a little study and mix his own rations.[370]

Scientists did not like it but the success of feed manufacturers with farmers made them a force to be reckoned with. Balanced ration feeds as innovation in things addressed farmers' needs better than scientists could. Scientists chalked up the popularity of these feeds to farmers' stubborn backwardness. Still, feed manufacturers had scientists in their own employ as technicians and were able to market their products using scientist expertise. It was one piece of their marketing strategy, or in other words, their communication of knowledge.

The conflict between German scientists and manufacturers of balanced ration feeds adapted to different conditions but mirrored the arguments raised by their American counterparts. As in the United States, manufacturers of molasses feeds were among the first developers of balanced ration cattle feeds in Germany around 1900. Since the viscous molasses had to be mixed with other feeds anyway, manufacturers began to improve its nutritional value with high-protein feeds. Other manufacturers of balanced ration feeds, particularly for chickens, followed in the 1910s. World War I stopped this development abruptly. The German state controlled the war economy of mixed feeds and molasses: the former decreased in quality, the latter in quantity because other uses of these resources took priority. After the war, state intervention combined with scientists' critique into restrictive legislation.[371]

All along, scientists had attacked mixed feed manufacturers. The German association of experiment stations had criticized low-quality or spoiled ingredients in mixed and molasses feeds, prices higher than the sum of their components, and chemical contents that largely did not match scientists' prescriptions. Accusations of adulteration and fraud sounded through German society as in the United States. Given a surplus in low-quality feeds after the war, scientists saw the only redeeming value of mixed feeds in improving nutritionally worthless feeds and making unpalatable feeds palatable, as

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370 Philip H. Smith, Ethel M. Bradley, *Inspection of Commercial Feedstuffs*, Massachusetts Agricultural Experiment Station Control Series, Bulletin 13, November 1920, 25.

371 Schmidt, 65-78. For the development in the 1920s and 1930s, see Emil Schwarzkopf, "Entwicklung der deutschen Futtermittelversorgung." (Dissertation, Emsdetten, University of Cologne, 1936).

molasses could. They endorsed the 1920 law on mixed feeds which allowed only three ingredients, curtailing efforts of balanced ration feed manufacturers. These had organized in a trade association in 1918, more than a decade after their American counterparts. Their campaign touting feed market expertise, industrial economies of scale, and cost savings for farmers was successful in repealing the law. As in the United States, the commercial success of balanced ration feeds with farmers allowed market agents to negotiate begrudging collaboration with scientists.[372]

[372] Schmidt, 78-82

**Selling feed sacks: Innovation in things for farmers**


Figure 22: A feed sack as printed in an advertisement by the Larrowe Milling Company of Detroit Michigan in 1912. Founded in 1910, this mill was one of many that produced balanced ration feeds that swept across the United States in the 1900s and 1910s, also making its way to Maine feed stores.[373]

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[373] The Larrow Milling Co., "Larro-feed," *American Hay, Flour and Feed Journal*, 21, No. 3 (August 1912), 34-35. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/uiug.30112064265231?urlappend=%3Bseq=154 . See also the collection description of *Larrowe Milling Company records, 1928-1940* at the Detroit Public Library (https://snaccooperative.org/ark:/99166/w61p64db, accessed 2/17/2021). Larro-feed was registered to be sold in

There it lay in the feed store, holding so much more than just feed. The print on the sack could only hint at the knowledge the feed contained. The print and the sack itself were part of the knowledge infrastructure stretching from feed manufacturer to farmer. The other part was the feed dealer man who bought the feed and told his customers about it. His product knowledge came from feed manufacturers and feed journals, as well as feedback from customers. The feed sack in the store of the feed dealer was a knowledge infrastructure of its own, mirroring the goals of extension but using different communication strategies to reach farmers more than improvers.

The label of the feed sack was part of winning the trust of farmers. It not only clearly identified the contents of the sack but also gave guarantees of the nutritional contents of the feed. Correct labeling and nutritional content guarantees were the key pieces of the feed regulation laws of Northeastern states in the late 1890s and early 1900s.[374] These had been the result of collaboration across the agrarian-industrial knowledge society. Improvers, scientists, state agents, and market agents agreed that these laws were beneficial to all. Balanced ration feeds, however, went beyond this collaboration. Market agents introduced this innovation in things not only against the resistance of scientists but against the established standard feeds on the market. Similar to food labels, feed manufacturers had to make brand labels like "Larro-feed" standard and trustworthy names to farmers, beating out unbranded, self-describing feeds like cottonseed meal or cereal bran. Balanced ration feed labels thus put more emphasis on describing the use rather than the thing itself. As the Larro-feed sack shows, "ready ration for dairy cows" communicated the key advantages of this product: ready to feed and already mixed for a specific purpose. Images of ideal dairy cows on the feed sack reinforced the message that ideal feed could be relied upon. Packaging, rather than extension agents, assured farmers that they were feeding their cows well.[375]

The feed sack itself was a trust technology. Feed fraud had been the battle cry from improvers which had unleashed scientists and state agents on feed manufacturers and dealers. The results had been

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Maine at least in 1914 and 1915, see Maine Agricultural Experiment Station, *Official Inspections* 72 (August 1915), 176.

[374] Wherry, 41-50.

[375] For the challenge of building trust in industrially processed foods, see Cohen.

regulatory laws which feed manufacturers met with employing their own chemists to guarantee nutritional content. Large-scale feed manufacturers with an eye on long-term success used regulatory laws to cull the industry of its bad apples. In the years following the passage of these laws in the 1900s, feed manufacturers also found ways to address the potential for fraud by shippers and dealers of feed. Tested and nutritionally guaranteed only upon leaving the factor, shipping whole train cars of loose feed in bulk made it easy for shippers or dealers to mix in lower quality and lower priced feedstuffs like rice hulls, oat hulls, or ground corn cobs.[376] Sending samples to experiment station scientists was the solution provided by extension. The sealed feed sack was feed manufacturers' solution. Rather than catching fraudulent feeds and their dealers after the fact, sealed sacks aimed to prevent fraud before it happened. Cotton sacks were cheaper than wooden barrels, which had gone out of use with mass production of cotton bags and increased timber demand and prices in the late nineteenth century.[377] Industrial production of sacks and specialized machines to fill feed sacks allowed scaling up. Advertising told farmers to trust feed sacks. In 1903, ads by the American Cereal Company of Chicago reminded customers that their Quaker Dairy Feed was "sold in sealed sacks only."[378]

The feed sack of balanced ration feeds also contained feeding instructions. On Larro-feed sacks, the key label is barely noticeable just below the cows: "See feeding instructions within bag." Unremarkable as this small label might seem, it stood for a remarkable innovation which scientists, improvers, and state agents had been unable to create. Scientists' arduously developed standard rations were flexible in principle but assembling rations was a demanding task that required detailed knowledge and training. Balanced ration feeds were the materialization of scientists' feeding standards, static and uniform. As the ad accompanying the feed sack image above ensured feed dealers: "To insure uniformity, we analyze every batch after mixing. Larro-feed is *always the same – always good*."[379] That is why feed

[376] "Feed Trade Review," in *American Hay, Flour and Feed Journal*, October 1903, 442.
[377] Kendra Brandes, "Feed Sack Fashion in Rural America: A Reflection of Culture," *Online Journal of Rural Research & Policy* 4, no. 1 (January 1, 2009).
[378] *American Hay, Flour and Feed Journal*, October 1903, 440.
[379] The Larrow Milling Co., "Larro-feed," *American Hay, Flour and Feed Journal*, August 1912, 34-35.

manufacturers could include the same simple instructions with every sack. The final translation came with the bag. This took out the guesswork for farmers. Even if they had learned how to mix balanced rations, standardized feeds, surefire instructions and scientific guarantees played to farmers' preference for risk aversion and efficiency. For a small price, farmers could replace extension with the feed sack and its dealer.

The feed dealer became a credible source of information to farmers. In the late nineteenth century, industrially processed foods and feeds from far away comingled with produce sold by local farmers on the shelves of general stores. Where the food industry identified the grocer as a key builder of trust in their clientele, feed manufacturers aimed to educate feed dealers to teach farmers about balanced ration feeds. Educational messages targeted at feed dealers appeared in feed journals like the Eastern *American Hay, Flour and Feed Journal* with the motto: "A magazine that brings the miller and shipper in touch with the dealer."[380] In the 1900s and 1910s, these journals painted the ideal picture of the feed dealer. When farmers walked through the door, they could tell if a store was trustworthy. The ideal store was clean and well-organized, offering a variety of feeds, from bulk concentrated and byproduct feeds to hay to balanced ration feeds in sacks. Everything had its proper place, presented in iron-lined bins protecting the feed against rats, older wares in front, new ones in the back to prevent spoilage. The dealer himself had a familiar face and knew the farmers coming in. A successful feed dealer would stay in the background, speak in courteous tones, maybe have a blackboard advertising up-to-date market prices, and he would never try to persuade a customer to buy something he did not want to buy. He knew quality products and fair prices would have farmers talking instead of him. Still, his belief in the products he sold also went into consistent and strategic advertising, but never without the ability to back it up with quality and results. Honesty is what farmers were supposed to see in every communication, whether in store presentation, customer interaction, or printed advertising. Honesty made a credible feed dealer. That was

[380] Its competitor "Flour and Feed," covered mostly western markets.

the message of feed and food manufacturers alike when they trained feed dealers and grocers in their battle against accusations of adulteration and fraud.[381]

AMERICAN HAY, FLOUR AND FEED JOURNAL. 25

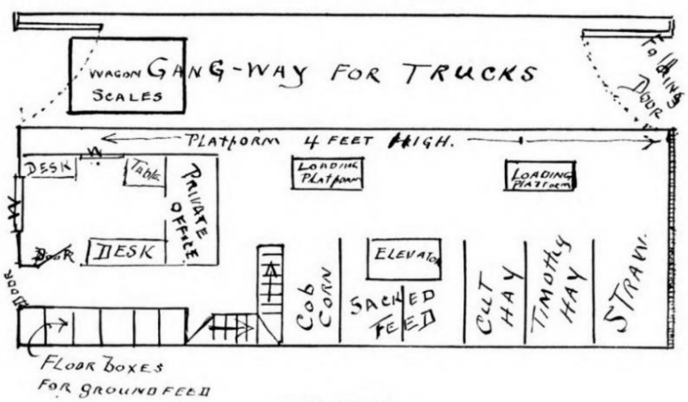
# Good Storekeeping.

PLANS AND SUGGESTIONS FOR THE LAYOUT OF RETAIL FEED STORES AND WHOLESALE GRAIN AND FEED WAREHOUSES.

In opening this department we take for our first illustration and subject the up-to-date feed store owned by Mr. E. Armacost, of Baltimore, Md. Two years ago when Mr. Armacost needed a larger space to handle his increasing business he selected a site at 545 and 547 West Biddle street. A modern two-story brick store and warehouse was erected, 40 feet wide by 160 feet deep. The first floor has a height of 15 feet. A space 8 feet 6 inches wide on the north side is given to a driveway through the entire length of the building. A wagon scale is located about 10 feet inside the front entrance, with the weight beam showing just outside the office window. The loading and unloading platform is raised about 4 feet above the ground, on a level with the ordinary wagon body. There are two hanging stagings midway between floors to allow for loading and unloading, at the same time, from the upper story. An elevator, run by electricity, is located between the stagings, while an outdoor hoist is placed in the rear of the second floor. Large fire hose is conveniently connected with a standpipe. This hose is used in warm weather for washing down and cooling off the horses.


The second floor, which is reserved for storage purposes, has fire hose and electric light equipment complete.

The retail business is carried on entirely from the ground floor. A glance at the floor plan shows the excellent arrangement for quickly supplying the various small orders. The office in front is in the centre space between the driveway and store entrance. Directly opposite the office door several bins have been placed against the south wall, containing the ground feed to be sold by small measure. They are built of wood, have drop covers, and are lined on the bottom and sides with galvanized iron as a protection against rats. The drop covers slant to the front, thereby preventing any water or dust getting into the boxes. Above these boxes are placed shelves, which hold axle grease, veterinary medicines and small articles. Mr. Armacost believes in having his store kept clean and tidy, and attributes part of his success to the fact that the customers were attracted to his place by the orderly and systematic arrangements he has always insisted on.




GROUND FLOOR PLAN.

Figure 23: Page from *American Hay, Flour and Feed Journal*. Starting in October 1906, the article series "Good Storekeeping" presented role model stores from different parts of the country, each with a photo of the storefront and a floorplan of the retail section of the store.[382]

[381] There were frequent prescriptions or reports of ideal behavior of feed dealers in these journals, consider these examples: "Fun and Philosophy," in *American Hay, Flour and Feed Journal*, October 1903, 465. For a discussion of blackboards to mark prices, see "Letters," in *American Hay, Flour and Feed Journal,* November 1903, 502. For advertising advice, see Dundas Henderson, "Dealer's Advertising Service," in *American Hay, Flour and Feed Journal*, January 1913, 26.

[382] "Good Storekeeping," in *American Hay, Flour and Feed Journal,* October 1906, 25. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/wu.89047265665?urlappend=%3Bseq=371.

Feed manufacturers identified honest dealers as an integral part of their work educating consumers about the advantages of balanced ration feeding. Educating farmers was good advertising, not just for a knowledgeable dealer. It was creating a large-scale customer base for the whole feed industry. So, similar to educating official extension agents, feed merchants hired salesmen trained at agricultural colleges. In the early 1900s, a brochure of the University of Maine included in its list of students' potential careers "salesmen for fertilizers, stock feeds, cream separators, farm machinery and many other things."[383] Feed salesmen educated both farmers and local feed dealers.[384] They mirrored how the extension service partnered with the new institution of the Farm Bureau starting in the late 1910s and early 1920s.[385] Feed manufacturers also emulated scientists and extension in creating their own bulletins, such as the AFMA's "Educational bulletin" by the "Scientific Educational Department," or the reading course "How to Feed for Bigger Live-Stock Profits" by the Live Stock Feeding Association of Pleasant Hill, Ohio.[386] The knowledge infrastructure of the feed industry worked parallel to extension but with its own dynamics.

The honest feed dealer became a kind of extension agent. The lesson for dealers was to understand balanced ration feeding well enough to translate it to farmers in convincing ways. Such a lesson appeared in a 1903 feed journal article. It broke down the whole innovation in principles of scientific feeding to this: "It simply means giving the cow such kinds of food, balanced in proportions, each to each, that she will make the most milk for the least cost."[387] Straight-forward, common-sense language was crucial.[388] Convincing farmers meant sales. So, the editor intended to equip dealers with the right answers to critical customers, such as this stereotypical farmer's attack on a feed dealer:

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383 "Scrapbook: Maine Bulletins, Timely Helps for Farmers and Other Announcements: 1903-1913" at University of Maine, Fogler Library, Special Collections, UPub 6.7-8.
384 For advice for traveling feed salesmen, see e.g. Frank Farrington, "Developing a Line of Customers," in *Flour & Feed*, October 1917, 18-19.
385 Alfred Charles True, *A History of Agricultural Extension Work*.
386 Consider this issue of the bulletin: Frederick D. Fuller, *What Chemistry Teaches About Food for Animals*, vol. 4, Educational Bulletin (Milwaukee, Wis.: American Feed Manufacturers' Association, 1917). Pleasant Hill Live Stock Feeding Association O. and Charles Conger Palmer, *How to Feed for Bigger Live-Stock Profits* (Pleasant Hill., O.: Live Stock Feeding Association, 1919).
387 *American Hay, Flour and Feed Journal*, October 1903, 448.
388 See also "The educational value of advertising," in *American Hay, Flour and Feed Journal*, January 1910, 31.

> Do you know that there are not twenty-five farmers in this county who believe a blamed word you say on this balanced ration business. Why, I have kept and fed cows for twenty years; don't you think I know something about cows and how to feed them?[389]

Such farmers of the "old fashioned, conservative type"[390] could be convinced by arguing for the economic advantage of balanced rations, the editor argued. "Simply hammer away upon the truth that ignorance is expensive while knowledge saves money."[391] And to drive home this point, he likened the knowledge of animal nutrition to knowledge of machinery. "Knowledge of the machinery and of the best fuel for the purpose helps wonderfully toward success."[392] Farmers had had to learn more about farm machinery in the preceding decades, especially the expensive effect a lack of grease in the right spots could have on mowing machines and the like. The likening of animal to machine was also common in extension messages but its link to good economy had quite a different ring to it from a feed dealer who heard from many farmers in the vicinity and who knew about his product.[393]

Race was part of every step bringing balanced ration feeds from field to consumer. As described above, race devalued the labor of black workers on cotton fields supplying cotton to produce feed sacks and cottonseed to seed crushing plants. There, the majority of laborers were also black Americans.[394] The mixing factories producing balanced ration feeds also used black labor. Larry Wherry's history of the feed industry recounts an early method of producing molasses feeds as byproducts from corn processing. At A.G. Winter's plant in Owensboro, Kentucky, the common practice in 1899 was "to spread the dry ingredients on the floors of the factory, sprinkle on molasses from a sprinkling can, and have a crew of barefooted negroes, with shovels, mix it into soft masses the size of croquet balls and dry these in open burlap pans in a hot-air room." Racialized labor then bled into racialized advertising. A Wisconsin feed

389 *American Hay, Flour and Feed Journal*, October 1903, 448.
390 Ibid.
391 Ibid.
392 Ibid.
393 For the industrial mindset behind the language of the agrarian-industrial knowledge society, see Auderset and Moser.
394 Wrenn.

company used a common racist stereotype in a 1909 advertisement for balanced ration feed (see Figure 24). As in American society, race was woven through the entire fabric of the American feed industry.[395]


Figure 24: Part of ad for Badger feed. This company touted in its name the state animal of Wisconsin where Chas. A Krause Milling Company was located. Krause was also a vocal member of the AFMA. A racially overdrawn African American child with big lips and in underwear provided the intended punchline of a joke that relied on the stereotype of stupid, animalistic black people to advertise the palatability of this feed.[396]

The key strategy of feed dealers was product samples. As in extension, they learned that visual evidence and firsthand use on farmers' own farms were the most convincing arguments for the benefits of

[395] Racist images in advertising were a global phenomenon since the eighteenth century, see Linda C. L Fu, *Advertising and Race: Global Phenomenon, Historical Challenges, and Visual Strategies* (New York: Peter Lang Inc., International Academic Publishers, 2015). For racist images in late-nineteenth and early-twentieth-century German advertising, including products made from tropical and subtropical oil crops, see David Ciarlo, *Advertising Empire: Race and Visual Culture in Imperial Germany* (Cambridge, Mass: Harvard University Press, 2011).
[396] *American Hay, Flour and Feed Journal*, October 1909, 51. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/uiug.30112064265272?urlappend=%3Bseq=283.

innovation. The Larro-feed ad above offered dealers twenty trial sacks which the manufacturer would buy back after three months if they did not sell, even paying 6% interest to compensate for the dealer's investment. Also, they authorized dealers to give customers a moneyback guarantee because it "makes dairymen safe in giving it a fair trial."[397] Addressing the skepticism and risk aversion of farmers turned into money for the dealer and manufacturer, as the ad assured dealers. "You know how goods *move* when you throw them into your customer's wagons and say 'Feed one sack—money back if not pleased.'"[398] This strategy was also a takeaway in the instructional story of the critical farmer in the 1903 feed journal article. The dealer convinced the skeptical farmer to give balanced rations a one-week trial in comparison to one week of the expensive hay he swore by. The farmer returned after the trial and exclaimed: "I wouldn't have believed there was such a difference between them."[399] Feed dealers had the advantage over extension. They translated innovation in principles into farmer language, made the recommended feeds readily available, and lessened any economic risks. While scientists, improvers, and extension agents often did not account for "backward" farmers' need for economic security, market agents put it front and center.

From manufacturer to dealer, the feed industry measured the success of feeding in production results, not chemical analysis. In 1914, the AFMA representatives who grilled Prof. Elmer Savage wanted feeding experiments with balanced ration feeds and their real prices instead of just chemical analysis and calculations of nutrient prices. While they appreciated chemical analysis to make feeds comparable, the "proof of the pudding was in the eating. An actual experiment is far better than theory."[400] The evidence of a successful dairy feed was in the milk pail. Another ad for Larro-Feed in 1913 emphasized guaranteed satisfaction for "dealer, dairyman and cow […] until its results show in the milk pail with increased profits."[401] An ad for Schumacher feed by the Quaker Oats company in June 1914 presented the

[397] The Larrow Milling Co., "Larro-feed," *American Hay, Flour and Feed Journal*, 21, No. 3 (August 1912), 34.
[398] Ibid, 35.
[399] *American Hay, Flour and Feed Journal*, October 1903, 448.
[400] "Feed Manufacturers Hold Great Meeting," *Flour & Feed*, June 1914, 29.
[401] *Flour & Feed*, December 1913, 35.

production record of the "New World's Champion" dairy cow Sophia (see Figure 13). Her "sensational record" of milk, butter, and butter fat production was due to the "World's Greatest Feed." Improvers and farmers alike believed that feeds of the same chemical analysis could produce different results, a problem scientists had yet to explain. Producers wanted to see production results and profit, the key evidence in advertising, in customer trials, and in the feed store.[402]

The communication of market agent knowledge to farmers came down to the point of purchase. The ad for Schumacher feed encouraged dealers to hang it in their window. It also included a photo of the feed sack. The feed dealer's store was the classroom, the feed sack was the schoolbook. Market agents outnumbered extension agents manifold. Their knowledge infrastructure was not formal education, like extension, but it taught farmers all they needed to know, if they had the money to invest.

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[402] Compare Wherry.


Figure 25: 1914 ad for Schumacher feed by the Quaker Oats Company of Chicago. Printed in *Flour & Feed*, this full page advertisement caught the eye, presented yield evidence, included use instructions, and assured profits. It asked feed dealers to put the ad itself into their window.[403]

[403] *Flour & Feed*, June 1914, 27. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/uiug.30112064272146?urlappend=%3Bseq=27.

## The customer is king: The knowledge system of market agents

Market agents filled an important gap in the agrarian-industrial knowledge society. They were innovators in their own right who fit the other actors of the agrarian-knowledge society into their own knowledge system. Like the other actor groups, their success relied on mutually beneficial collaboration. What market agents contributed was to learn and fulfill farmer demands at scale. Unlike scientists and improvers who expected farmers to learn the complexities of what they deemed progressive farming, market agents made farming easier. They contributed to the general push to convince farmers to practice more capital-intensive farming, but they were the only ones to offer more than the promise of increased profits in return. They provided reliable market expertise and the ability to translate innovations in principle and place into standardized and thus reliable, easy-to-use products. Where improvers and scientists aimed to elevate farmers' intellect, market agents truly met them where they were. The market logic of supplying consumer demands functioned differently from the logic of education. Education constantly looked to the future, to the rich harvests farmers could reap if they only took schooling seriously. The market looked intently to the present, to the profit a little more financial investment could provide farmers now. Market agents did not replace extension but worked alongside it, learned from it, complimented it. Where extension educated farmers from the top down, market agents did so from the bottom up.

The market agent knowledge system was built on this idea. Farmers, as consumers, stood at the top. Their purchases shaped innovations in things even more than their written or verbal feedback to market agents. Market agents could play the role of maker, seller, buyer, and even producer, sometimes all at the same time, like a seedsman selling directly to farmers. To be sure, improvers as testers, scientists as technicians, and state agents as legislators also filtered consumer demands to makers. Their collaboration provided much of the knowledge that went into the production of innovations in things. At the same time, testers, technicians, and legislators demanded compliance with their input. Communication of innovations in things relied heavily on their approval because their voices reverberated loudly through marketing material. Market agents had license to be selective of their approving messages but always had to represent them faithfully. Through this collaboration, market agents utilized every possible channel to communicate to farmers. Whether through word of mouth or from the mouth of experts, market agents wove together oral, written, pictorial, and physical communication through a variety of actors like no other actor group.

On the supply side, market agents pressured producers of raw materials to improve the quality of their production. Many of these producers were farmers themselves. Through the twentieth century, these were increasingly nonwhite farmers in the global South who could be exploited for greater profit for market agents and white farmers in the global North. On the flipside, when it came to farm outputs in Germany and the United States, consumers pushed farmers to increase the quality of their production. Creamery operations, for example, translated consumer demands to farmers, in the Sauerland and Maine as elsewhere, and pushed them to change their practices. As much as the market logic served farmers on one side, it put more pressure on them on the other. Whether for farm inputs or farm outputs, market agents made sure they educated farmers to buy from and produce for the market as the solution to the pressures of a globalizing agricultural market. Inspired by self-interest but offering support, market agents' message to farmers was: "Take our hand and buy in or get out of farming."

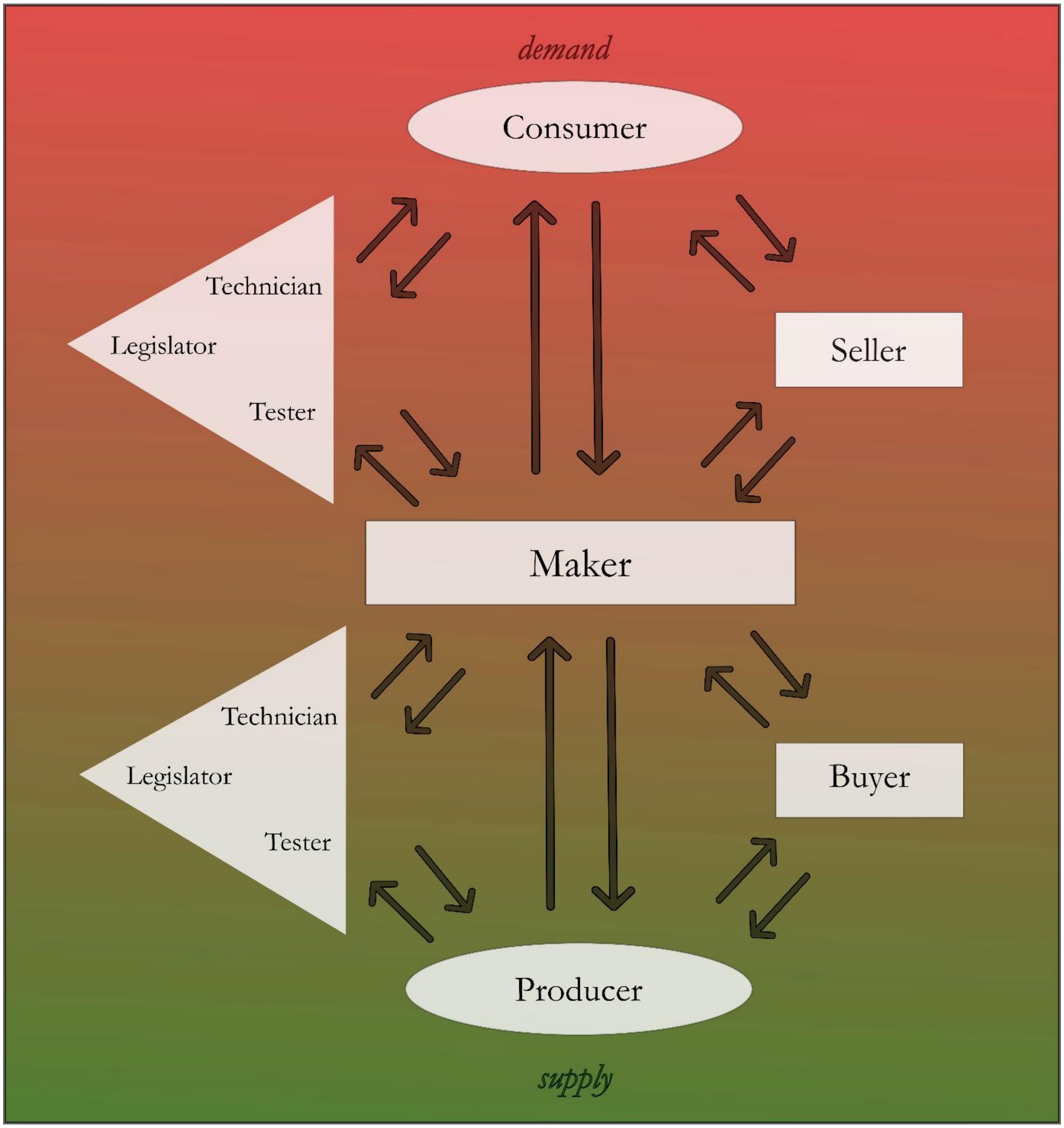


Figure 26: The knowledge system of market agents.

## CHAPTER 5

## INNOVATION AT HOME

> Then it was the duty of us kids to "watch the cows" every morning. This consisted of letting them graze in the dooryard and along the adjacent roadside for an hour or so, but we had to be there all the time to keep them out of the garden and away from the apple trees. This was not so bad at first and in nice weather. But later it got monotonous, and in bad weather it became downright disagreeable. But Dad would point out that we had to have a certain sized milk check to pay the feed bill, to say nothing of buying groceries and shoes for the kids. […] But once in a while we would get interested in a diversion like throwing windfall apples at each other and before we knew it the cows were in the garden, and Dad would come roaring around the corner of the house and catch us and the cows, both at fault.[404]

At the core of farm life stood relationships between people, animals, and material things. Over their conversations, the voice of those promoting new ways of farming was barely a whisper. But when their relationships with the land, with their cows, or with their store clerk would either fail or show them unexpected gains, then those humans on the farm would try to make out what the breeze winds of change were trying to tell them. The "why" had to blow off the farmers' hat for them to chase the "how" traveling on the same gust. Once caught, the people, animals, and material things had to find new ways to agree, to fit the new into the old, to remake their relationships that made the farm, the neighborhood, and the town a home. Change had to be slow for homes to remain homey.

The quotation above was written in 1951 by Mert Parsons, the son of Oscar and Luella Parsons of South Paris, Maine. Mert reminisced about his childhood and teenage years on their family farm in the style of *The Youth Companion*, popular youth stories on a Maine farm. His recollections of farm life in the 1910s and 1920s are tinged in warm nostalgia and his later education as agricultural economist at the University of Maine and Cornell University. They combine the memories of youth with insights into farm innovations, enmesh farm family with farm work, and inform the personal with the professional. Mert was one of those extension agents who grew up on a farm before there was a formal extension service. He

[404] Merton S. Parsons, Mary Clifford Colley, and John T. Parsons, *Life on the Farm and in the Village: South Paris, Maine,1910-1925,* ed. Jeffrey R. Parsons (South Paris, Me.: J.R. Parsons, 2009), 29.

understood how his father and mother ran their farm, but he learned later how it should have operated. His stories are full of what the agrarian-industrial knowledge society had to learn: farms were homes.[405]

Scientists, improvers, state agents, market agents, and extension agents all targeted the farm family. They had to gain footholds in institutions, businesses, and media in remote towns and small neighborhoods to change the minds of farm families. Without convincing this target audience, all of their expertise and credibility would crumble. But farm families were not just the passive targets most members of the agrarian-industrial knowledge society made them out to be. As several micro-historical studies of particularly New England farm family decisions since the seventeenth century have argued, farmers had minds of their own, as varied as the lands they worked, the animals they raised, and the neighbors they laughed with. But all of them possessed a keen sense of what was possible in their particular circumstances. These were not eternally conservative naysayers. Those promoting change did not speak their language and did not know the true costs of investment in innovation. Innovation did not just cost the time to read or the money to buy new things. It demanded effort in renegotiating the relationships between people, animals, and material things. This was no small feat and required great care and often a slow pace, yet those not living the farm life could not understand why many farm families were so careful and critical of innovation.[406]

This chapter explores the dynamics of farm families and farm communities in their negotiation of agro-industrial innovation in the late nineteenth and early twentieth century. I compare a case study of a farm family in South Paris, Maine, with a case study of the agricultural association of Serkenrode in the Sauerland. Both case studies are exceptional in their quantity and quality of surviving documentation. Both the Robinson-Parsons family and the Serkenrode association had a reputation for engaging with

[405] Ibid, xi-xvi.

[406] For studies advocating for the rational abilities of farmers and their careful family decisions and adaptations of agricultural practices in New England, see Brian Donahue, *The Great Meadow*; Gail E. Nessell, "The Lowing of the Cows and the Sound of the Whistle": Old Meets New on the Goodale Farm, Marlborough, Massachusetts, 1819-1858," *Dublin Seminar for New England Folklife Annual Proceedings* 11 (July 1986): 36–48; Vickers, "Competency and Competition;" Vickers, *Farmers and Fishermen*. For Germany, see David Warren Sabean, *Property, Production, and Family in Neckarhausen, 1700-1870* (Cambridge; New York: Cambridge University Press, 1990).

innovation early as compared to their neighbors. Still, their contrasting engagements with industrial byproduct feeds and cooperative dairy factories suggest some effects social, economic, and environmental conditions had on farm family decisions generally. In the functional processes of knowledge negotiation of farmers within the agrarian-industrial knowledge society, these case studies were representative of larger trends across the United States and Germany. Finally, the results of the negotiation of innovation endorsed outside of western Maine and the Sauerland brought changes in agricultural practice, economy, and society that resemble other challenging agricultural regions.

## Life beyond improvement: the knowledge system of farm families

The knowledge system of farm families lay embedded in their homes. At the center was the farm family living on the farm. While these were patriarchal households, farm men could decide as little without their families as without their wallets. Farm work was largely family labor, divided in often unequal ways, but a joint effort nonetheless. Live-in hired help had less of a say but their labors had to be negotiated in their work agreements. And at the end of the day, everyone still had to live together – with each other, with their animals, and with their neighbors. Farm families did not live in a vacuum, but in frequent contact to other families in their vicinity. Barter of farm produce and the exchange of help in farm labor were as much part of these relationships as social visits. Neighborhoods existed as part of larger town or village communities where farm families could purchase goods and farm inputs or sell farm outputs.[407] Town institutions, such as church communities or benevolent associations, as well as business partners, brought farm families into conversation with farm and townsfolk alike. Beyond the town, communication happened largely by mail, letters to family and friends and far-away business partners going out, journal and newspaper subscriptions and mail-order purchases coming in. The closer these networks were to the farm family and its home, the more credible their advice and evidence.

[407] Thomas Hubka described neighborhood mutuality in New England in this vein. See Thomas C. Hubka, "Farm Family Mutuality: The Mid-Nineteenth-Century Maine Farm Neighborhood," *Dublin Seminar for New England Folklife Annual Proceedings* 11 (July 1986): 13–23; Hubka, *Big House, Little House, Back House, Barn*.

A small part of these circles were those people connected to farming who promoted agricultural innovation. Farm families probably perceived members of regional agricultural associations, leaders of farmers' clubs, and writers for farm journals as progressives. Merchants of agricultural goods might not have seemed as progressive as these improvers, but the innovations they sold communicated progress all the same. Among them, officially educated agricultural teachers or extension agents had the obscure credibility of theory behind them making them the ultimate progressives. Their share in the relationships of the farm family was small but they embodied the link of farm communities to agricultural innovation and the agrarian-industrial knowledge society.

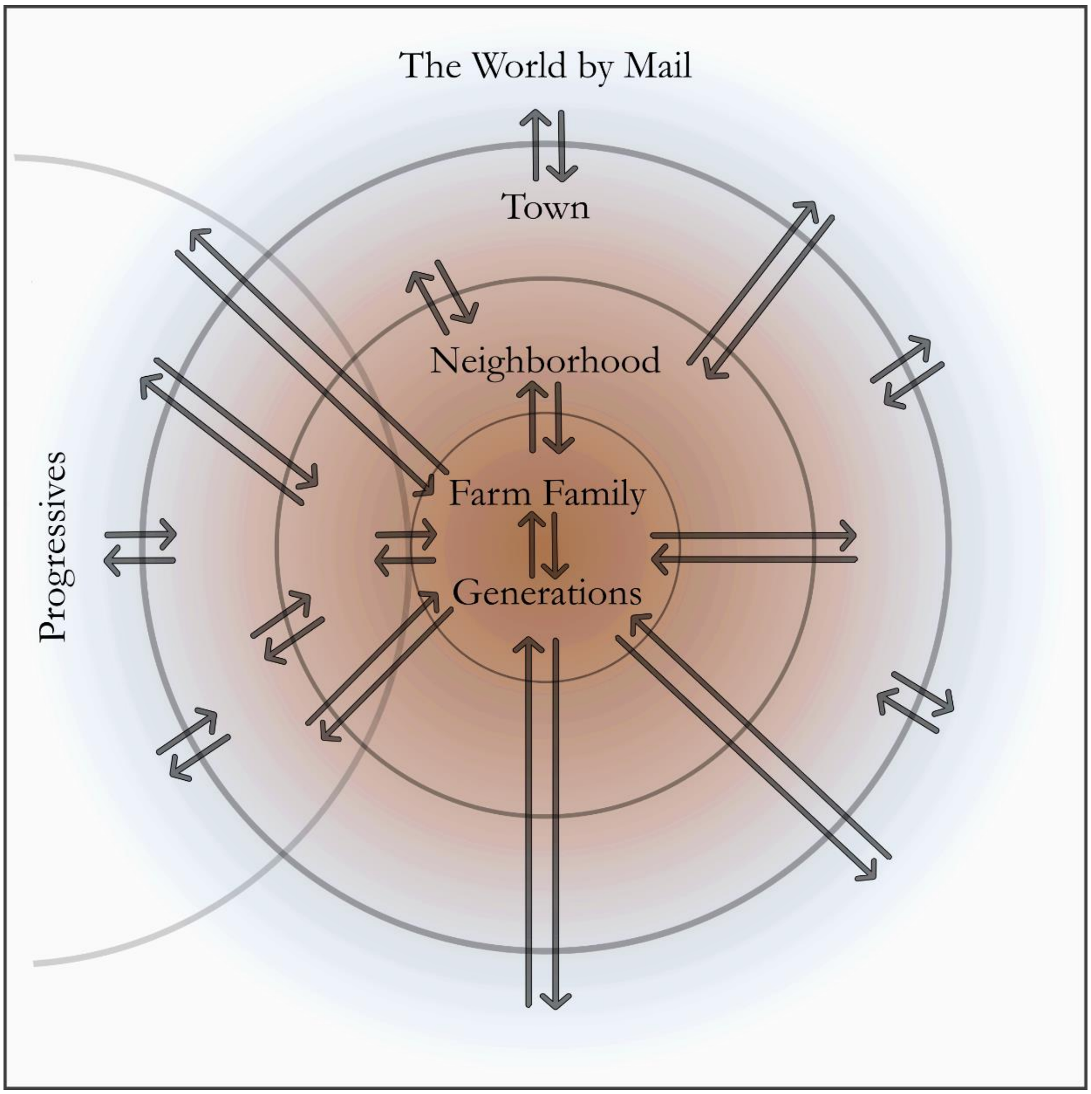


Figure 27: The knowledge system of farmers.

**Meet the Robinson-Parsons: Family and Farm Knowledge in South Paris, Maine**

The Robinson-Parsons family of South Paris, Maine, had begun as a 100-acre lot bought in 1787 by Stephen Robinson when white settlers had protruded more and more into the ancestral lands of the Abenaki people. About one hundred years later, the farm, which now included about 250 acres, had passed through Stephen and his wife Jemima's daughter Apphia and her husband John Parsons, Jr. to their son Stephen Robinson Parsons and his wife Mary. These hundred years on the farm had already seen several of the numerous offspring and their families join the growing stream of rural Mainers leaving for the west, especially in the mid-nineteenth century. Stephen and Mary were those who stayed behind on a prosperous farm which passed to them with John Jr.'s death in 1868. Between 1865 and 1879 they had six children of their own. Their youngest son, Oscar Wallace Parsons, would take over the farm operations before his father's death in 1905. He would start his own family with his wife Luella, their four children born between 1904 and 1914. They managed the farm until 1922 when Oscar died unexpectedly. These two generations of the Robinson-Parsons family led the farm through the changes in farming which global competition and the agrarian-industrial knowledge society brought to South Paris: Stephen and Mary from the 1860s to the late-1890s and then Oscar and Luella on to the early 1920s.[408]

[408] Jeffrey R. Parsons and Mary H. Parsons, *Letters from the Attic: A Compilation of Letters and Other Documents Found at the Robinson-Parsons Farm in South Paris, Maine, and in Related Family Collections, 1818-1982* (Ann Arbor, Michigan: Jeffrey R. Parsons and Mary H. Parsons, 2018), 5-36. Compare to Hal S. Barron, *Those Who Stayed behind.*

Figure 28: The main farmhouse of the Robinson-Parsons farm.[409]

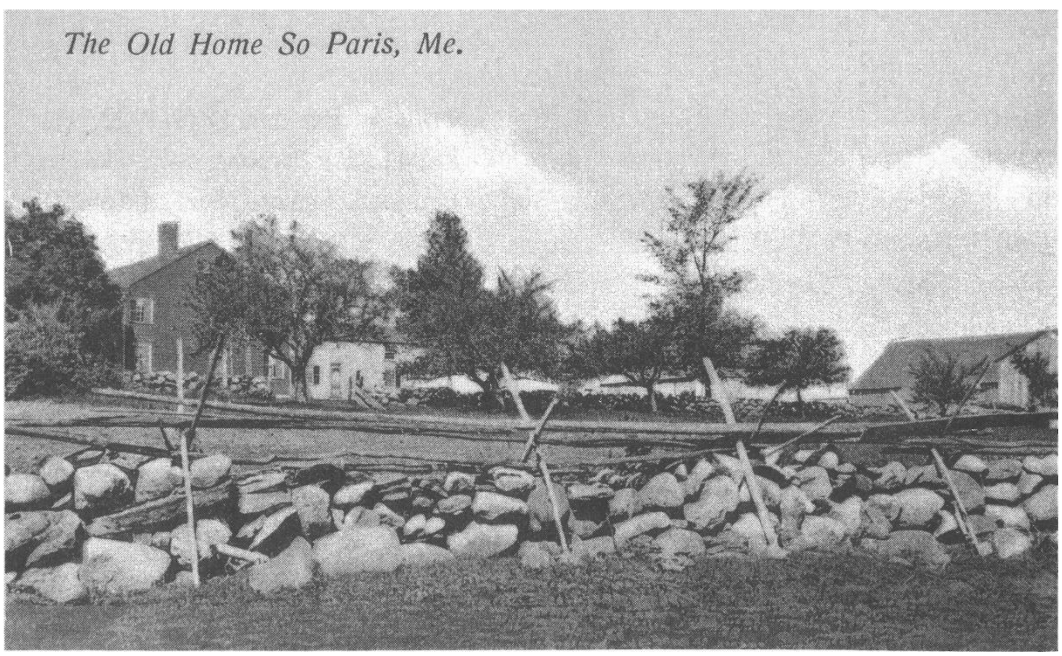


Figure 29: View of farm buildings of the Robinson-Parsons farm from the southeast, Summer around 1900.[410]

[409] Jeffrey R. Parsons, An Imperfect History of the Robinson-Parsons Homestead Farm, South Paris, Maine, 1787-1978, 1978, Bethel Historical Society.
[410] Parsons, Clifford Colley, and Parsons, *Life on the Farm and in the Village: South Paris, Maine,1910-1925*, 2.

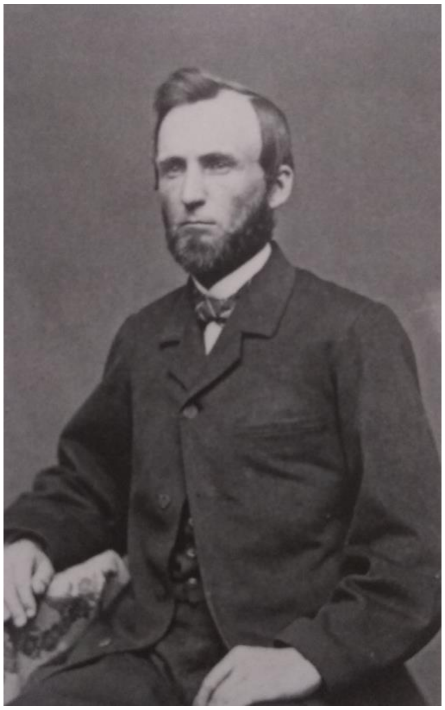

Figure 30: Stephen Robinson Parsons, born in 1830, around 1865. He took over farm management of his aging father John in the early 1860s.[411]

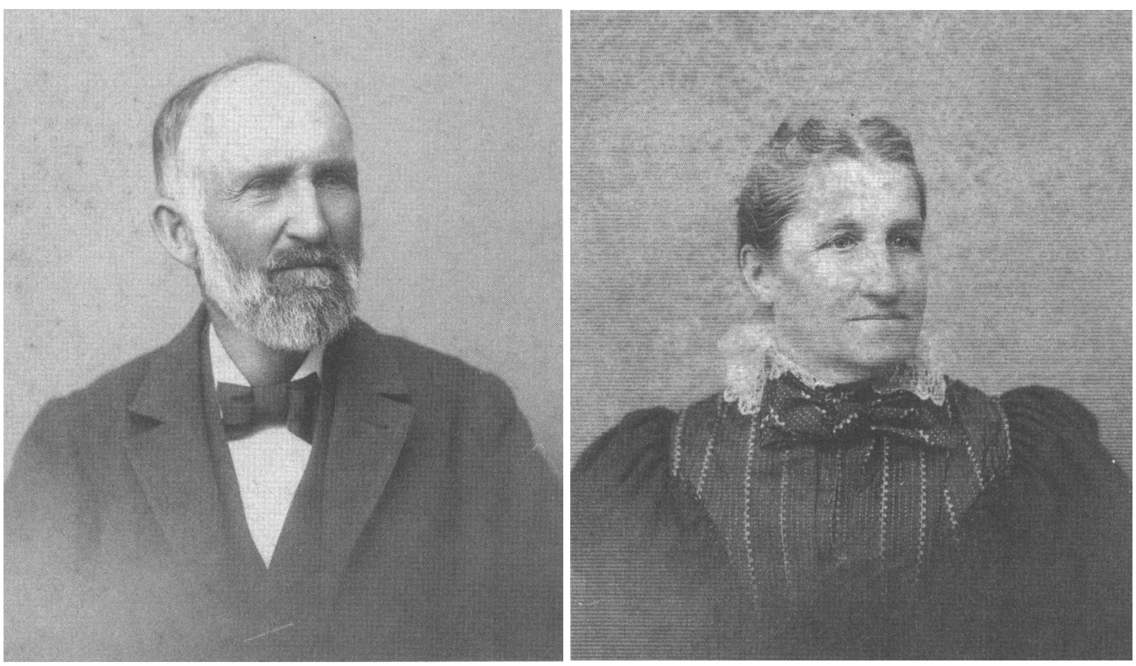

Figure 31: Stephen Robinson Parsons and Mary (Thomas) Parsons, around 1900. Stephen was training his youngest son Oscar around this time, ceding more and more tasks in farm work and management to him.[412]

[411] Parsons and Parsons, *Letters from the Attic*, 520.
[412] Parsons, Clifford Colley, and Parsons, *Life on the Farm and in the Village: South Paris, Maine,1910-1925*, 8.

Figure 32: Oscar Parsons, 1897. Even though he did not graduate from high school, this was to have been his graduation photo. He was learning farm work and management from his father Stephen.[413]

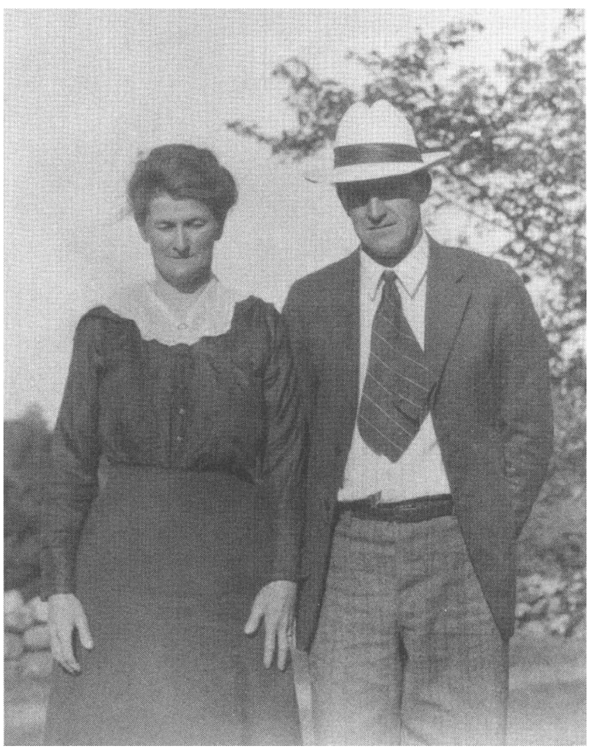

Figure 33: Luella and Oscar Parsons, 1920. By this time, Oscar was training his son Mert in farm work and operations, most likely impressing enough upon him to attend the University of Maine and Cornell University to go into agricultural economics.[414]

[413] Ibid, 9.
[414] Ibid, 12.

An interest in education and engagement with farm innovations reverberated through these generations. The first settler of the farm, Stephen Robinson, had been a founding member and active supporter of the Paris Social Library since 1797.[415] His son-in-law and father of Stephen Robinson Parsons, John Parsons, Jr., had been a graduate of nearby Hebron academy and a schoolmaster for more than ten years before he became a farmer. John trained his son Stephen as a farmer and gradually passed along farm management to him in the 1850s and 1860s before John died in 1868. He and his wife Apphia also passed along the appreciation of a formal education as Stephen and Mary sent their four eldest children to Hebron academy. Stephen was also a member of the Paris Library Association.[416] This mindset reached into Stephen's approach to farming, so much so that his obituary in 1905 summarized him as "progressive, and always one of the first to try any new invention that would facilitate farm labor."[417] Stephen and Mary certainly passed some of this mindset on to their youngest son Oscar albeit with some disadvantage. Oscar's older brother John had been in line to take over the farm but was not suited to the task. "A dreamer and a malcontent,"[418] John cared more about collecting bird's eggs than about farming. Oscar was born in 1879, when his father Stephen was 49 years old. In the early to mid-1890s, Stephen got too old to handle the farm management on his own and began relying more and more on his apt son Oscar even though he was only in his early teens. As a result, Oscar missed some school summers and never graduated high school, even though he had good grades, including in chemistry.[419] Very young in the 1900s, he combined the role of farm manager with the joys of being a young adult. He followed sports games and, before his marriage, "cart[ed] his Edison phonograph around Oxford County by buggy for the entertainment of his friends."[420] Nevertheless, Oscar and Luella passed on the value of a formal education to their children. After Oscar's untimely death in 1922, all four of their children

[415] Mary H. Parsons, email to author, August 31, 2021.
[416] A least he was in 1887. Collection of Receipts labeled SRP 1860s-1880s, private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[417] "Obituary for Stephen R. Parsons," *Oxford Democrat*, May 30, 1905.
[418] Parsons and Parsons, *Letters from the Attic*, 13.
[419] Ibid, 521.
[420] Ibid, 14.

attended college. His eldest son Mert received degrees in agriculture from the University of Maine and Cornell University and made a career in agricultural economics. In short, Oscar certainly knew how to farm and could appreciate farm innovations, but he never garnered quite the progressive reputation of his father.[421]

The knowledge infrastructure of improvement and extension reached into the lives of Stephen and Oscar and their families. Both subscribed to farm journals and general newspapers with farm sections. Stephen read his father's *Genesee Farmer* and the *American Agriculturalist*. John Jr. seems to have foregone the more obvious choice of the *Maine Farmer*.[422] Oscar also preferred national farm journals like *Successful Farming*, published in Des Moines, Iowa. Among various general newspapers, both read the local newspaper, the *Oxford Democrat*, which had an active farm section which included articles from various agricultural journals, including the *Maine Farmer*. At least between the 1880s and 1900s, Stephen cut out specific articles of interest to him, as did Oscar at least in the 1900s. Through the newspapers, both knew about extension activities by agricultural colleges and Stephen even attended an 1880 lecture in neighboring Norway by Jeremiah Wilson Sanborn, superintendent of the New Hampshire agricultural college farm.[423] Stephen was a member and long-time secretary of the South Paris Grange, which discussed farm questions although not to the extent of local farmers' clubs.[424] Both Stephen and Oscar attended the local annual fair of the Oxford County Agricultural Association where Stephen

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[421] Parsons and Parsons, *Letters from the Attic*, 9-19; Parsons, Clifford Colley, and Parsons, *Life on the Farm and in the Village: South Paris, Maine,1910-1925.*
[422] Stephen Robinson Parsons' notebook, 1875-1882, Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI, Dec 24, 1881; Parsons and Parsons, The Diary of Stephen Robinson Parsons, Jan 21, 1860, Jan 3, 1862, Dec 16, 1862.
[423] Henry Harrison Metcalf and Frances Matilda Abbott, *One Thousand New Hampshire Notables; Brief Biographical Sketches of New Hampshire Men and Women, Native or Resident, Prominent in Public, Professional, Business, Educational, Fraternal or Benevolent Work.* (Concord, N.H.: The Rumford printing company, 1919), 75. Stephen Robinson Parsons' notebook 1875-1882, Dec 29, 1880. Later, Oscar cut out an article on demonstration work in Lewiston by instructor and later assistant professor Arthur W. Gilbert at the University of Maine from 1905 to 1907. See the article pressed in Oscar Parsons' notebook, 1900-1917, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI. For the appointments of Gilbert, see *Annual Report for the University of Maine for the year 1905*, The Maine Bulletin Vol. 8, No. 6, Feb 1906, 9; *Annual Report for the University of Maine for the year 1907*, The Maine Bulletin Vol. 10, No. 3, Nov 1907, 9.
[424] Minute Books of the South Paris Grange, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI.

occasionally entered items for premiums.[425] Stephen is not mentioned as an attendant of the Paris meeting of the Maine Board of Agriculture on January 25, 1872, which was discussed in chapter 2, but it is very likely he attended. In any case, he would have fit in well. On the continuum between farmers and improvers, Stephen stood firmly in the middle as what I call a local improver: interested in innovation but only engaged in local improver institutions rather than in county or state affairs. Apparently urged by his peers to run for office, he refused and remained a quiet improver, preferring involvement in various South Paris civic associations and the role of secretary in the local Grange.[426] Oscar leaned more to the farmer side, quiet in improvement matters but interested and able to understand them.

The knowledge infrastructure of the market also touched both of their lives. Stephen invested in various business ventures, many of them connected to farming and his own farm practice, such as his stock in a new design farm gate and "Mathew's Patent Compound" for livestock.[427] Most prominently, he was the secretary of the South Paris Dairying Association and largest investor in the cheese factory it operated from 1873 to 1884.[428] After cutting out an ad for the Lufkin Swivel Plow and investigating several Maine sales agents, Stephen ordered one from the manufacturer in Alstead, New Hampshire, in 1884. This company later approached him to promote and sell this new piece of farm machinery in South Paris.[429] Stephen also kept in touch with other market agents. On January 31st, 1879, he jotted down the instructions and farming ideas of a fertilizer salesman who came to the farm and left a brochure for a Vermont fertilizer company he represented.[430] Both Stephen and Oscar kept brochures of various new farm products in their documents, from fertilizers to feeds to farm implements. They frequented local feed stores and mills in South Paris but occasionally also in surrounding towns. Through local stores, thrifty

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[425] Parsons and Parsons, The Diary of Stephen Robinson Parsons, October 3, 1860.
[426] "Obituary for Stephen R. Parsons," *Oxford Democrat*, May 30, 1905.
[427] Collection of Receipts labeled SRP 1860s-1880s, private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[428] Records of the Paris Dairying Association, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[429] Old Newspaper Clippings – (SRP's) all farming related material, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI; Stephen R. Parsons, misc – prob. 1901 or 1902, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI; Stephen R. Parsons business letters, 1872-1901, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[430] Stephen Robinson Parsons' notebook, 1875-1882, Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI, January 31, 1879. The company was Sparhawk and Ballard.

Stephen also received small memoranda booklets with blank pages for his records and advertisements for various products, including cottonseed meal. He also kept records of various Maine and New England stores and companies selling all kinds of farm inputs by mail order. It seems Stephen engaged more widely in market connections than his son Oscar, bordering on functioning as a market agent himself.[431]

Their different grades of involvement in improvement and market connections were a result of their family history. Oscar did not benefit from prolonged parental training like his father had. Stephen had worked under his father's guidance for twenty-four years, until his father died when Stephen was thirty-eight years old. Oscar got about ten to fifteen years of guidance from his father at a time when this young adult certainly had plenty of other things on his mind than farm improvements. Stephen died when Oscar was only twenty-six. As training on the farm went, Stephen received more of it than his son Oscar.[432]

Their different abilities to engage in improvement and the market also came from diverging financial situations on the farm. Stephen had been the sole heir of the Robinson Parsons farm in 1868 and began his farm operations more or less debt free. By contrast, Oscar had to pay his five siblings as joint heirs an annual share of the farm profits from 1905 to 1918. Once their mother Mary died in 1918, Oscar had to pay substantial sums to buy his siblings out of the farm inheritance. Oscar not only learned less about how to appreciate improvements than his father, but he had less means to invest in them.[433]

## The view from the meeting: Local agricultural association and farm knowledge in Serkenrode, Westphalia

The agricultural association of Serkenrode (*Landwirtschaftlicher Lokalverein Serkenrode*) represented farmers of a small township and village of the same name and parts of neighboring townships in the Sauerland. Founded in 1866, its membership declined from its heyday of over 250 in the late 1870s

[431] Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[432] Parsons and Parsons, *Letters from the Attic*, 9-19.
[433] Ibid.

to less than 150 in the late 1880s, its meetings were generally attended only by 20 to 50 farmers.[434] Active roles in commissions of the association were generally taken up by even fewer farmers. The active farmers were those with more land. In a sample of 1877 to 1889 of agricultural landowners in the villages of Serkenrode and closeby Ramscheid, this shows clearly in the participation.

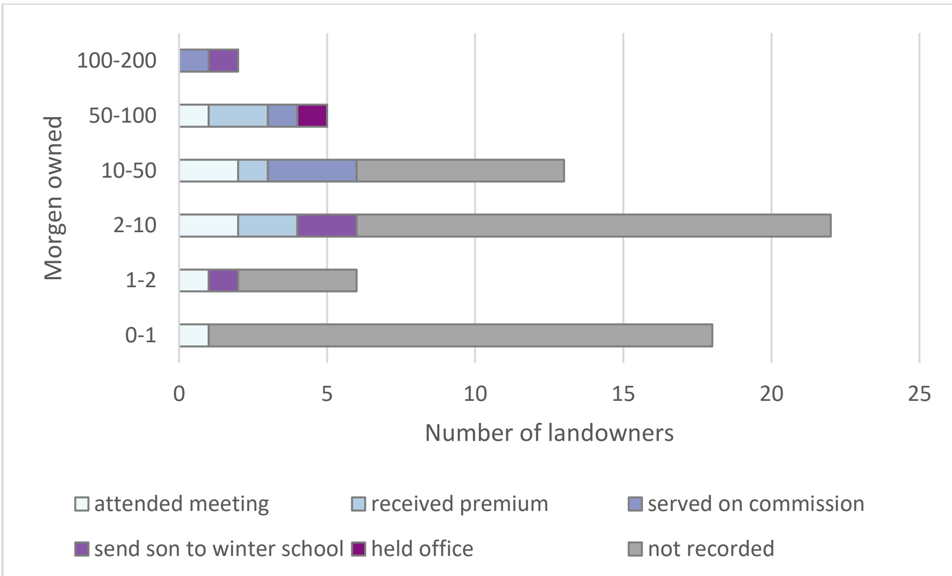


Figure 34: Participation in Agricultural Association in Villages Serkenrode and Ramscheid, 1877-1889. This graph records only the most involved participation per agricultural landowner, weighted in this order: attended meeting, received premium, served on commission, sent son to winter school, held office.[435]

434 Minute books Serkenrode. Membership numbers could be identified for the years 1880, 1881, 1884, 1885, and 1886 in the annual reports of the district Arnsberg agricultural association (*Landeskulturgesellschaft Arnsberg*), most of them found in *LAV NRW W*, K 001 / Oberpräsidium Münster, Nr. 1765 - Band: 2 "Landeskulturgesellschaft für den Regierungsbezirk Arnsberg," see e.g. Frhr. von Hövel, "Jahresbericht der Landeskultur-Gesellschaft für den Reg.-Bezirk Arnsberg," *LZWL*, April 1, 1881, 111; *Jahresbericht der Landeskultur-Gesellschaft für den Regierungsbezirk Arnsberg pro 1886* (Lüdenscheid: Buchdruckerei von Ed. Horn jr., 1887), 25.

435 Farm sizes were calculated from Regierungsbezirk Arnsberg, Kreis Meschede, Liegenschaftsbuch des Gemeindebezirks Schliprüthen, Band I and II, Art. 1-163 and Art. 170-, Katasterarchiv, Fachdienst Liegenschaftskataster und Geoinformation, Kreisverwaltung Olpe; association activity was recorded from Minute books Serkenrode; list of students of Fretter winter school came from its extant annual reports found in Finnentrop Gemeindearchiv, Folder 1267, "Errichtung einer ländlichen Fortbildungsschule Fretter." While membership of the Serkenrode association is not recorded by name for the period of 1877 to 1889, its minute book names some farmers and their activities in the association, not all from the town of Serkenrode as its membership area included the whole township Serkenrode and nearby towns. Also, the Fretter winter school annual reports list the names and hometowns of its students, also largely beyond just the town of Serkenrode. This list of farmers is incomplete as the minute book rarely recorded attending farmers to its meetings and the winter school annual reports of 1884/5 and 1887/8 to 1889/90 could not be located. Also, this graph excludes those recordings of participation that could not be linked reliably to a particular agricultural landowner. There were at least eight students from Serkenrode and Ramscheid at the winter school. Even though they cannot all be represented in the graphic as they could not be clearly matched to Serkenrode farms, it is clear that each farm size category of more than one hectare sent at least one of their sons to

Still, the association and especially its leadership were the prime promoters of improvement and connection to its infrastructure. On the spectrum between improvers and farmers, leaders largely stood closer to improvers yet mostly remained within the boundaries of their township and Meschede county. Members stood closer to farmers, often quietly agreeing with improvement measures presented to them but able to understand and use them if their means permitted. In the association minute book, the association secretaries noted some of the back and forth between members and leadership, audience and lecturers, allowing a rare, hazy window into the decisions made by farm families in the township.

The Serkenrode agricultural association was the key connecting point of local farm families to improvement and extension. Through the late nineteenth and early twentieth century, it subscribed to Sauerland and Westphalian farm journals for its members, the *Landwirtschaftliche Zeitung für Westfalen und Lippe* (LZWL) and the farm journals of the agricultural association Märkisch Sauerland, published in Lüdenscheid, and of the county association Wittgenstein, published in Berleburg. Its leaders also published in the local general newspapers, the *Mescheder Zeitung* (MZ) and the *Sauerländisches Volksblatt* (SVB), whose editors also included other agricultural content. Association members placed copies of farm journals in village pubs or scheduled them to be read out loud.[436] They also specifically intended them to be read by farm women and discussed by the whole farm family, even though members and attendants of association meetings and lectures were generally men.[437] Association leaders were often well-versed in improvement matters and held lectures themselves or invited guest speakers from nearby agricultural schools, gravitating more towards invited experts with official state credentials in the

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the winter school. Two of those unmatched had the last name Schmitt and were from Ramscheid, where there were only two landowners with the family name Schmitt, one 10 to 50, the other 50 to 100 hectares in size. These two sons did not take over their family farm, so they cannot be matched with certainty. Two others remain unmatched entirely.

[436] Minute books Serkenrode, January 6, 1879, December 10, 1879, October 21, 1880, July 8, 1883, October 26, 1884, August 30, 1885.

[437] Johannes Dornseiffer, "Vom Bauernstand II.", *SVB*, November 19, 1879, 2.

1900s.[438] Modeled after institutions in the neighboring province of the Rhineland, the association started the first agricultural winter school in Westphalia in 1880. The school moved several towns over late in the 1880s.[439] From its beginnings through the 1910s, the association held an annual or biannual fair at changing villages in the township. It awarded monetary premiums, often state-subsidized, largely as part of a cattle show but also for manure storage and other improvements. The fairs had raffles for farm tools and machinery, usually an informative or celebratory lecture, and a joint meal, drinks, and music, turning the fair into an event for the whole farm family. Still, the main audience of the association were farm men of the younger and older generation.[440]

Market agents also touched the lives of Serkenrode farm families through the association. From its early days through the 1890s, the association leaders canvassed members for joint fertilizer orders, at times extending this practice to seeds and feed. Before they joined orders of larger associations, Serkenrode leaders requested offers from dealers, compared and discussed them at general meetings, and placed orders. Enabled by the association, some of its members formed a cooperative to purchase farm and household inputs (*Konsumverein*) in 1880. From 1880 to 1883, leaders and members formed a dairy association with a local cheese and butter factory. They used the meetings of the agricultural association for their own meetings and at times took over their whole business. Local smiths and factories as well as larger manufacturers from as far as the Rhineland and the Ruhr region came to fairs to demonstrate new agricultural machinery. Periodically, the association would send select members to larger farm exhibitions and cattle markets across Westphalia to learn about and purchase new farm machinery and purebred

[438] Minute books Serkenrode. This fits what Marten Pelzer has found for the Lüneburg region, see Marten Pelzer, "'Was die Schule für das heranwachsende Geschlecht ist;'" Marten Pelzer, "Landwirtschaftliche Vereine als Wissensagenturen."

[439] Fritz Söbbeler, *Landwirtschaftsschule Fretter – Eslohe – Meschede: Einige Daten Und Fakten Zu Ihrer Geschichte Und Entwicklung von Der Gründung Bis Zur Gegenwart* (Meschede: Verein ehemaliger Landwirtschaftsschüler und – schülerinnen Meschede und Landwirtschaftsschule/Höhere Landbauschule Meschede, 1996); *Fünfundzwanzigster Jahresbericht der zweisemestrigen landwirtschaftlichen Winterschule zu Elspe über das Schuljahr 1904/05 (*Olpe: F. X. Ruegenberg, 1905). The neighboring winter school in Elspe, Olpe county, technically began operation on the same day but lacked the private antecedent set up by Vicar Johannes Dornseiffer in Fretter the previous winter.

[440] Minute books Serkenrode, compare Pelzer "'Was die Schule für das heranwachsende Geschlecht ist;" Pelzer , "Landwirtschaftliche Vereine als Wissensagenturen:"

livestock. From the 1890s onward, keepers of purebred bulls and boars offered their services to local farmers for a fee, also receiving state subsidies to do so through the association. Association leaders and its most active members were in close contact with market agents selling agricultural inputs and sometimes turned into market agents themselves, buying and processing farm outputs.[441]

The programs and connections of the association went through cycles of innovation and growth to maintenance and atrophy depending on its leaders. Amtmann Josef Kayser and Vicar Johannes Dornseiffer in the late 1870s and early 1880s had pushed Sauerland specific innovations and knowledge infrastructure, refusing to integrate into the wider agrarian-industrial knowledge society. They were among the most vocal supporters of Wagner's fodder cultivation discussed in chapter 2. By contrast, agricultural teacher Josef Schmidtberger in the early 1890s and former agricultural teacher Franz Hinders in the early 1900s pushed extension infrastructure and communication reaching beyond the Sauerland. In between, local estate owners without formal education took over association leadership and largely maintained or abandoned the activities and relationships forged by their progressive predecessors and followers. Translation of agricultural innovation from elsewhere to Serkenrode farmers was easier with trained extension advocates versed in local conditions at the helm of the agricultural association.

Members also shaped these bursts in innovation and links to knowledge infrastructure. Even though they might pay their membership fee, some farmers did not attend association meetings, lectures, or even fairs. In 1883, Serkenrode leadership complained that farmers had been too lazy to transport their cattle to the fair's cattle show, making for a pitiful display.[442] Over the following decades, increase in the amount and number of premiums as well as larger interest and funding for breeding cattle helped mitigate the expense in time, labor, and money that came with participation in the cattle show.[443] Access to agricultural journals caused the most pronounced negotiations throughout the 1880s. Association leaders

[441] Minute books Serkenrode; Finnentrop Gemeindearchiv, Folder 1267, "Errichtung einer ländlichen Fortbildungsschule Fretter."
[442] Minute books Serkenrode September 5, 1883.
[443] Compare for example the 32 premiums amounting to more than 500 Mark awarded in 1903 for a display of 84 pieces of cattle. Minute books Serkenrode, August 5, 1903.

had to balance financial straits and member complaints in a succession of unsatisfactory models of sharing subscriptions between members. Their negotiations came to a head in late 1884 when leaders suggested a model in which they would filter content in agricultural journals for publication in local newspapers rather than give members direct access to journals. Members were not pleased even though this model was by far the cheapest. By August 1885, members forced a change back to sharing copies within villages. They accepted the power of journal editors in selecting content but elected local leadership in front of them could not fulfill that same function.[444] Association members were not just passive recipients of whatever leaders passed to them. If innovations and communications fit, they would consider or even support them. If they disappointed, members had the power to reject innovations, whether or not the rest of the local or wider agrarian-industrial knowledge society agreed on them.

Different in their particulars, the various kinds and levels of engagement of Paris, Maine, and Serkenrode farmers reveal how knowledge infrastructures of the agrarian-industrial knowledge society reached into daily lives. They made small but influential contributions of ideas, practices, and amchines that could help solve problems on family farms. In both places, these knowledge infrastructures integrated into farm family relationships and encouraged negotiation of innovation. While infrastructure connections were alike, outcomes of these negotiations were very different. Depending on their individual and shared contexts, farm families would choose whether and how to engage in the farm innovations presented to them.

## Minds changed: Negotiating innovation with market agents and family on the Robinson-Parsons farm

Cows had been part of the Robinson-Parsons from its founding. Most of the milk fed the family or was sold or bartered as butter or cheese. The cows ate hay and maybe some fodder corn but little mind was paid to extending this feed base. Potatoes, corn, wheat, oats, and barley grew on their fields, apples in their orchards. The ten to fifteen cows shared their humble barn with a few pigs; sheep had their own

[444] Minute books Serkenrode, January 6, 1879, December 10, 1879, October 21, 1880, July 8, 1883, October 26, 1884, August 30, 1885.

barn. The cows were part of the farm but they had to compete with various other plants and animals vying for human attention.[445]

On September 11, 1871, the cows on the Robinson-Parsons farm rose in importance. Their main keeper, Stephen Robinson Parsons, began to note down their milk production in a thick little notebook. The inspiration came from Stephen's neighbor Harvey Swett, who offered five cents per quart, delivered to Harvey's house. This had been enough to get Stephen's mind thinking about what his cows ate and, more importantly, what their feed cost. His haying operation largely continued as it had been, but Stephen began to buy meal and corn in bushels to improve his feeding. He also tried to mix this with bran once in January before he moved on to mixing with middlings for the rest of the season before pasturing resumed in May 1872. In a neat list in the back of his notebook, he noted down the amounts and cost of purchased feed interspersed with pages recording his milk deliveries. Like so many other expenses and incomes of his farm operation, Stephen wanted to remember the cost of feed and delivery of milk, keeping track of his income per winter. In the first winter, he seems to have calculated feed cost against milk sales. He continued selling milk and buying feed the next year and the next and then for the rest of his life. Stephen seems to not have expected this enterprise to do as well as it did. His first milk and feed records he had placed at the end of his notebook like he would several other trial, transitory accounts. But his milk and feed records turned out to be not so transitory. So, Stephen continued these accounts page by page from right to left. By 1875, Stephen had filled this account book with all kinds of expenses from the front and feed and milk from the back. He was well underway experimenting with meal, corn, bran, and middlings according to milk production and prices. A simple trial had changed his farm forever.[446]

Stephen had joined the improvers of his neighborhood when it came to feeding. How had this decision been possible? One key ingredient was Harvey Swett's father, William, the biggest dairy farmer in Paris, sales agent for a new design of hay tedder, and a very active member in the county agricultural

[445] Parsons and Parsons, *Letters from the Attic*, 5-36; Parsons and Parsons, The Diary of Stephen Robinson Parsons.
[446] Stephen Robinson Parsons' notebook, 1870-1875, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI.

society and state board of agriculture.[447] In January 1871, William Swett had returned full of enthusiasm from the winter session of the Maine Board of Agriculture in Farmington, the biggest town one county over. He had given a lecture on better management of dairy cows alongside L. L. Lucas, the improver described in chapter 2. William also heard lectures on European scientific feeding experiments, Vermont butter making, livestock parasites, and farmers' clubs. The most influential lecture, however, had been by Xerxes A. Willard, the dairy editor for the influential *Rural New Yorker*, detailing the successful operation of associated dairying in New York state.[448] With this manual in hand and the positive feedback to his cattle management lecture, it took William and a few other South Paris improvers only a few weeks to bring the matter before their farmers' club. They read out sections of Willard's lecture, had parts of it printed in the *Oxford Democrat*, and brought in a former South Paris farmer to report on his experience with associated dairying in Massachussetts. They then proposed immediate establishment of an association for a cooperative cheese and butter factory.[449]

Associated dairying and better feeding were the talk of the town. Stephen might have attended one of these farmers' club meetings or read about them and the Farmington meeting in the *Oxford Democrat*.[450] Or he might have read the subsequent promotional dairy articles from the *Maine Farmer* republished in the *Democrat*.[451] The direct encouragement to intensify dairy farming probably came from Harvey Swett. He engaged Stephen's milk deliveries, but his father William Swett paid for them. Harvey might have also shared some insight into the feeding practices on their farm. The concentrated feeds

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[447] *Nonpopulation Census Schedules for Maine, 1850-1880*. Microfilm. Maine State Archives, Augusta; Census Year: *1870*; Census Place: *Paris, Oxford, Maine*; Archive Collection Number: *9-145*; Roll: *9;* Page: *7-8*; Line: *12*; Schedule Type: *Agriculture;* Goodale, *Report Maine Board of Agriculture 1870*, 3; Goodale, *Report Maine Board of Agriculture 1871*, 3; Goodale, *Report Maine Board of Agriculture 1872*, 3; "Bullard's Hay Tedder," *Oxford Democrat*, May 28, 1869, 4; "The Oxford County Agricultural Fair," *Oxford Democrat*, Oct 8, 1869, 2.
[448] Goodale, *Report Maine Board of Agriculture 1871*, 10-32, 67-153.
[449] "Farmers' Club—Paris," *Oxford Democrat*, Jan 27, 1871, 2; "Farmers' Club—Paris," *Oxford Democrat*, Feb 3, 1871, 2.
[450] "Maine Board of Agriculture," *Oxford Democrat*, Jan 20, 1871, 4; "Maine Board of Agriculture. Farmers' Convention at Farmington," *Oxford Democrat*, Jan 27, 1871, 4; "Maine Board of Agriculture. Farmers' Convention at Farmington," *Oxford Democrat*, Feb 3, 1871, 4; "Maine Board of Agriculture. Farmers' Convention at Farmington," *Oxford Democrat*, Feb 10, 1871, 4.
[451] "Dairying in Maine," *Oxford Democrat*, Feb 24, 1871, 4; "Dairying in Maine," *Oxford Democrat*, March 3, 1871, 4.

Stephen began to use certainly mirrored the advice of William Swett as presented in his lectures at the South Paris farmers' club and at the Farmington meeting of the Maine Board of Agriculture.[452] He also could have learned about them at the local flour and feed mill of David N. True and the local feed and fertilizer dealer A. E. Shurtleff, both in South Paris. Incentive and know-how came through the same personal channels and reinforced each other. As improvers began to understand, plugging farm innovations *and* the promise of profit into the social networks of the neighborhood could convince farmers to change their practices. At least it had convinced Stephen Robinson Parsons and his family.

Many Maine improvers ignored the families behind the farmers as an audience. When meetings of the state board of agriculture had argued over how to use farmers' clubs to reach those stubborn farmers, they had thought about attracting farm wives as keepers of proper manners and their daughters drawing younger farmers. What they overlooked was that farm women also listened to the lectures given at these meetings. Association and club reports seldom listed the women attending and their contributions were rarely noted, but they were there – not just because their husbands were, but because they cared.[453] Even in patriarchal households, male farmers had to negotiate agreement with their families, especially when they relied on family labor as in dairying.[454]

Nineteenth-century dairy labor in the Northeast required collaboration and flexibility of the whole family. While work in the house and garden was generally defined as women's labor and work in the field as men's, dairy production passed through both of these realms and connected them in the barnyard. Historian Nancy Grey Osterud has demonstrated that especially on Northeast dairy farms, these gender assignments were flexible. Women could help out in the hay field, men could take on milking or churning the butter, depending on personal preference and family composition. On the Robinson-Parsons farm in

[452] "Farmers' Club," *Oxford Democrat*, Dec 23, 1870, 4; Goodale, *Report Maine Board of Agriculture 1871*, 10-20; Stephen Robinson Parsons' notebook, 1870-1875.
[453] Consider this lecturers' special note of farm women in the audience at this lecture: A. W. Cheever, "Cattle Foods and Methods of Producing Them," in *Twenty-Fourth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1880 (Augusta: Prague & Son, 1880)*, 27.
[454] For the culture of respect and reciprocity farm women in fact cultivated in rural organizations that included both men and women, see Nancy Grey Osterud, *Bonds of Community: The Lives of Farm Women in Nineteenth-Century New York* (Ithaca: Cornell University Press, 1991).

1871, both Stephen and Mary had a stake in dairy labor. In his 1860s diaries Stephen did not mention doing dairy work, so he probably stuck to the fields, but his detailed milking and feeding notes suggest he spent a good deal of time with the cows and made feeding decisions. His wife Mary almost certainly knew how to make butter and cheese, and would have noticed the effect feed could have on butter and cheese properties. She had been a hired hand for the Robinson-Parsons household in the early 1860s before she married Stephen in 1865. She gave birth in 1865, 1867, 1869, and 1871, which undoubtedly made making cheese at home more challenging, as historian Sally McMurry has identified. Stephen and Mary probably relied more and more on hired help to relieve Mary of this burdensome work.[455]

The inventory of the farm upon the death of Stephen's father John in 1868 gives a glimpse into this work process. It included ten pails, tin pans, two wooden bowls, butter boxes and firkin, a cheese press and hoops, two cheese screens, and 32 pounds of cheese. These tools tell the story of the arduous process of making butter and cheese: milking the cows in the morning and evening, carrying the milk in pails usually to a cool basement, letting the cream rise in shallow tin pans, skimming off the cream to store before churning the cream into butter and working, washing, and salting the butter in a wooden bowl before storing it in butter firkins and boxes. For cheese production, the process was even more involved. Then cleaning, scalding, scouring, and drying the tools added more work. This tremendous amount of labor fell on the farm women. So most likely transferring the labor of butter and cheese making to a community factory required family decision making.[456]

So, arguments for associated dairying did not just convince Stephen, they must have convinced Mary. Selling the milk rather than butter or cheese eliminated all of the work involved in making butter and cheese except the cleaning and scalding of milk cans. Familiar with demanding dairy labor and

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455 Osterud, *Bonds of Community*; Nancy Grey Osterud, *Putting the Barn before the House: Women and Family Farming in Early-Twentieth-Century New York*, electronic resource (Ithaca: Cornell University Press, 2012); Sally Ann McMurry, *Transforming Rural Life: Dairying Families and Agricultural Change, 1820-1885*, Revisiting Rural America (Baltimore: Johns Hopkins University Press, 1995).
456 Parsons and Parsons, *Letters from the Attic*, 10-11, 26-28; Meredith Leigh Quaile, "Sisters in Toil: The Progressive Devaluation and Defeminization of Ontario Dairywomen's Work and Tools, 1813–1914" (Ph.D., Canada, Memorial University of Newfoundland (Canada), 2010); Sally Ann McMurry, *Transforming Rural Life*; Osterud, *Bonds of Community;* Nancy Grey Osterud, *Putting the Barn before the House*.

occupied with four children under age ten in the house, Mary must have been all for making the shift to associated dairying. Their neighbor William Swett, like many other improvers, was aware of the potential of cheese and butter factories to lighten the workload of women, but they still appealed only to the men in their audiences as the patriarchal decision makers, never mind that their wives and daughters were often sitting right beside them.[457] Improvers viewed lightening farm daughters' workload as a means to keep them from moving to the cities and depopulating the countryside. Also, farm wives would be more cheerful, would not age as fast from being overburdened, would have more time for beautifying the farm home and flower gardens, and could raise their intellects by reading books and magazines. Helping women would help men, or so went the argument. Many improvers envisioned farm women in the image of bourgeois city women, confined to the household, ornamental garden, and social affairs. In reality, however, dairy women like Mary doubtlessly discussed the matter with their husbands and argued for the great labor and financial advantage it provided, not for the bourgeois domesticity improvers imagined, but for the good of the farm. Profitable and labor-saving, farm women and men learned that associated dairying was a win-win for the whole farm family.[458]

The ensuing payments of the cheese factory drove more thinking about feeding. And when cheese factories turned to creameries, they favored those farmers who thought like their operators. Informed by scientists' ever churning research, the thoughts of factory cheese and butter makers materialized in the milk – then cream – they demanded. William Swett and other private buyers Stephen engaged in the 1870s paid by the quart of milk. The South Paris cheese factory, established in 1873, measured the milk delivered in pounds. Beginning in the 1880s, creameries in the area began to pay Stephen for just the cream, separated within standard-size milk cans and measured in inches. In 1893, the Babcock test for

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[457] Goodale, *Report Maine Board of Agriculture 1870*, 355-356.

[458] For a very good example for the numerous improver arguments promoting associated dairying for the sake of lightened women's workload, see D. H. Thing, "Advantages to Accrue to Farmers' Wives and Daughters By Associated Dairying," in Goodale, *Sixteenth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1871*, 35-40. For the lecture William Swett seconded, see John H. Gurney, "Associated Dairying," in Goodale, *Fifteenth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1870*, 334-348. They generally mirror the arguments outlined by McMurry, *Transforming Rural Life.*

butter fat entered Stephen's life and henceforth all creameries he delivered to paid him for pounds of butter fat contained in the cream he delivered.[459] On the one hand, this evolution showed efforts to prevent fraud by farmers adding water to their milk deliveries or skimming the cream. On the other, paying for cream and then fat content pushed farmers to feed for fat content. This mechanism extended the reach of the creamery operators into the feeding practice of farmers as no lecture or neighbor's advice could have done. Using high-protein feeds and principles of ideal rations now paid more than ever before.

Stephen's feeding practice certainly went along with the push and pull of intensification, but he changed carefully, conscious of his means. On March 3rd, 1881, he noted the beginning of presumably his first experiment with cottonseed meal: "commenced to feed 5 two year olds with about 1 qrt bran & 3/4 pint cotton seed meal once a day."[460] This was certainly a careful trial since he spent only $1.70 on 100 pounds of cottonseed meal, enough for about one and a half months of his specified feed regiment. His incentive at this time had not changed. Stephen was major shareholder and secretary of the South Paris Dairy Association, which operated the cheese factory he sold to in pounds. So, Stephen seems to have started his trial on his own volition. This was different when the Poland Dairy Association began paying Stephen for his butter fat content in January 1893. It seems to have taken Stephen about half a year to adapt his production from volume to fat content. Judging from this time span and in the absence of feed records for this time, it is most likely he changed his feeding regimen to achieve these results: a direct result of the introduction of payment for butter fat.[461]

[459] Developed in 1890 by Stephen M. Babcock, agricultural chemist at the experiment station of the University of Wisconsin – Madison, this easy-to-use test determined the percentage of butter fat in the milk which would then be multiplied by the number of pounds of the cream Stephen delivered to arrive at the pounds of butter fat he would be paid for. Ionel Rosenthal and Baruch Rosen, "100 Years of Measuring the Fat Content of Milk," *Journal of Chemical Education* 70, no. 6 (June 1, 1993): 480-482; Micah Rueber, "Is Milk the Measure of All Things? Babcock Tests, Breed Associations, and Land-Grant Scientists, 1890-1920," in *Science as Service: Establishing and Reformulating American Land-Grant Universities, 1865-1930*, Nexus: New Histories of Science, Technology, the Environment, Agriculture & Medicine (Tuscaloosa: University of Alabama Press, 2015), 93–114.
[460] Stephen Robinson Parsons notebook, 1875-1882, March 3, 1881.
[461] The volume and fat content of cream was also related to breeding and care of cows but it is unlikely that Stephen exchanged the animals of his herd this quickly or that a potential change of his stable had such a dramatic effect.

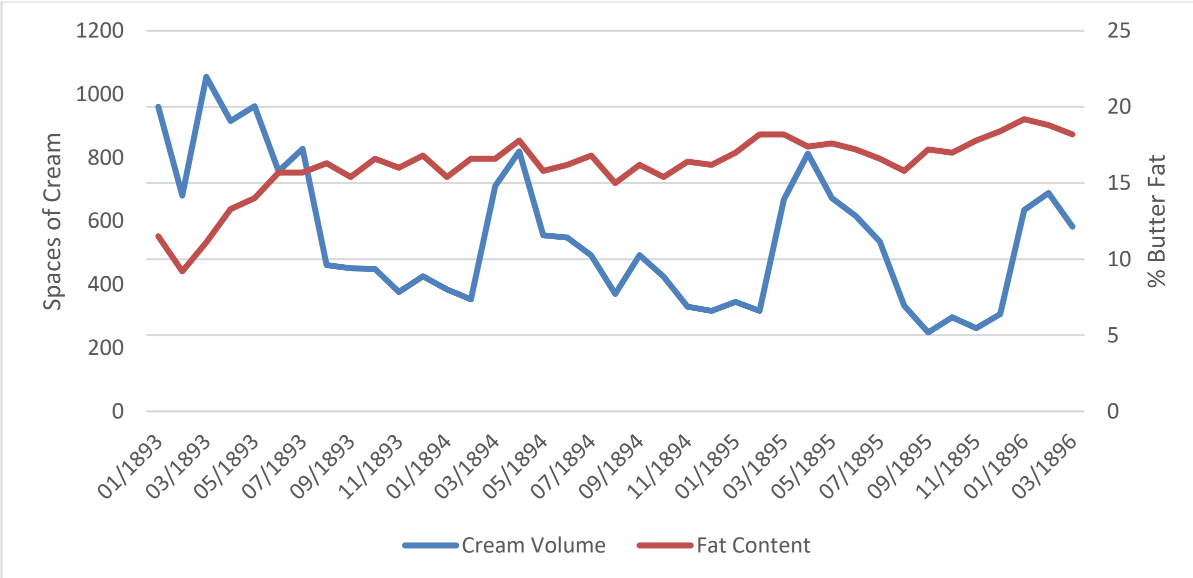


Figure 35: Stephen Robinson Parsons' Initial Cream Sales Paid by Fat Content, 1893-1896. "Spaces" of cream were a new measure of volume for cream which Stephen also had to learn.[462]

From January to June of 1893, the fat content was the lowest Stephen ever recorded whereas the volume of cream was much higher than the seasonal pattern he established in the following years. In 1896, Stephen copied a standard for cream content into a little booklet in which he collected short facts to remember: "Good Cream tests 15 to 20 % fat – 18 is a good average." By that time, he had raised his production to exactly that good average and continued to raise it. While Stephen was capable and motivated to intensify his feeding on his own terms, industry standards based on scientific methods also shaped his feeding practice.[463]

The translation of scientists' principles also made their way into Stephen's feeding. Around 1896, Stephen copied into his fact book an ideal ration:

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[462] The graph is based on the monthly pay slips Stephen received from the Poland Dairy Association, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI. Sometime in 1893 or 1894, Stephen noted in his little fact notebook: "The cream measure called a space is the amount in a cylinder 8 ½ in in diameter and 19/64 of an inch high." See Stephen Robinson Parsons' notebook marked "Compliments of… American Cotton Oil Co. etc," private archive of Jeffrey and Mary Parsons, Ann Arbor, MI. In 1896, the Poland Dairy Association switched to measuring cream in pounds again. In 1901, Stephen switched his deliveries to the Turner Centre Dairying Association which took the cream in spaces again.

[463] Stephen was aware of the influence creamery operators had over the feeding practice of their patrons. Most likely in the late 1890s, he cut out an article reprinted from Dairy World which advised creamery operators to make sure patrons were feeding for firm, yet spreadable butter, just like consumers wanted it. "Old newspaper articles."

Ration for one day for animal weighing 1000 lbs

| | |
|---|---|
| 16 lbs | meadow hay |
| 8 " | bran |
| 2 " | O[ld]. P[rocess]. [linseed] oil meal |
| 6 " | corn meal[464] |

The formatting of this little copied text hinted at its origin. It had found its way to Stephen from one of the standard feeding manuals of the day, probably through one of the farm journals to which he subscribed.[465] First published in 1883, Elliott W. Stewart's "Feeding Animals: A Practical Work upon the Laws of Animal Growth" had become a widely respected work on animal feeding from an improver's perspective. Several other publications quoted his sample rations, usually endorsed by dairymen's associations.[466] In Maine, it was assigned as a textbook at the State College along with Henry Prentiss Armsby's "Manual of Cattle Feeding."[467] It included several sample ideal rations which Stewart had adapted from the productive rations of a Thomas Horsfall of England, who published in the 1850s and 1860s. Stewart used the methods of American and German scientists including Armsby and Emil Wolff to recalculate these rations to include American feedstuffs. However, Stewart's ideal ration was not immediately useful to Stephen. Underneath it, he noted the conversion of the ingredients from weight to volume, pounds to quarts, rounded "for feeding purposes."[468] As in his previous experiments, Stephen seems to have used a measuring cup rather than a scale when assembling the rations for his cows. It made measuring easier and faster. The translation chain from laboratory to barn worked, but it did not anticipate the practical difficulties scientific standards caused for use in practice.

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464 Stephen Robinson Parsons' notebook marked "Compliments of… American Cotton Oil Co. etc." Compare to Stewart, 350.

465 Several of the "facts" in his fact book he marked as coming from the *Maine Farmer*, for example. The "old process" was also a change from the original Stewart publication reflecting the change in processing linseed meal in the 1890s.

466 Lowell Stewart Hardin, "Jersey Cattle. First Prize Essay," in *The Jersey Cow; Her Origin, Breeding, Management, and Worth* (New York: American Jersey Cattle Club, 1885), 34; Thomas Day Curtis, "The Rational Ration," in *The Illinois State Dairymen's Association. Tenth Annual Report*, ed. R. P. McGlincy (Elgin, Illinois: The Advocate-News Printing, Publishing and Binding House, n.d.), 30; Thomas Day Curtis, *Hints on Dairying*. (Farmer and Dairyman: Syracuse, NY, 1885), 47.

467 See e.g. University of Maine and Office of Student Records, "Catalogue of the Maine State College, 1894-1895, Pages 55-116," General University of Maine Publications, 1895, https://digitalcommons.library.umaine.edu/univ_publications/29, 69-70.

468 Stephen Robinson Parsons' notebook marked "Compliments of… American Cotton Oil Co. etc."

Stephen adapted this ideal ration to fit his experience and preference. His selection of this specific ration is meaningful. Stewart's several sample rations were usually quoted together to give farmers a variety to choose from according to local availability and price. Stephen did just that. He had fed bran and corn meal since the early 1870s. Judging from his careful price notations and calculations, these feedstuffs were not only available and cost effective, they were very familiar. He evidently judged the ratio of these feeds in the light of his own feeding trials. This experience also shaped his adaptation of Stewart's ideal ration. Among the weight to volume conversions, he did not note the conversion for linseed meal, specified in Stewart's ideal ration, but for cottonseed meal. His feed purchases between 1897 and 1902 noted linseed meal only once for hens and hogs, not for cows, for which he bought cottonseed meal. Both marketed as protein-rich industrial byproduct feeds, Stephen seems to have substituted the previously satisfactory cottonseed meal for the prescribed linseed meal without concern for their different chemical compositions. Scientists had intended their sample ideal rations to inform farmers' existing feeding practice to approach scientific feeding. Judging from his rounded conversions and unconcerned substitutions, Stephen cared about improving his own trials rather than matching scientists' feeding standards.[469]

The only ideal ration Stephen recorded was but a glimpse into his feeding practice. In the winter of 1897-8, he purchased bran, corn meal, and mixed feed (usually several cereal milling byproducts akin to bran) as low-protein concentrated feeds. They were similar nutritional composition and in price, between 74 and 80 cents per bag. For the more expensive and effective high-protein feeds, Stephen was more distinguishing. In November 1897, Stephen chose Chicago gluten meal at $1.20 per bag. This newcomer among high-protein feeds was a byproduct of corn processing for glucose production. He fed this gluten meal all through winter until March 1898 when he experimented with cream gluten meal, a very similar product, for $1.05. This apparently proved unsatisfactory or increased in price because in

[469] For the different compositions of high protein feeds, see Henry Prentiss Armsby, *The Computation of Rations for Farm Animals*, Pennsylvania State College. Agricultural Experiment Station. Bulletin of Information No. 1 (State College, Pa., 1898), 39.

mid-April, Stephen switched to cottonseed meal for $1.10 per bag, which he used until he turned the cows out to pasture in early July. It seems that Stephen did not care much about exact equivalents of high-protein feeds, much less about calculating and comparing the money value of the nutrients contained in them.[470] The price of the feed and its performance seems to have made the difference in his choice of feed. Scientists had designed their principles of ideal rations for farmers to navigate the ever-expanding feed market. It seems that Stephen was able to do this dynamically on his own, informed not by detailed calculations but his own trials. These trials Stephen tweaked with the translated bits and pieces of scientist principles and improver adaptations that reached him. Still, the results of his own trials, on his farm, with his cows, by his hands, seen with his eyes, and draining and filling his wallet seem to have been the most credible evidence shaping his decisions.

Stephen's feeding decisions also shaped the decisions of his son Oscar. His feed purchases from the time Stephen died in 1905 into the late 1910s largely circle around the same items: bran, corn meal, mixed feed, middlings, cottonseed meal. Oscar seems to have distinguished between cereal milling byproducts less than his father. His son Mert illuminated Oscar's frequent notes of purchasing "grain" when he reminisced that this meant "any feed concentrate such as bran, corn meal, or mixed feed."[471] The feed staples remained unchanged and blended together in use.[472]

Both Stephen and Oscar experimented with new feeds on the market. Stephen took note of some of the brand names of new feeds in the late 1890s, such as Victory feed, King Gluten, or Chicago Gluten. Oscar in his time tried hominy and probably balanced ration feeds for chicks. Also, Stephen had been interested in condimental feeds, which were added to rations in small amounts but promising more rounded nutrition and medicinal effects. Stephen took home a free brochure on Climax condimental feeds and bought two packages of Baum's condimental feed in the winter of 1901-02, but not thereafter. Either Stephen and his student Oscar had been disappointed by this trial or they followed scientists' warning that

[470] As Armsby did in his 1898 bulletin, ibid, 39.
[471] Parsons, Clifford Colley, and Parsons, *Life on the Farm and in the Village: South Paris, Maine, 1910-1925*, 106.
[472] Compare Parsons, Clifford Colley, and Parsons, *Life on the Farm and in the Village: South Paris, Maine, 1910-1925*.

condimental feeds were overpriced and unfit to replace proper veterinary care. It seems both Stephen and Oscar engaged with feed innovations in their own trials.[473]

Finally, Oscar departed from his father's practice in larger bulk purchases of some feeds. He continued to buy several feeds by the 100-pound-bag as his father had done, at most four at a time, spending less than $5 at the local South Paris store or mill.[474] This had allowed Stephen flexible choices according to current price and that was advertised by feed manufacturers as convenient and saving in storage cost and expertise. However, it seems Oscar began to mix his father's small purchases with larger orders, preferring savings in bulk purchases over convenience and cost in transport and storage. Oscar bought feed by the half ton, cottonseed meal in 1914 and bran in 1918.[475] In March 1917, Oscar traveled more than fifteen miles to West Minot to buy 4 bags of cottonseed meal, 16 bushels of cracked corn, and 14 bushels of meal for $46.70, on which he received a one-dollar discount.[476] Still, like his father, Oscar preferred to mix his own feed rather than pay a little more for the balanced ration cattle feeds sold more and more in the stores he frequented.[477]

Feeding knowledge and practice was negotiated between generations. On the Robinson-Parsons farm, Oscar continued what his father had taught him, in specific practices but also in ways of thinking. Oscar continued Stephen's combined records of income and expenses to the degree that without knowledge of Stephen's death, it is close to impossible to see when he took over his father's little notebook. At the same time, Oscar tried double entry bookkeeping in a different notebook, separating his debits from his credits on opposing pages. After a few months, however, he combined this approach with

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473 Oscar also introduced a silo to add to his rough fodder at the latest in 1909, an innovation of the time, previously unavailable to Stephen. Oscar Parsons' check book, 1909-1911, Aug. 2, 1909, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
474 Stephen Robinson Parsons' notebook marked "Feed acct 1897&8," private archive of Jeffrey and Mary Parsons, Ann Arbor, MI
475 For the cottonseed purchase, see Oscar Parsons' check book, 1913-1914, Nov 10, 1914, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI. For the bran, see Oscar Parsons account book, 1905-1918, March 17, 1918, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
476 Receipt kept in an envelope included in Oscar Parsons account book, 1905-1918.
477 South Paris feed dealer A. E. Shurtleff became an agent for Pratt food. Ads by South Paris feed dealer C. B. Cummings & Sons in 1900 included several commercial feed brands, see e.g. *Oxford Democrat*, Jan 30, 1900, 3.

his father's, noting income and expenses on the same page but followed by a credit and a debit column.[478] Feeding was no different. Oscar negotiated what his father had taught him with his own trials inspired by what he might have read or heard. Conditions changed in the market, in farm innovations, and on the farm. Oscar had learned from his father not one static feeding practice adapted to conditions prevailing before Oscar's time, as improvers and scientists had accused farmers since the eighteenth century. Rather, Oscar had learned how to adapt to changes in available farm funds, market prices, and feeds, extending his father's way of thinking into the twentieth century.

**Minds unchanged: Association members refuse to feed differently in Serkenrode**

> Next there was a short explanation of pasture feeding of cattle. The agricultural teacher Hinders tried to explain the physiological effect of the individual nutrient groups as well as the advantages of rational feeding and the calculation of a feed account. However, the subject seemed to find favor only with single audience members as only three of those present participated in the discussion whereas Mr. Hinders was given the advice to lead by example in this area himself.[479]

From the late 1870s to the 1910s, Serkenrode farmers generally did not order commercial feed by way of the agricultural association even though leadership pushed and offered. They placed joint orders for fertilizer and seed, but not for feed. Individual farmers might have ordered feed through the purchasing cooperative (*Konsumverein*), but by and large farmers refused to purchase feed and calculate ideal rations. Unlike the Robinson-Parsons, no trial, no words, and no incentive could convince these farmers. Why? There are multiple answers.

Industrial byproduct feeds competed with Wagner's fodder cultivation as an innovation. Even though both innovations were based on scientists' principles of animal nutrition, Wagner's method of growing more protein-rich hay was specifically designed with Sauerland farmers in mind, to diminish or replace purchases of industrial byproduct feeds. In Serkenrode, the agricultural association and its active

[478] Oscar Parsons account book, 1905-1918.
[479] Minute books Serkenrode, October 26, 1884. Original: "demnächst fand eine kurze Erläuterung der Wiesenfütterung des Rindviehs statt. Der Landwirtschaftslehrer Hinders suchte die physiologische Wirkung der einzelnen Nährstoffgruppen, sowie die Vortheile einer rationellen Fütterung und die Aufstellung eines Futter-Etats zu erklären. Die Sache schien jedoch nur bei Einzelnen Anklang zu finden, denn an der diskussion betheiligten sich nur drei der Anwesenden, dagegen wurde dem Hr. Hinders der Rath ertheilt, auf diesem Gebiete erst einmal selbst mit gutem Beispiele voranzugehen."

members repeatedly and unanimously praised Wagner for this work. Vicar Dornseiffer in his 1883 annual report for the association made very clear that Wagner's much-lauded method should replace the purchase of industrial byproduct feeds. He pointed out that the feeding and monetary value of Wagner hay was superior to peanut cakes, the most nutritious and most expensive industrial byproduct feed on the market. In an idealized example arguing for livestock rather than cereal farming, Dornseiffer included in his sample calculation 200 Mark for "mixed cereal grist or other concentrated feed, even though this appears superfluous in the light of the previously mentioned analyses of Wagner's fodder cultivation."[480] Local Serkenrode improvers sent mixed messages, at times encouraging feed purchases, at others arguing against them. Serkenrode farmers already had the innovation they needed to solve their feeding problem.

Wagner's method fit the existing practices of Serkenrode farmers better than industrial byproduct feeds. Association leadership reflected the generally held conviction that hay and grass were the normal fodder for cattle. Farmers could know for themselves the hay they grew as opposed to factory-processed byproduct feeds they bought. Wagner's innovation focused on improving the quality of hay. While Wagner's fodder cultivation was difficult and expensive to establish, feeding its hay was easy because it was not new at all. Also, farmers could use it to continue to grow their own supply of fodder as they had been. Dornseiffer's idealized fodder and feed supply reflected the preference. He listed meadows and Wagnerian fodder fields on the rough fodder side and growing mixed grains and a mixture of oats and vetches on the feed side. Later in the 1883 report, he described the increased focus on growing root crops for feed like mangold, rutabaga, or kohlrabi.[481] Farmers seem to have valued the familiarity, independence, and market resistance of growing their own feed and fodder over the promise but also unfamiliarity and market dependence of industrial byproduct feeds. As much as improvers attacked farmers for sticking to old practices, Sauerland improvers learned that fitting time-proven practices into

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[480] *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883* (Paderborn: Bonifacius, 1883), 10. Original: "Mischkornschrot oder sonstiges Kraftfutter, obschon dieses nach Maßgabe der früher erwähnten Analysen des Wagnerschen Futterbaues als überflüssig erscheint."
[481] Ibid, 9-10, 22.

innovations made them agreeable to farmers. Industrial byproduct feeds were not easily understood as a useful innovation.

Serkenrode association members did not lack the cash or credit to purchase agricultural inputs. In 1866, the Serkenrode association began placing joint orders for various kinds of fertilizer and continued these orders almost every year into the 1900s. By the 1880s, the joint value of these orders hovered between 1,000 and 2,000 marks and also expanded to joint orders for seed.[482] In 1882, the Serkenrode association had also facilitated the establishment of two rural credit cooperatives (*Darlehensverein*) in the township, one of which provided close to 20,000 marks in loans in its first and close to 40,000 marks in its second year.[483] By and large, Serkenrode farmers chose to largely invest their money and loans into fertilizer and seed rather than industrial byproduct feed.

This choice was related to farmers being more familiar with cereal agriculture than market-oriented livestock farming. Against the scientific argument that industrial byproduct feeds fed livestock and their manure was as good as commercial fertilizer, Serkenrode improvers argued that growing more and better fodder and feed would do the same and reduce the fertilizer bill.[484] It seems Serkenrode farmers were reluctant to embrace livestock farming fully. All the new demands that came along with it, including new skills and knowledge, created risk. Buying fertilizer rather than feed enabled a trial and mixed operation of livestock and cereal agriculture by growing fodder, feed, and cereals. Toward the end of the 1880s, Sauerland farmers also found that once Wagner's fodder fields were tilled over, their soil was improved by Wagner's plant mix and produced ample amount of grain.[485] While their limited cash

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[482] Minute books Serkenrode, February 8, 1866, March 16, 1880, October 18, 1883, August 30, 1885.
[483] *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883* (Paderborn: Bonifacius, 1883), 15; *Vierter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1883-1884* (Paderborn: Bonifacius, 1884), 9.
[484] Dornseiffer argued as much and the district agricultural association soon reported that this prediction had come true for a local farmer. *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883*, 11; *Jahres-Bericht der Landeskultur-Gesellschaft für den Regierungsbezirk Arnsberg 1888.* (Münster: Theissing'sche Buchdruckerei, 1889), 19. For the scientific argument, see Joseph König, *Chemische und technische Untersuchungen der Landwirthschaftlichen Versuchsstation Münster in den Jahren 1878-1880. Zweiter Bericht*, (Theissing'sche Buchdruckerei: Münster, 1881), 14.
[485] *Jahres-Bericht der Landeskultur-Gesellschaft für den Regierungsbezirk Arnsberg pro 1887.* (Lüdenscheid: Ed. Horn jr., 1888), 11.

resources certainly played a role, Serkenrode farmers largely did not purchase industrial byproduct feed because they favored a much slower and safer shift to livestock farming than their leaders had envisioned.

In fact, slow change turned out to be the wiser choice because the market incentives fluctuated significantly through the late nineteenth century. Despite the glorious promises of Serkenrode association leadership, their cooperative creamery stopped operations after three years in 1883 and left the association a hefty debt of 820 Mark, paid back only in 1893.[486] Had farmers invested in milk production, the creamery would not have survived anyway. Improver prophesies proved false across the Sauerland, as no creamery survived the 1880s if it was located in the difficult uplands.[487] Farmers turned to breeding beef cattle and hogs but boom and bust of cattle prices through the 1880s and early 1890s made this a risky undertaking, too. While there was more state and association support for breeding cattle, prices of cattle largely remained tied to fodder production. When fodder failed, farmers were forced to sell their cattle, which glutted the market.[488] The ups and downs of the weather influenced the market and thus the incentive to improve feeding practices. The new focus of intensification lay on breeding, unaffected by the climate and funded by state subsidies. Feeding was largely an afterthought for improvers and farmers.

Serkenrode farmers had a fundamentally different understanding of industrial byproduct feeds from the improvers leading them. When the cooperative creamery lacked sufficient milk deliveries in the winter of 1880-81, association leaders explicitly pushed farmers to purchase industrial byproduct feeds (*Kraftfutter*).[489] They understood the main goal of purchasing feed to be improving the quantity and quality of milk production. Farmers did not heed this advice. In fact, they refused to buy feed through the association all through the 1880s up until 1894. When association leaders offered to place joint orders for feed in July 1883, the assembled members replied they could not gauge their demand as of yet as rain had

486 Minute books Serkenrode, Oct 1, 1893.
487 Consider e.g. the report by the provincial agricultural association of 1888 which lists a whole row of creameries but none of them in the upper Sauerland. *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1888* (Münster: Theissing'sche Buchdruckerei, 1889), 68.
488 Consider the annual reports of the Landeskulturgesellschaft collected in *LAV NRW W*, K 001 / Oberpräsidium Münster, Nr. 1765 - Band: 2 „Landeskulturgesellschaft für den Regierungsbezirk Arnsberg." Reports for 1886, 8; 1888, 12; 1889, 2; 1890, 2; 1893, 3; 1894, 5; 1899, 9.
489 Minute books Serkenrode, Dec 20, 1880.

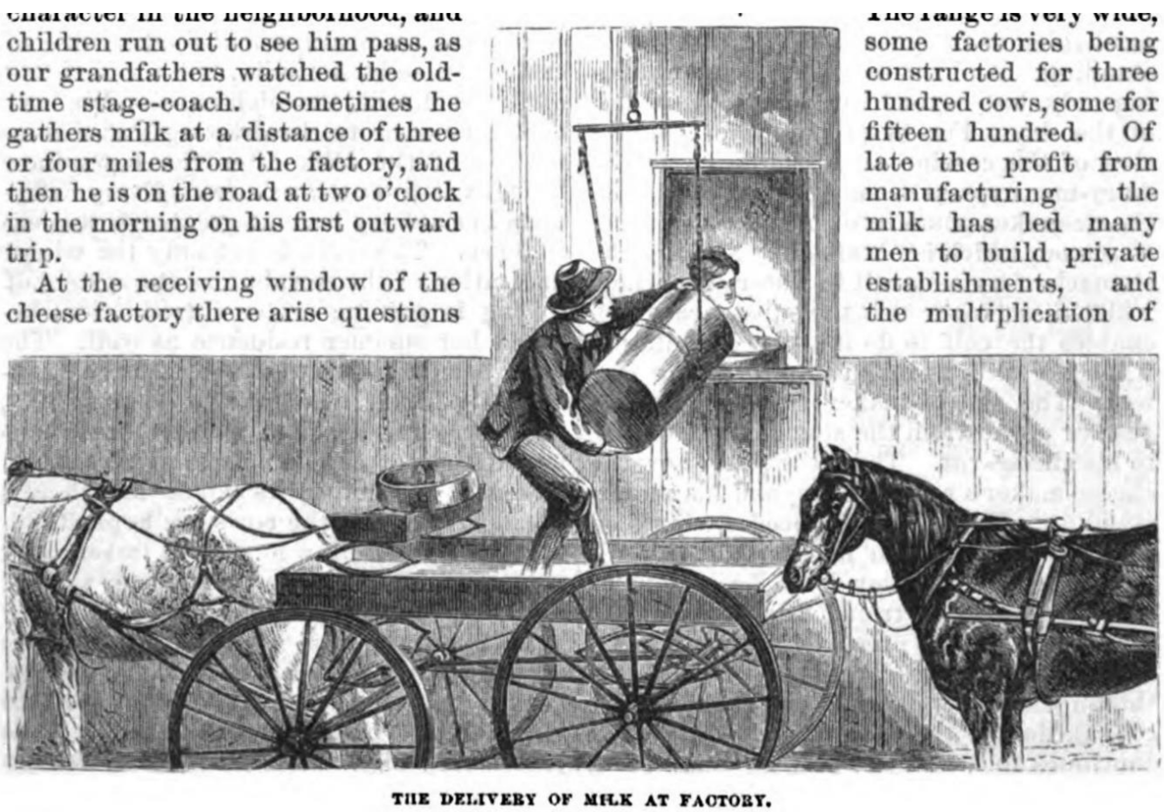
come after long drought which might save their harvests of summer cereals, root crops, and grass and clover hay. In the end, they did not order feed through the association.[490] To Serkenrode farmers, industrial byproduct feeds were an emergency measure. As long as their own feed harvests were sufficient to bring cattle through the winter, they did not need to buy additional feeds. Serkenrode farmers still understood their feed by volume, not by nutritional composition. Lectures by agricultural teacher Hinders in 1884, as by his successor Josef Schmidtberger in 1890, did not change this fact.[491] In January 1894, the severe feed crisis of the previous year and promises of financial support by the association and town administration, enabled Schmidtberger to convince association members to order peanut meal.[492] With insufficient positive examples in their neighborhoods and only extreme crisis motivating farmers, joint orders for feed did not catch on. When Hinders returned to the association as president in 1901, he suggested a joint order for several popular industrial byproduct feeds to respond to the most recent feed crisis, but to no avail.[493] Farmers focused on improving their own fodder and feed production and on breeding cattle and pigs more suited to fattening. Even a trial born out of necessity could not bring association members to change their feeding strategy because it could not transform farmers' ways of thinking about feeding.

Farm families negotiated the use of innovations not only with communicators of the agrarian-industrial knowledge society. Their whole home drove negotiations: their family members, their animals, their lands, their buildings, their neighbors, their relationships, their town – in short, their place. This was why farm families were not passive targets to convince of innovation. They chose very carefully and drove negotiations in their own right. Promoters of innovation usually did not understand which new

[490] Minute books Serkenrode, July 8, 1883.
[491] Minute books Serkenrode, October 26, 1884; June 22, 1890. Newspaper articles by local substitute agricultural teacher Strecker in 1883 also attempted to explain the principle of ideal rations to readers, reproducing the arguments of his teachers at the agricultural academy Poppelsdorf. This seems to have had little to no effect on farmers. W. Strecker, "Ueber Futternormen," *Mescheder Zeitung*, Dec 9, 1881; W. Strecker, „Futteretat," *Mescheder Zeitung*, Dec 20, 1881.
[492] Minute books Serkenrode, Jan 28, 1894.
[493] Minute books Serkenrode, Sept 1, 1901. The association bill for that year lists no increase and is specifically described as a fertilizer bill. Minute books Serkenrode, November 23, 1902.

knowledge and skills their suggestions actually entailed. Thus, they also often failed to grasp the full investment of time and resources required to make innovation work in farm families' homes. Scientists, improvers, extension agents, state agents, and market agents had no way of knowing the specific conditions of every farm family, they largely dismissed the task as unfeasible. It was up to farm families to figure out the required adaptations in family and labor dynamics, farm economy and environment, and relationships beyond the family. They largely did so quietly, uninterested in giving feedback to those telling them to change their ways. The turn to dairying for creamery production shows that farm families were keenly aware of the true costs and risks involved in integrating outside innovation on their farm.

**<u>At the creamery window: Neighborhood and market agent negotiation</u>**


character in the neighborhood, and children run out to see him pass, as our grandfathers watched the old-time stage-coach. Sometimes he gathers milk at a distance of three or four miles from the factory, and then he is on the road at two o'clock in the morning on his first outward trip.

At the receiving window of the cheese factory there arise questions

The range is very wide, some factories being constructed for three hundred cows, some for fifteen hundred. Of late the profit from manufacturing the milk has led many men to build private establishments, and the multiplication of

THE DELIVERY OF MILK AT FACTORY.

Figure 36: The Creamery Window as pictured in *Harper's New Monthly Magazine*, 1875. The accompanying article described the industry as it developed in New York State, which functioned as a model for Maine factories. The article noted the crucial point of the creamery window: "At the receiving window of the cheese factory there arise questions which end sometimes in ill temper, sometimes in the courts of law. All is not milk which comes in cans, and all milk is not good milk."[494]

[494] *Harper's New Monthly Magazine*, November 1875, 818. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/msu.31293022884955?urlappend=%3Bseq=830.

In Serkenrode and South Paris, local improvers and farmers established a cooperative dairy factory. The South Paris factory produced mainly cheese whereas the Serkenrode creamery produced cheese and butter. Both factories were part of a dairy factory boom in their region, in Serkenrode in the early 1880s, in South Paris in the early 1870s, followed by a bust and a transformation. In both places, local improvers and farmers tried to negotiate agreement within the neighborhood and with market agents as the spearheads of the agrarian-industrial knowledge society. These factories functioned as knowledge infrastructure that linked innovation to incentive more directly than any other institution. Advice of extension agents, schools, and farmers' clubs could be dismissed as disconnected from the particularities of farms without direct consequence other than maybe name-calling. Communication by the creamery was not advice at all, it was money. It communicated in the form of payment or refusal to pay.

Local improvers and farmers had invited this stark discipline themselves as a strategy to solve a spatial problem. Robbed of their previous markets of cereals and other crops by global competition, farmers in western Maine and the Sauerland needed a new market. In the late nineteenth century, wheat traveled on steamboats across oceans and along canals, in railroad cars across continents – without spoiling. Milk did not travel far at all. In 1870, if farm families were lucky (like the Robinson-Parsons or the Swetts), they lived near a railroad station and could ship milk without cooling to the closest city, maybe 50 miles away. Most farm families produced butter and cheese at home to overcome the distance to well-paying urban markets. The cheese factory was the next step in solving the problem of distance.

However, the factories created another spatial problem. In the United States and Germany, there had been precedents of neighboring farm families pooling their milk for butter and cheese making. The nature of milk and cream drew sharp boundaries around the distance between these farms. Dairy factories industrialized this process and promised to increase production, but they were still bound by the distance milk could travel on horse-drawn carts before spoiling. In Maine and the Sauerland, this distance was at most about five miles or eight kilometers. These small neighborhood processing centers, euphemistically called factories, were often situated at cross-roads between farm neighborhoods. Still, as with any business enterprise, they had to balance cost of construction and operation with what they could earn. To maximize supply, their operators and owners had to achieve two tasks: convince as many farmers as possible within a five-mile radius to deliver their milk, and convince them to intensify production with better feeding, breeding, and care of more cows. Consumer demand, the shelf-life of milk, proximity of farm neighborhoods, and economic imperatives of industrial production enmeshed dairy factories with the promotion of innovation.[495]

This made cross-roads dairy factories different from all other knowledge infrastructure. Economic self-interest motivated local improvers and farmers to convince their neighbors to adopt dairy milk production and its association. They only retained access to industrial processing and larger markets if the factory continued operation. What was more, most of the first dairy factories in both regions were cooperatives. Many of those delivering the milk also owned part of the factory. Once farmers committed to deliver milk to these local factories, they also enrolled in the efforts to convince more farmers to join them and to use better practices. As they saw it, the factory bound together the fates of all local farm families.

**The first task: Convincing farmers to become patrons**

Building trust in a dairy factory cooperative was paramount. First, farmers had to know that the operators of the dairy knew what they were doing. After their first year of operation, both the Serkenrode and South Paris cheese factories explained their bad results as lack of experience. The Serkenrode cheese factory had to discard large amounts of cheese because of an incompetent cheesemaker. Its operators also had little knowledge of market connections or consumer demand. The cooperative employed a competent Swiss cheesemaker who selected his dairy laborers; it sent future agricultural teacher Franz Hinders to a regional creamery institute to learn about marketing and processing; and they co-engaged the dairy

[495] James G. Gibb, David J. Bernstein, and Stephen Zipp, "Farm and Factory: Agricultural Production Strategies and the Cheese and Butter Industry," *Historical Archaeology* 43, no. 2 (April 2009): 83–107; Osterud, *Bonds of Community*; Osterud, *Putting the Barn Before the House*; McMurry, *Transforming Rural Life*; Fritz Söbbeler, "Gewinnung und Behandlung der Milch einst und jetzt," in *Bauern im südwestfälischen Bergland*, ed. Rötger Belke-Grobe et al., vol. 1 (Münster: Ardey-Verlag/CVK, 2006), 315–30.

instructor employed by the newly founded provincial dairy association to give a lecture about creamery operations.[496] The South Paris Dairying Association described the quality of its first year's production as good, but the inexperience of its leaders had contributed to high production costs. Their subsequent votes to replace a milk vat, cover the sealing above it with sheathing paper, and give the authority to hire cheesemakers to its directors suggest South Paris operators also had much to improve.[497]

Farmers also had to trust their fellow farmers. They were literally pooling their milk with them. For many, this must have been most unusual. The quality and thus the financial return for all could be ruined by one delivery of spoiled milk. This misfortune befell Serkenrode in early 1881. To secure production and restore trust, the board of the association introduced tests for spoiled milk and a strict policy to refuse failing deliveries.[498] The South Paris factory also followed the practice to "test the milk often enough to ascertain that it is sound."[499] The senses of their cheesemakers were the original tests of milk and could fairly reliably exclude spoiled milk deliveries.[500] What they could not yet determine reliably was fraud. Both creameries measured milk deliveries in weight. This meant that farmers could skim their milk or add water to it. The cheese factories cared about the ratio of milk delivered to cheese produced, which in essence meant they wanted the fat in the milk but not its water. Early factories seem to have had limited means to measure fat content, such as a graduated cream glass. More reliable measurements of milk and cream deliveries came only in the mid-1880s.[501] Until then, suspicious looks between patrons failed to inspire general confidence in cooperative cheese factories.[502]

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[496] *Zweiter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1881-1882* (Paderborn: Bonifacius, 1882), 8; *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 1533 , "Errichtung von Sammelmolkereien;" *Jahresbericht über den Zustand der Landeskultur in der Provinz Westfalen 1881* (Münster: Theissing'sche Buchdruckerei, 1882), 24.
[497] Stephen L. Goodale, *Report Maine Board of Agriculture 1873*, 412; Records of the Paris Dairying Association, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI, 10-11.
[498] Minute books Serkenrode, March 21, 1881.
[499] Records of the Paris Dairying Association, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI, 14.
[500] Compare e.g. Francis Barnes, "Associated Dairying," in *Twenty-Fifth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1881*, (Augusta: Sprague & Son, 1882), 206-225; *Harper's New Monthly Magazine*, November 1875, 818-819.
[501] Rosenthal and Rosen.
[502] Landrat Hammer in the early 1880s recorded his impression of farmers' refusal to join cooperatives: "it can be explained more so with the existence of mutual rivalry and distrust as well as with the costs." undated letter draft by

Finally, cooperative cheese factories inspired conflict between shareholders and patrons. The Serkenrode factory operated year-round, and its board of directors set the milk prices paid to patrons. There was no obligation for farmers to continue deliveries at any point. The South Paris factory usually operated from May or June to September and engaged farmers for their milk deliveries for the whole season. Only after the factory's cheese had been sold were farmers paid out of profits according to their proportion of milk deliveries. In Serkenrode, cheese factory operators set the price for milk and paid upon delivery, not according to the profit they made from cheese and butter sales. Also, cooperative by-laws in both places divided participants into shareholders who had invested funds into the cooperative and patrons who delivered milk to the cooperative but did not own shares. Shareholders received a dividend on their investment whether they delivered milk or not. At the incorporation of the South Paris Dairying Association in 1873, at least 25% of shareholders were non-farmers, and they held more than 25% of shares (see Figure 36). The Serkenrode Dairying Association reportedly had six larger and six smaller farmers as shareholders but this also soon included Dornseiffer, a priest, not a farmer. These constellations invited conflict. As one of their opponents called them in an 1881 South Paris lecture, these "speculators" skimmed off the profits of the cheese factory. Wealthy farmers double dipped and non-farmers sucked money out of the milk patrons had delivered.[503] As a result, the South Paris association repeatedly voted to reduce profits for shareholders and include patrons in some of the cooperative's decisions. The Serkenrode association reduced shareholder dividends and raised milk prices at the risk of factory profits and, in fact, bankruptcy. Cooperative cheese factories brought out the economic inequalities of farm neighborhoods and created reasons for farmers to shun cheese factories altogether.

Markus Hammer, in LAV NRW W, K 333, Folder 1784, "Einführung des sogenannten Wagner'schen Futterbaus." Original: "mehr noch aus dem Bestehen gegenseitiger Rivalität u. Mißtrauens, wie aus dem Kostenpunkte erklären läßt."

[503] Barnes, "Associated Dairying." Barnes held a similar lecture at South Paris that year, see page 136 of the same annual report.

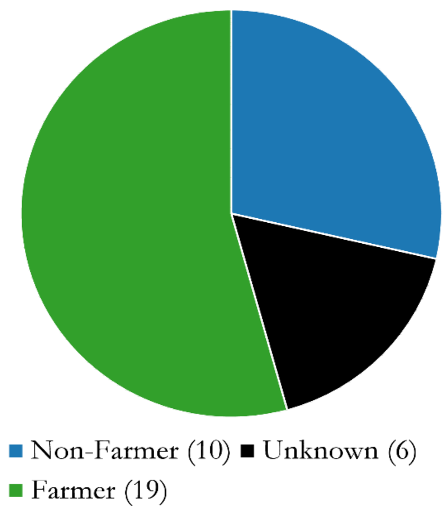


Figure 37: Occupation of South Paris Shareholders (1873) in 1880.[504]

**The second task: Convincing patrons to intensify production**

Where the dynamics of dairy factories and farmers' trust were very similar in Serkenrode and South Paris, the strategies to convince farmers to intensify production were fatefully different. Those deciding the fate of the Serkenrode factory presented it as the crowning piece in the systemic revolution from cereal to dairy farming – an imperative of the changing times without alternative. Vicar Johannes Dornseiffer made the necessity for better feeding abundantly clear in his 1883 agricultural association report. "Increased fodder supply is the indispensable requirement for our cooperative creameries. […] More fodder, more livestock, better animal care and husbandry, refinement of our local breed, excellent milk cows and – – creameries!! One follows the other."[505] Even when the Serkenrode creamery failed the following year, Dornseiffer did not change his tune. In defiance of creamery failures all over the

[504] Based on Records of the Paris Dairying Association, private archive of Jeffrey and Mary Parsons, Ann Arbor, MI, 1-2; 1880 United States Federal Census, Year: 1880; Census Place: Paris, Oxford, Maine; Roll: 484; Page: 257A- 288C; Enumeration District: 134, https://www.ancestrylibrary.com/interactive/6742/4241569-00640?backurl=https%3a%2f%2fsearch.ancestrylibrary.com%2fsearch%2fdb.aspx%3fdbid%3d6742%26path%3d&ssrc=&backlabel=ReturnBrowsing#?imageId=4241569-00640

[505] *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883*, 6-7. Original: "Vermehrte Futtervorräte sind die unerläßliche Vorbedingung unserer Sammelmolkereien. [...] Mehr Futter, mehr Vieh, bessere Pflege und Haltung des Viehs, Veredelung unseres Landschlages, vorzügliche Milchkühe und – – Molkereien!! Eins folgt aus dem andern."

Sauerland, he predicted a restart. "We repeat it: under the current conditions, the creameries have a future also in the Sauerland; it cannot at all be different."[506] Hard-pressed for cash income, seeing all other cash crops taken from farmers by a globalizing market, proponents of the Serkenrode factory predicted doom for all who did not conform to the new standards set by the market.

Things were different in South Paris. Several promising cash crops balanced farm income and growing seasons: sweet corn for emerging canneries, corn stalks to feed cattle, apples in the fall, timber in the winter, maple syrup in the spring, dairy in the spring and summer. Promoters of dairy factories would have been fools to say they were the only option. Rather, they served up dairying profits as an option rather than the only saving grace. In South Paris, on December 12, 1883, the Oxford County Agricultural Society held a farmers' institute speaking to cheese factory operators' interests. The afternoon session before a filled hall combined lectures on associated dairying and better feeding which the *Oxford Democrat* reporter called "of unusual interest." Secretary of the Maine Board of Agriculture, Ziba Alden Gilbert, emphasized in his lecture that only a mix of feeds provided "all the elements of a perfect food" and "produces good results at the pail."[507] The advice was tailored to farmers engaged in dairying, whether in home or factory processing. South Paris factory operators offered another way of earning a profit, inviting farmers into the demanding embrace of progress but also leaving space for alternative approaches.

These diverging expectations influenced cheese factory operations. In November 1881, the Serkenrode factory shareholders decided their factory had to operate year-round to accomplish a quick revolution to dairy farming. They mistakenly thought that operating through the winter would shore up farmers' trust in the factory and secure investment in the factory. But winter milk production required

[506] *Vierter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1883-1884* (Paderborn: Bonifacius Druckerei, 1884), 12. Original: "Wir wiederholen es: Unter den gegebenen Verhältnissen haben die Molkereien auch im Sauerland eine Zukunft; es kann gar nicht anders sein."
[507] "Farmers' Institute at So. Paris," *Oxford Democrat*, Dec 18, 1883, 5.

intensive stall feeding which few local farmers could afford. Making things worse, a summer drought caused a fodder shortage that winter.[508]

Rather than inspiring farmers, Serkenrode factory operators' forced idealism blinded them to the needs of patron farm families. Lack of fodder had not been a temporary crisis. It was a recurring problem for decades. Byproduct feeding for winter production of milk was an innovation on most farms, requiring capital and expertise many farm families were not willing to invest. When even association members preferred careful incremental change in farming, calls for a revolution were more than misplaced. In 1883, Dornseiffer chose to highlight the butter prices garnered by the creamery as compared to local merchants. Also, he emphasized that patron farm families "as commonly admitted, had not felt a lack of milk and butter for household needs."[509] Farmers preferred to have women produce butter at home for family use and sale to local merchants, even if profits were lower and labor investment higher. This approach seems to have generated a sense of control over production and home supply, very much opposite to the dependence on neighbors' ability and honesty. The Serkenrode cheese factory closed on October 15, 1883 after only two and a half years of operation. In addition to lacking the trust of farmers, local improvers had overestimated the pace farmers would choose to intensify feeding and thus milk production. Serkenrode factory proponents could not follow farmers' rationality in choosing not to deliver milk to the factory. They made a revolution the only alternative and were surprised when farm families did not show up.[510]

By contrast, the seasonal operation of the South Paris cheese factory fit the variety in farm family choices and abilities. The survival of the factory was not linked to the intensification of winter feeding. Like the Parsons and Swetts, those farm families able and willing could take advantage of the local

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[508] Minute books Serkenrode, November 6, 1881.
[509] *Dritter Jahresbericht der landwirtschaftlichen Winterschule zu Fretter für das Schuljahr 1882-1883*, 8. Original: "im Haushalte, wie allgemein zugegeben wird, ein Ausfall an Milch und Butter zum eigenen Bedarf nicht verspürt worden [ist]."
[510] Compare also the newspaper article by the Serkenrode agricultural association leadership, in which they complained about lacking milk deliveries in specific villages, falling short of farmers' capabilities. "Unsere Ziele," *Mescheder Zeitung*, July 26, 1881.

market or the railroad connection to the Portland market for milk sales during the winter. Others continued to produce butter or cheese at home during the winter. While buying additional feed for the winter promised profits for all dairy sales, this choice was left to each farm family. As result, the South Paris cheese factory thrived for almost a decade. After its first difficult year in 1873, its number of engaged cows exceeded 200 1874-1876, more than most other factories across the state. Many cheese factories in Maine had been established with similar enthusiasm only to find the local milk supply too limited to cover costs of operation. From the first cheese factory in Maine in 1871 their number grew to 60 in 1875 only to decrease to less than 25 in 1880.[511] In 1879, the cheese factory in South Paris had lost some of its initial patrons, but likely still engaged between 150 and 200 cows.[512] All cheese factories in Maine operated only in the summer.

Farm family choices in South Paris remained individual to each farm. Within 5 miles of the cheese factory, farm families would have been able to sell their milk to the factory but made different choices. Distance mattered most. The majority of patron farms in 1879 lay within a two-mile radius around the factory (see Figure 37). While almost all of these patron farms owned at least three cows, a handful of similar farm families decided not to deliver to the factory despite its proximity.

Beyond the two-mile radius of the factory, only select farm families sold their milk to the factory. The connections of neighborhood seem to have played a significant role in the uplands south of the factory. This is where several officers of the Dairying Association lived, including Stephen Robinson

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[511] Stephen L. Goodale, *Report Maine Board of Agriculture 1873*, 403-412; Samuel L. Boardman (ed.), *Abstract of Returns of the Agricultural Societies of Maine, 1874* (August: Sprague, Owen & Nash, 1875), 144-157; Geo. E. Brackett, "Associated Dairying in Maine," in *Twentieth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1875* (Augusta: Sprague, Owen, Nash, 1875), 84-93; *Twenty-first Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1876* (Augusta: Sprague, Owen, Nash, 1876), XXII-XXV; *Twenty-second Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1877* (Augusta: Sprague, Owen, Nash, 1876), 121-128; *Twenty-fourth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1880* (August: Sprague & Son, 1880), 10.
[512] The number of farmers selling milk noted in the 1880 census added up to 159 cows in Paris, but it is unclear if they sold to the factory and farmers from neighboring Norway and possibly Hebron also delivered milk to the factory. *Nonpopulation Census Schedules for Maine, 1850-1880*. Microfilm. Maine State Archives, Augusta.. Census Year: *1880;* Census Place: *Paris, Oxford, Maine;* Archive Collection Number: *15-156;* Roll: *15;* Schedule Type: *Agriculture. (https://www.ancestrylibrary.com/imageviewer/collections/1276/images/31862_222218-00373?ssrc=&backlabel=Return).*

Parsons as its secretary after 1875, William Swett as its president throughout, and several directors. The cluster of farms around William Swett's farm had begun to sell milk as early as 1869. Still, not all of them sold milk, even though farm size, farm value, number of cows, and distance to the factory were similar to the farms in their neighborhood. The contrast to other neighborhoods further than two miles from the factory reveals the exceptional status of the southern neighborhood.

Beyond the 2-mile radius, farms with less than six cows did not sell milk to the factory. It is unclear if they had to deliver their milk to the factory themselves or if the "milk peddler" listed in the 1880 South Paris population census collected milk in these neighborhoods.[513] Given the distances a milk collector would have had to travel twice a day to reach all patron farms, the dairying association might have defined collection routes through only the neighborhoods with the most patrons. If farms in other neighborhoods had to deliver the milk themselves, this might have deterred them from participating in the factory business. Farms with at least six cows seem to have been able to make this potential investment although not all of them did. Distance of more than two miles to the cheese factory seems to have been an obstacle to selling milk. The ability to produce a surplus of milk and proximity to the cheese factory might have enabled farm families to sell milk but they also had to choose to do so.

Neighborhood negotiation and individual decision interacted. Along the valley road north of the factory and in Paris Hill to the northeast, a handful of farm families who had been principal patrons, shareholders, officers, and canvassers of the dairying associations before 1879 withdrew their involvement. One of them was Jairus K. Hammond of Paris Hill. In 1882 and 1883, he became a member of the Maine Board of Agriculture and gave two lectures on the benefits of private dairying. He listed calculations of several dairying farms in South Paris as well as in neighboring Norway and Hebron. They had several different feeding regimes, not all of them including commercial feed. One of them sold all of

[513] George C. Pratt, 17 years of age listed on1880 United States Federal Census, Year: 1880; Census Place: Paris, Oxford, Maine; Roll: 484; Page: 285A; Enumeration District: 134, https://www.ancestrylibrary.com/interactive/6742/4241569-00640?backurl=https%3a%2f%2fsearch.ancestrylibrary.com%2fsearch%2fdb.aspx%3fdbid%3d6742%26path%3d&ssrc=&backlabel=ReturnBrowsing#?imageId=4241569-00640!.

its milk, another sold milk only for a few weeks, several produced butter and cheese at home. One fattened his hogs on the whey left after cheese production – a byproduct which most likely would have been poured out as waste at the cheese factory.[514] One listed some innovative equipment which eased butter-making and a respondent to the lecture in 1882 advocated that men should take over home production with these tools to relieve farm women. These were flexible, and individual decisions. There was no animosity towards the cheese factory in Hammond's words. He simply argued that farmers could make a profit by specializing in dairy farming in whichever way suited their situation. Deciding against the factory and neighborhood cooperation did not mean less investment in dairying. Neighborhood relationships, exchange, and shared investment could impress farm families to agree on selling to the factory, but patrons and even former promoters of cheese factories understood that these were individual decisions each farm family had to make for itself.[515]

[514] The South Paris cheese factory was not able to put a value on the whey left in production when asked for these statistics by the Maine Board of Agriculture. Samuel L. Boardman (ed.), *Abstract of Returns of the Agricultural Societies of Maine, 1874*, 144-157; Geo. E. Brackett, "Associated Dairying in Maine," 84-93; *Twenty-first Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1876*, XXII-XXV.

[515] J. K. Hammond, "Profits of Private Dairying," in *Twenty-sixth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1882* (August: Sprague & Son, 1883), 141-151; J. K. Hammond, "Profits of Dairying," in *Twenty-seventh Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1883* (August: Sprague & Son, 1884), 61-66.

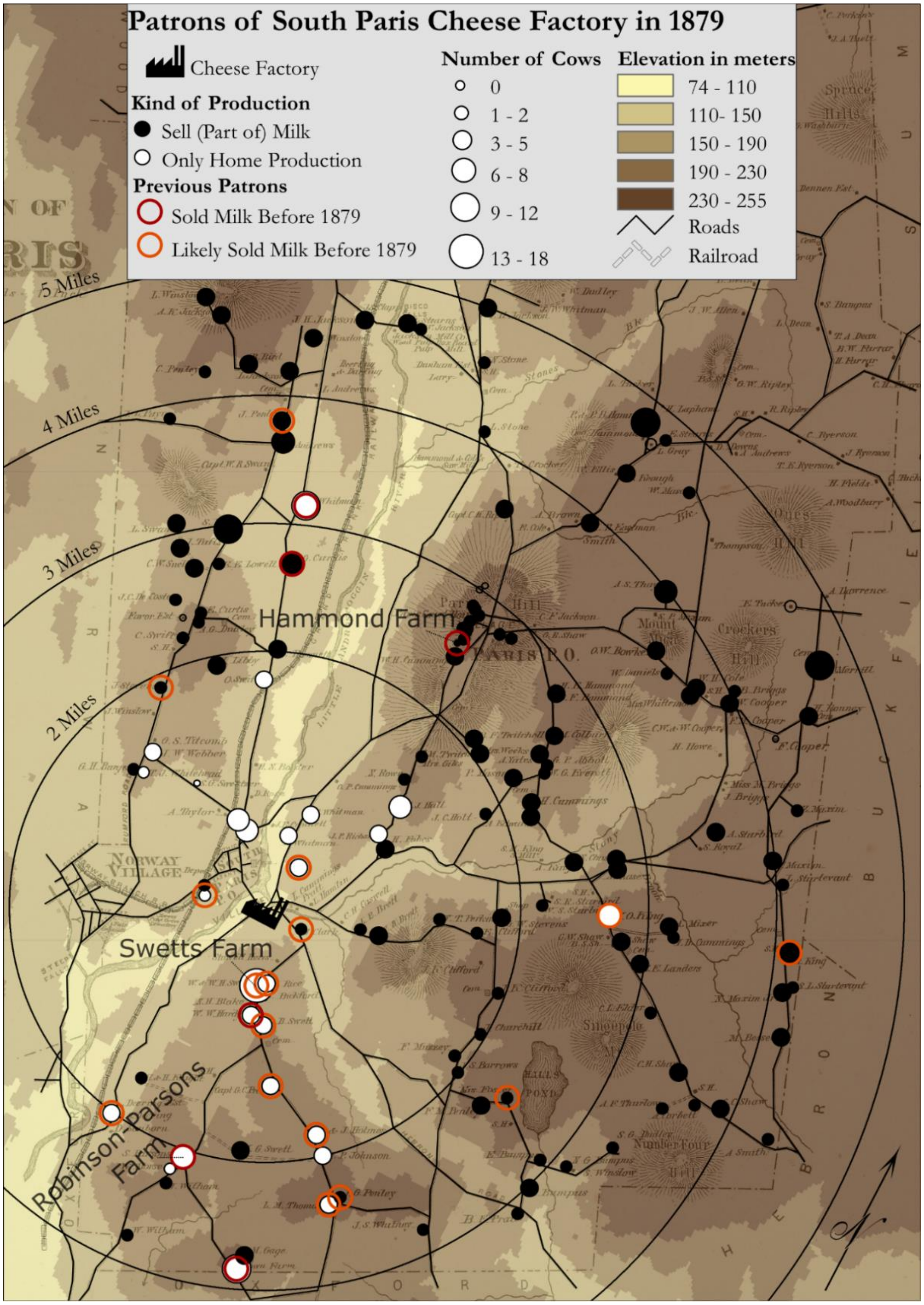


Figure 38: Patrons of the South Paris Cheese Factory in 1879.[516]

[516] This sample only includes farms with dairy production in South Paris within a five-mile radius of the cheese factory but several farms in neighboring towns also sold milk to the factory. The basemap is an 1880 county atlas

**Transformation and its limits: Economies of Scale and Farm Family Flexibility**

In the end, farm families' need to feel like masters of their own destiny brought down both dairying cooperatives. The South Paris cheese factory began to note down unusually low milk deliveries in 1880. The Maine Board of Agriculture annual report for 1881 also noted its decline: "its patronage of late has been on the wane, and with it, confidence in the business as a profitable industry."[517] Production at the factory continued to decrease until the closure of the factory in 1884. A year before, the Serkenrode creamery had ceased operations after a much shorter run. Farm families in both places found other strategies to operate their farm and have cash income on their own terms, without becoming dependent on their neighbors.

The key lay in transportation innovations that enabled geographically expanded and dispersed economies of scale. In Serkenrode and the wider Sauerland, creameries restarted only in the 1900s, whether private or cooperative. That is when railroad expansion and later the first motorized trucks began to enable larger milksheds. The decades in between also prepared farm families for the shift. Contrary to early 1880s improver views, Sauerland farming did not die with the creameries. Farmers continued to

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which also recorded the first initial and last name of homeowners. I matched these names with those in the population and agricultural census for 1880. I also used the listing order and the date the census taker recorded the information to estimate his route through the neighborhood. This allowed me to verify matches for the indication of proximity to neighbors. The information on milk sales in 1879 was listed in the 1880 agricultural census. This map makes the assumption that milk-selling farms within delivery distance of the cheese factory sold their milk to the factory. Some might have sold milk to the Portland market instead, but the majority most likely sold at least part of their milk to the cheese factory. Farms marked as previous patrons Stephen Robinson Parsons had listed in his daybook in 1874. I assigned as likely previous patrons those farms which had been recorded as shareholders, officers, or canvassers in the minute book of the South Paris Dairying Association, and those farms listed as selling milk in the 1870 agricultural census. H. E Halfpenny and John W. Caldwell, *Atlas of Oxford County, Maine.* (Philadelphia, PA: Caldwell & Halfpenny, 1880), 12-13; *Nonpopulation Census Schedules for Maine, 1850-1880*. Microfilm. Maine State Archives, Augusta.. Census Year: *1880;* Census Place: *Paris, Oxford, Maine;* Archive Collection Number: *15-156;* Roll: *15;* Schedule Type: *Agriculture.* *(https://www.ancestrylibrary.com/imageviewer/collections/1276/images/31862_222218-00373?ssrc=&backlabel=Return); Nonpopulation Census Schedules for Maine, 1850-1880*. Microfilm. Maine State Archives, Augusta.. Census Year: *1870;* Census Place: *Paris, Oxford, Maine;* Archive Collection Number: *9-145;* Roll: *9;* Schedule Type: *Agriculture.* (https://www.ancestrylibrary.com/imageviewer/collections/1276/images/31862_222212-00532?ssrc=&backlabel=Return); Stephen Robinson Parsons' notebook, 1875-1882, March 24, 1875; Records of the Paris Dairying Association, MI, 1-2; State of Maine, *Maine Elevation DEM_2019*, Raster digital data, https://maine.hub.arcgis.com/datasets/da81878de621437f81c06ce176738b94.

[517] *Twenty-Fifth Annual Report of the Secretary of the Maine Board of Agriculture for the Year 1881*, (Augusta: Sprague & Son, 1882), 136.

raise and breed livestock for slaughter and home production of dairy (see Figure 38). While there were no coordinated breeding goals for cows, Serkenrode association members bought more and more purebred pigs, beef cattle, and dairy cattle. Charging neighbors and association members to use their purebred bulls for breeding was a flexible arrangement facilitated even more by state subsidies for the purchase of these animals. By the 1900s, the newly founded Sauerland Association for the Improvement of Cattle Breeding (*Verband zur Hebung der Rindviehzucht im Sauerland*) could count on some breeding experience to coordinate breeding goals and promote better feeding regimens. The small number of creameries dotting the railroad lines through the mountainous Sauerland found enough farm families that paid attention to milk production of their animals. Infrastructure expansion and technological innovation allowed larger milksheds and flexible farm family decision-making.[518]

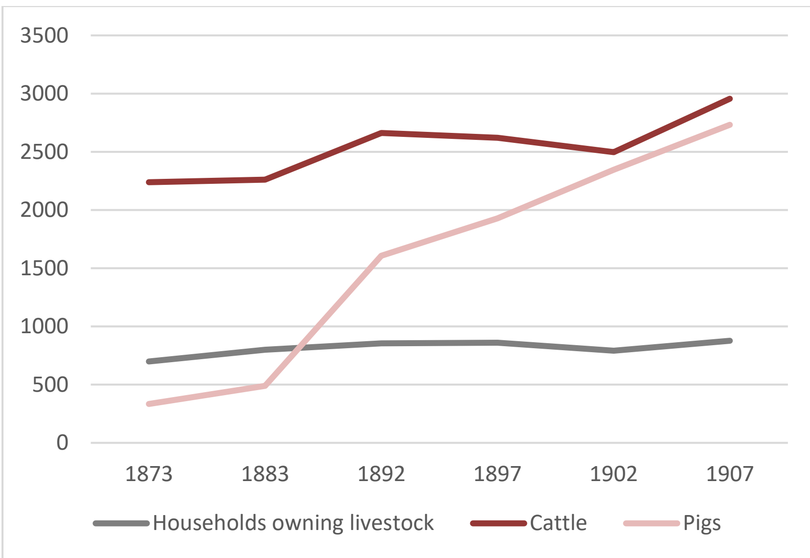


Figure 39: Number of Cattle and Pigs in Amt Serkenrode, 1873-1907. This was the district of the Serkenrode agricultural association in which livestock farming only slowly increased in cattle but exploded in pigs. Production for slaughter sustained farmers before the restart of creameries in the region.[519]

[518] Serkenrode minute books; Fritz Söbbeler, "Gewinnung und Behandlung der Milch einst und jetzt;" Fritz Söbbeler, "Molkereien," in *Bauern im südwestfälischen Bergland*, Band 1, Rötger Belke-Grobe et al. (eds.) (Münster: Ardey, 2006) 330-334; Fritz Söbbeler, Rindviehhaltung und -zucht; Milchgewinnung; Molkereiwesen – Stufen ihrer Entwicklung im Sauerland vom 19. Bis ins 21. Jahrhundert, 2010, unpublished manuscript, private collection Hubertus Mathweis, Sallinghausen.

[519] *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 285, "Viehzählung am 10. Januar 1873;" *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 664, "Viehzählung am 10. Januar 1883;" *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 552, "Viehzählung am 1. Dezember 1892 und 1. Dezember 1893;" *LAV NRW W*, K 333

This was also true in South Paris and western Maine. The introduction of refrigerated railroad cars in 1881 accelerated the decline of the South Paris cheese factory as creameries established processing stations at railroad stations across the region. They sold butter, sweet cream, or milk to Portland and Boston markets as well as Maine tourist destinations. Milksheds of individual creamery plants grew over the following decades.[520] Only cheese factories at a distance from the railroads survived.[521] These changes meant that farm families no longer had only one option to sell their cream. Stephen Robinson Parsons chose his business partner in the cream business carefully. In 1886-1887, he switched creamery operations three times between nearby West Paris, New Gloucester, and Poland, Maine. These creameries competed with one another in the prices they paid patrons, as farm families knew. In June 1891, Stephen seems to have abandoned deliveries to a Portland creamery because their Poland competitor paid 8 instead of 7 cents per inch of cream. Farmers in both regions negotiated their farming practices less with their neighbors and more with local market agents representing much larger companies.

/ Kreis Meschede, Landratsamt, Nr. 3463, "Viehzählung am 1. Dezember 1897;" *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 3474, "Außerordentliche Viehzählung am 1. Dezember 1902;" *LAV NRW W*, K 333 / Kreis Meschede, Landratsamt, Nr. 3477, "Viehzählung am 2.12.07."

[520] Hornsby, Judd, and Hermann, *Historical Atlas of Maine*, plate 53.

[521] *Fifteenth Annual Report of the Bureau of Industrial and Labor Statistics for the State of Maine, 1901* (Augusta: Kennebec Journal Print, 1902), 22-40.

Figure 40: Poland Creamery, Poland, Maine, with horse-drawn milk carts in front, in 1901. This was Stephen Robinson-Parsons creamery of choice from at least 1891 to 1900. In 1901, it was one of the most up-to-date creameries in the state, serving the butter and cream needs of the Poland Spring House, a tourist retreat owned by the creamery proprietor.[522]

The reach of the creamery window grew. What it offered gained definition. Demands for cleanliness and cooling remained imperatives and farmers who did not fulfill them would have their milk returned, only good enough for the feed pail of the hogs. The incentive for producing more butter fat by better feeding, breeding, and animal care became more pronounced and safer from fraud. In the 1890s, creameries introduced easy chemical tests for fat content of milk or cream, the Babcock test in North America, the Gerber test in Europe.[523] When the Bureau of Industrial and Labor Statistics for the State of Maine surveyed creamery operators across the state in 1901, they received well-informed answers on

[522] Ibid, 34-35. Digital image courtesy of HathiTrust. URL: https://hdl.handle.net/2027/mdp.39015067958838?urlappend=%3Bseq=42.
[523] Rosenthal and Rosen.

ideal rations. The men and women behind the creamery window knew what their patrons were feeding their cows. Still, creamery operators reported diverging ideas about ideal feeding. One answered "good high ground pasture and pure water." Another suggested "peas, oats, and Hungarian grass."[524] While the report summarized that operators largely agreed on cottonseed meal, bran, and cornmeal, they conceded that respondents disagreed about the ratios. "Each [farmer] would probably experiment till he obtained the best results from his own herd."[525] As on the Robinson-Parsons farm, the means to intensify and reap the benefits remained up to farmers because no two farms or herds were exactly the same. Sauerland creamery operators also knew this. The Allendorf creamery in Arnsberg county, pictured in figure 40, eventually prescribed strict cleanliness but only demanded a feeding regimen which nourished cows so they "manifest a certain wellbeing through their movement and appearance."[526] Even with larger geographic integration, the strategy of success remained the same: balancing the inflexibility of hygiene demands and standardization with flexible incentives for intensification.

[524] *Fifteenth Annual Report of the Bureau of Industrial and Labor Statistics for the State of Maine, 1901*, 27.
[525] Ibid, 28.
[526] Anton Lübke, "Die Allendorfer Molkerei – Eine Erfolgsgeschichte.," in *Allendorfer Lesebuch / Fickeltünnes e.V. - 600 Jahre Stadt Allendorf.*, ed. Anton Lübke (Sundern-Allendorf: Fickeltünnes, 2006), 516. Original: "durch ihre Bewegung und ihr Aussehen ein gewisses Wohlbefinden bekunden."

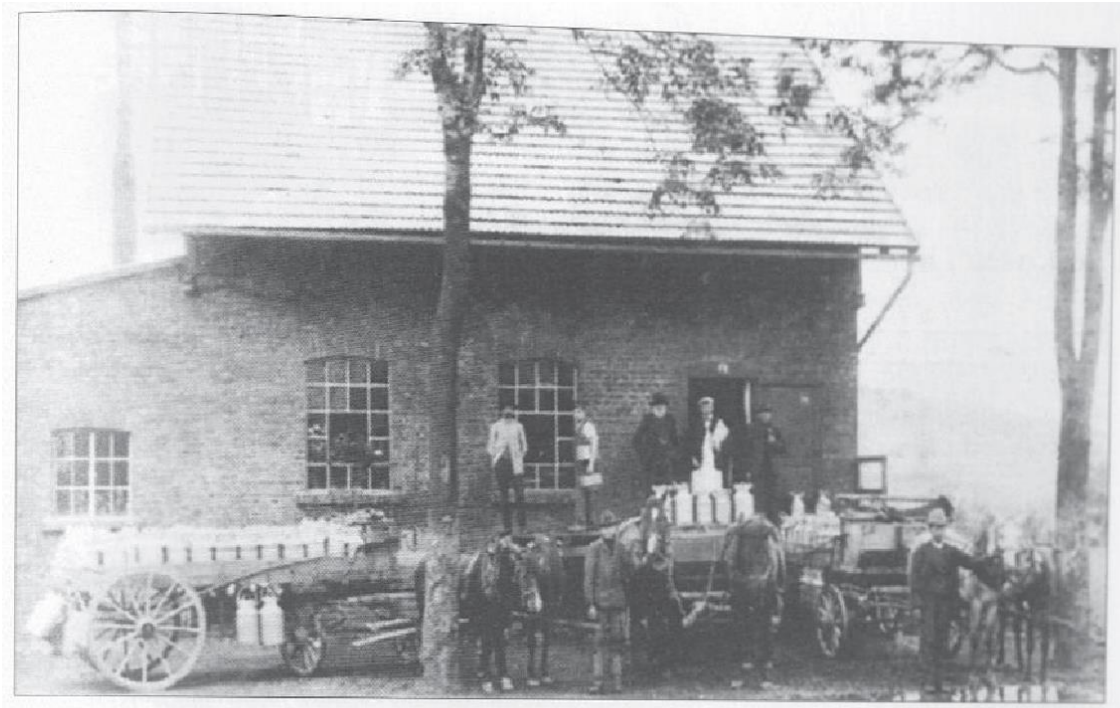

Figure 41: Horse-drawn milk carts in front of the creamery Allendorf (Sundern) in the Sauerland, 1907. Located in neighboring Arnsberg county, its foundation in 1902 had been facilitated by Elspe winter school teacher Alzeyer.[527]

The general dairying practice on the Robinson-Parsons farm, however, remained the same. The patterns of their milk sales followed the seasons from the 1870s to the 1910s, with a high in spring and early summer and a low in late summer through fall and winter (see Figure 41-43). The dynamics of the market which paid higher prices for milk and cream in the winter did not cause Stephen or Oscar to change their dairying system to winter dairying. This would have meant adjusting the calving schedule from throughout the year to focus on the winter, so more cows in their barn would produce most for better winter prices. This would have required heavy financial investment into commercial feeds for winter to raise milk flow. Both Stephen and Oscar purchased feeds for the winter, but they never shifted their dairying quite so drastically. Overall, it seems that their goal was to take advantage of winter prices as much as available funds, prices, and feeds allowed. In the winters of 1897-1900, Stephen's detailed feed

[527] Foto by Anton Voss, Allendorf. Taken from Söbbeler "Gewinnung und Behandlung der Milch einst und jetzt," 327. See also Lübke.

records suggest he tried to shorten and raise the winter dip in milk flow as well as increase the fat content of cream. After two successful winters, the winter of 1899-1900 was less successful despite similar investments in feed purchases, which might have prompted Stephen to abandon this trial.[528] Generally, however, the seasonal patterns of milk flow continue into Oscar's milk sales of 1918 and 1919.

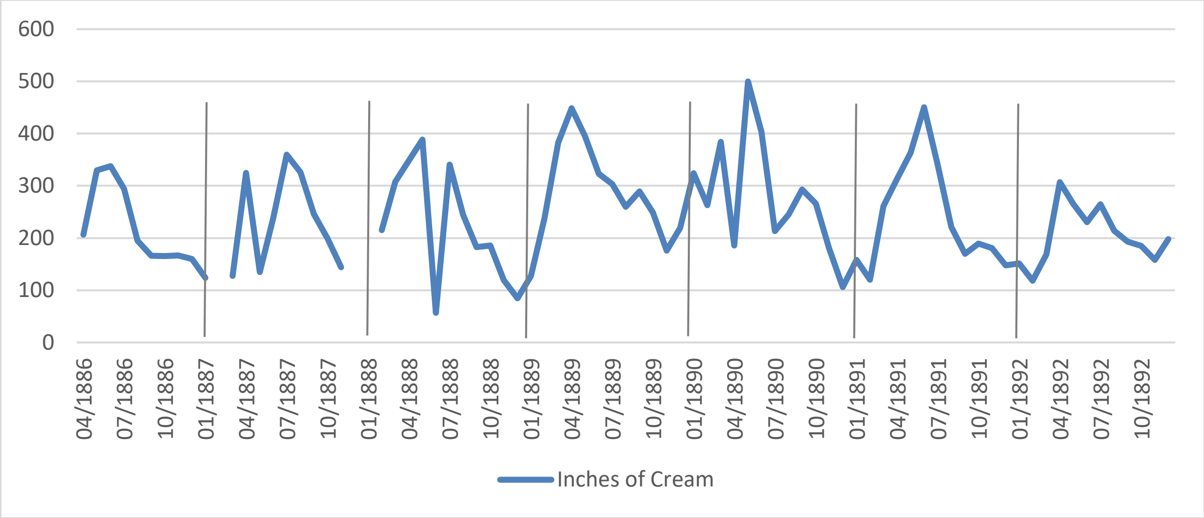


Figure 42: Stephen Robinson Parsons Cream Sales, 1886-1892.[529]

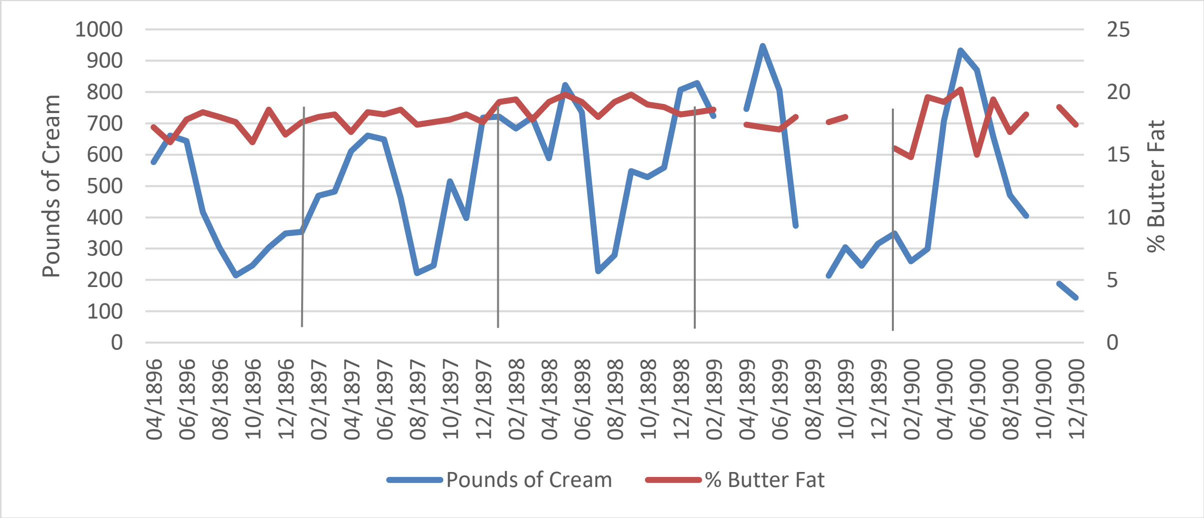


Figure 43: Stephen Robinson Parsons' Cream Sales, 1896-1900.[530]

[528] His feed records end after this. It is unclear if he simply wrote these in a different notebook now lost, had too few funds to continue the investment, or decided it was not worth the effort to record or try more feed purchases.
[529] Cream book, 1886-1887; Cream Book, 1887-1889; Cream Book, 1889-1891; collections of cream sale receipts, 1890-1901, all part of the Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[530] Collections of cream sale receipts, 1890-1901, Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.

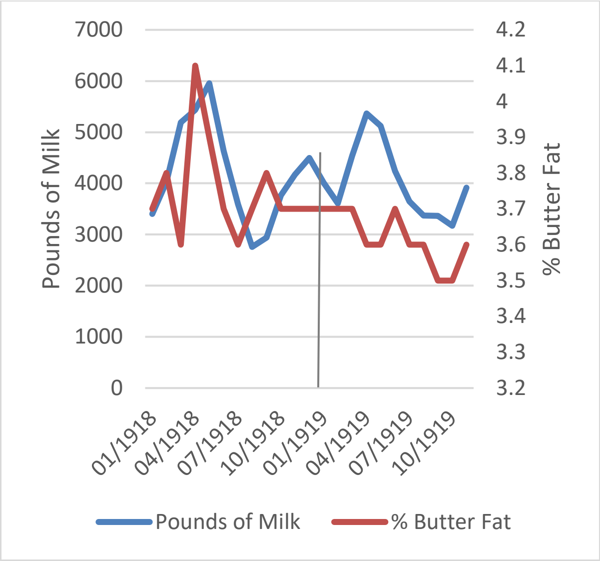


Figure 44: Oscar Parsons' Milk Sales, 1918-1919.[531]

The number and choice of cattle also changed little, although the age structure of cows in the Parsons' barn changed during Stephen's tenure. Apart from some upsets in the late 1860s and early 1870s, when Stephen had just taken over the farm on his own, he gradually departed from his father's practice by decreasing the number of one-year-olds and two-year-olds to fill their spots with more milkers (see Figure 44). Oscar largely continued this shift. These changes seem to have been concurrent with select introductions of purebred cows. In their records of when individual cows calved, Stephen noted a Jersey cow in 1885 and 1886, Oscar noted two or three Jersey cows as well as an Ayershire cow in the 1900s.[532] Since the tenure of Stephen's father John, neither of them increased the capacity of their barn. As much as the creamery window intended to reach into dairying practices and as much as messages of improvements reached farm families, at least the Robinson-Parsons farm and home remained remarkably stable.[533]

[531] Collections of cream sale receipts, 1918-1919, Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[532] Cow book, 1882-1891; Cow book, 1902-1917, Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[533] This conclusion mirrors a similar case study of an antebellum Massachusetts farm family, see Nessell.

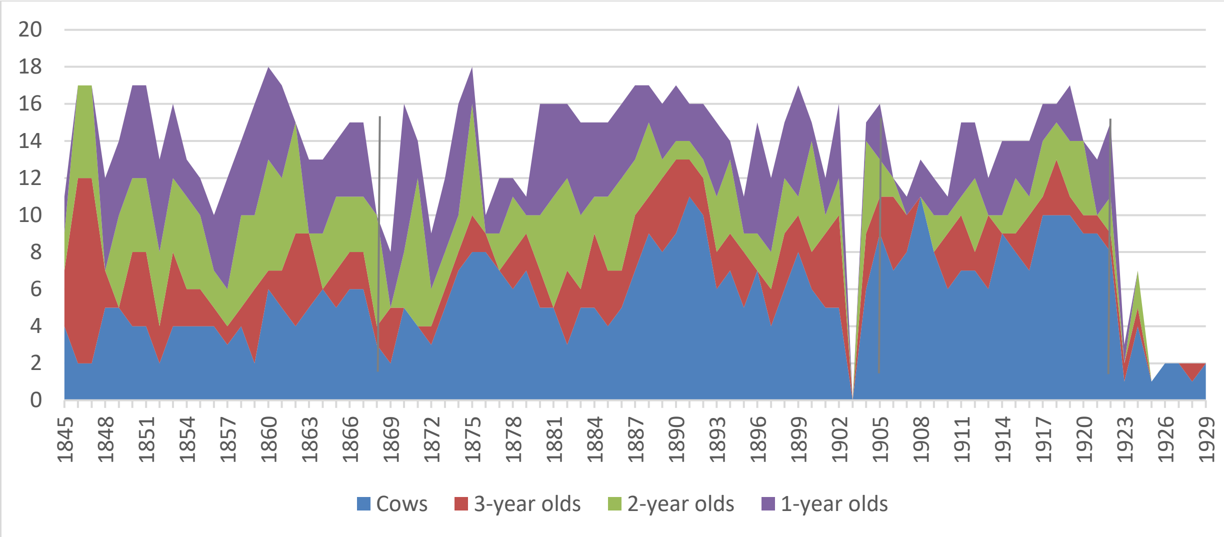


Figure 45: Cows on the Robinson-Parsons Farm, 1845-1929. The years when the farm owner died are marked with vertical lines, John Parsons jr. in 1868, Stephen Robinson Parsons in 1905, Oscar Parsons in 1922, when farm operations largely ended.[534]

## Expanding the Reach: Farm Families and Extension

> I have given you a few of the statements which I obtained from Oxford county dairymen. You will see by them that those who are making a specialty of the business, are making it more profitable than those who keep but a few cows, and are following that system of husbandry which was pursued by our fathers.[535]

> From year to year, we have the saddening experience that our expenses are not covered by the earnings from our lands, complain about high taxes and unfavorable conditions – and still, we cannot step out of our ken based on parentage to improve our situation by a changed farm system, by self-help, and by mutual support. [536]

Local improvers knew what they were up against: a whole generation that came before them. Both Jairus K. Hammond of Paris Hill and the Serkenrode agricultural association knew firsthand that their fellow farmers had been trained by their parents. Where scientists and improvers at a further distance from farmers treated the terms "like their fathers" and "backward" as synonyms, local improvers

[534] Data for 1903 is missing in the sources. Tables of local tax data, Private Archive of Jeffrey and Mary Parsons, Ann Arbor, MI.
[535] Jairus K. Hammond, "Profits of Private Dairying," 148.
[536] "Unsere Ziele," *Mescheder Zeitung*, July 26, 1881. Original: "von Jahr zu Jahr machen wir die betrübende Erfahrung, daß unsere Ausgaben durch die gewonnen Erträge aus den Besitzungen nicht gedeckt werden, klagen über hohe Abgaben und ungünstige Verhältnisse – und doch können wir aus unserem auf Herkommen beruhenden Ideenkreise nicht heraustreten, um durch eine veränderte Wirthschaftsweise, durch Selbsthülfe und gegenseitige Unterstützung unsere Lage zu verbessern."

understood the centrality of family farm training. When members of the agrarian-industrial knowledge society discredited what farmers had at home, this came across as an insult and generally led them nowhere with farmers. Local improvers applied soft pressure to dislodge the credibility of the most basic and most influential knowledge communication of any farm family. It was this strategy that expanded the reach of the agrarian-industrial knowledge society into the farm family.

Farm women became the new targets of the agrarian-industrial knowledge society. Whereas reaching into farm neighborhoods had been the goal in the late nineteenth century, the early twentieth century saw knowledge infrastructure building into the families that made the neighborhood. In both the United States and Germany, scientists began research into home economics to guide women's housework along principles of efficiency. Agricultural extension picked up this discipline for farm women. In Westphalia, traveling housekeeping schools (*Haushaltungsschulen*) educated rural women in how to organize their house, farm work, and also dairy labor more efficiently.[537] In Maine as in the rest of the US, the Home Extension Service became the female branch of the official extension service.[538] Feed and flour manufacturers soon also discovered farm women as their audience. Farm women had used feed and flour sacks to sow underwear in the 1910s and 1920s. Manufacturers then began selling their products in sacks of textile quality with attractive prints. The purchase of feed became a matter of feeding and of

[537] Frank Uekötter dismisses the relevance of Haushaltungsschulen for his knowledge history focused on the knowledge on agricultural production. In the light of my study, his decision was somewhat hasty, since the bourgeoning schools also included training on dairy work, livestock care, breeding, and feeding, gardening, orcharding, and bookkeeping. This was the case in Westphalia. Uekötter, *Die Wahrheit ist auf dem Feld*, 103-104; *Anleitung zur Einrichtung und Verwaltung von Wanderhaushaltungsschulen in der Provinz Westfalen*, Veröffentlichungen der Landwirtschaftskammer für die Provinz Westfalen, Heft 14 (Münster: Der Westfale, 1912), found in VWA - Vereinigte Westfälische Adelsarchive e.V., Nachlass Clemens V. August Maria von Twickel (1861-1916)**,** HAV. I. N5 189 "Unterlagen zur Landwirtschaftskammer Westfalen II"; Erziehungsanstalt Marienburg zu Coesfeld (Westfalen), *Haushaltungskunde: A. Handbuch B. Leitfaden für erweiterte Haushaltungsschulen*, (Bochum: Westfälische Verlags- und Lehrmittel-Anstalt GmbH, 1912), found in Archive of Landschaftsverband Westfalen-Lippe, 350/125 "Landwirtschaftliche Haushaltungsschulen, gen."
[538] See especially Karmen. See also: Sarah Stage and Virginia Bramble Vincenti, eds., *Rethinking Home Economics: Women and the History of a Profession* (Ithaca: Cornell University Press, 1997).

clothing the whole family.[539] In the process, extension generally pushed its bourgeois ideal of rural domesticity onto farm women, to varying responses.[540]

Farm youth also grew as an audience of extension. Where winter schools and university programs had targeted older teenagers and young adults, the next institutions of agricultural education were for children and young teenagers. In Westphalia as elsewhere in Germany, members of the agrarian-industrial knowledge society established rural continuation schools (*ländliche Fortbildungsschulen*). They filled the school years between elementary school (*Volksschule*) and winter schools, creating a clear farm education track for rural youth.[541] In Maine as in the United States, extension services created or took over their own youth branches, generally called 4-H, which was derived from their motto: head, heart, hand, and health.[542] The strategy to educate farm youth did not just aim at creating a generation of farmers more favorable to innovation. The trials of young farmers were also specifically intended to convince their parents to give extension a chance.

The agrarian-industrial knowledge society learned how central the farm family and its knowledge system were to achieve agricultural change. And whether through the expanding knowledge infrastructure or through the dealings with ever larger companies and cooperatives, farm families integrated into larger professional communities. They entered these relationships on their own terms as much as they could because they often meant rebalancing relationships in their neighborhoods and on their farms. Just like scientists, improvers, and market agents, farm families held on to their knowledge system while finding ways to connect and negotiate agreement with the knowledge systems of the agrarian-industrial

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[539] Brandes; Carol Richey, "From Feed Sack to Fashion," *Family Chronicle* 18, no. 6 (August 7, 2014): 48–50; Susan Strasser, *Waste and Want: A Social History of Trash*, 1st ed (New York: Metropolitan Books, 1999), 211-215.
[540] See e.g. United States Department of Agriculture, ed., *Social and Labor Needs of Farm Women: Extracts from Letters Received from Farm Women in Response to an Inquiry "How the U.S. Department of Agriculture Can Better Meet the Needs of Farm Housewives," with Special Reference to the Provision of Instruction and Practical Demonstrations in Home Economics under the Act of May 8, 1914, Providing for Cooperative Agricultural Extension Work, Etc*, Report of United States Department of Agriculture, no. 103 (Washington, D.C: G.P.O, 1915).
[541] Ministerium für Landwirtschaft, Domänen und Forsten, *Stand Und Entwicklung Der Ländlichen Fortbildungsschulen in Preussen 1902 Mit Einem Anhang Der Bis 1909 Ergangenen Wichtigsten Gesetzlichen Und Verwaltungsvorschriften Und Der Statistischen Erhebungen Aus Dem Jahre 1907*, Neudruck 1910 (Münster: Louis Espagne, 1910).
[542] Gabriel N. Rosenberg, *The 4-H Harvest: Sexuality and the State in Rural America*, Politics and Culture in Modern America (Philadelphia: University of Pennsylvania Press, 2016).

knowledge society. In the early twentieth century, the homes of farm families changed only slowly, but they grew ever more closely connected to other professional farm families elsewhere while the number of local family farms began to dwindle.[543]

[543] Compare Condon, Richard H.. "Living in Two Worlds: Rural Maine in 1930." *Maine History* 25, 2 (1985): 58-87; Condon, Richard H.. "Nearing the End: Maine's Rural Community, 1929-1945." *Maine History* 31, 3 (1992): 142-173; Ditt, "Aufstiege und Niedergänge," 235-242; Frese.

# CHAPTER 6

## CONCLUSION: TOWARDS A GLOBAL HISTORY OF AGRICULTURAL KNOWLEDGE

"Modern" agriculture was not made up of the most rational, the most profitable, or the most efficient innovations. Farming of the twentieth century was comprised of those innovations that allowed the most powerful to agree and to exclude those who did not. Industrialization and technological innovation expanded and accelerated global transport and markets of agricultural commodities in the late nineteenth century. Farm environments producing these commodities entered into competition with other farm environments around the globe. This global competition pushed similar changes in German and American farming. The result was conflict over what agriculture was to be. As I have shown in depth, the process of change included a complex, contingent process of multi-tiered knowledge negotiation between a variety of actors. Scientists, improvers, market agents, and farmers all shaped the future of farming. While the path of each innovation to each farm was historically and geographically contingent, actors shared perspectives, strategies, and evidence to establish their own authority, form expert communities, and reach their own goals. Knowledge was new in different contexts and different people melded it to fit their own needs. Each group was powerful in their own context. Just as improvers could not challenge scientists in chemical analysis, scientists could nullify neither market agents' understanding of prices nor farmers' familiarity with their livestock. Conflict had to be overcome. The patchwork of expertise had to be acknowledged and brought into agreement. Collaboration and contestation made the agrarian-industrial knowledge society as well as sustained agricultural change.

At the same time, I have shown that making the agrarian-industrial knowledge society resulted in exclusion. This finding fills a gap in previous research which focused on the in-group of agricultural "progress" and highlighted exclusion as a result of economic factors rather than as a part of knowledge formation. To reach their respective goals, scientists, improvers, market agents, and farmers only required a critical mass of farmers to change their practices. Enough farmers needed to "adopt" scientific principles for scientists to argue their innovation increased the national economy and thus deserved state funding. Improvers only needed enough farmers to copy their innovation in place to stabilize regional agriculture and justify improvers' elevated social position. Market agents only needed enough farmers to buy their innovations in things to make a profit. Farmers needed enough of their neighbors to innovate in their homes so that rural towns remained farming communities rather than isolated farm families left behind for industrial cities or distant shores. Each of these groups of actors sorted out as "backward" those farmers who were unwilling or unable to use capital-intensive innovation to solve the challenges of a globalizing market. Those who could not or would not learn, adapt, and pay were obstacles to "progress." The fundamental agreement within the agrarian-industrial knowledge society was the professionalization of farming. Rather than accepting the economic pressures of globalization as the immediate and primary reason for the industrialization of farming and the decrease in farms, I have demonstrated that knowledge negotiation in response to these pressures complicates this explanation. Alternative solutions did not become common practice because they excluded or devalued powerful rather than weak actors. The innovations that scientists, improvers, market agents, and farmers agreed upon were not designed to help all farmers. In the shared vision of future farming as a profession, that took shape in the late nineteenth century, not all those who farmed were farmers in the first place. Those who did not conform could not, and would not, be helped.

The agrarian-industrial knowledge society was also deeply involved in colonial policies, agricultural development, and labor exploitation into the twentieth century. Research, education, and extension were supposed to intensify agriculture in the greater national economy, including European and American colonies. Through the promotion and use of agricultural oils and their byproducts, American and German scientists, improvers, market agents, and farmers agreed on the devaluation of non-white labor to produce novel farm inputs and enable intensified production. The domestic agrarian-industrial knowledge society collaborated to extract nutrients from soils located at a distance from the farmers and general population they aimed to serve, whether using African-American labor in the American South or nonwhite farmers in European and American colonies around the globe.[544]

However, those involved with intensifying this resource extraction in the early twentieth century ran into the same problems their predecessors encountered in the mid and late nineteenth century. Non-white farmers disagreed with the goals, methods, strategies, and evidence that domestic research, extension, and education agreed upon. White European and American scientists, educators, and extension agents found their knowledge of the local environment to be inadequate, their methods to reach local farmers rejected, and the whole extension enterprise in jeopardy should they not learn from local farmers. Whether efforts with rice varieties in the Dutch East Indies, irrigation projects in British India, soil and crop improvement in German East Africa, cultivation practices in British Nigeria, dairy cattle in the Russian Kazakh Steppe, wheat farming in Italian Ethiopia, cotton farming all over the American South, or home extension in Florida: white scientists and extension agents in the first half of the twentieth century had to rebuild extension from the ground up. They had to learn that the nonwhite farmers they aimed to teach knew more about the local farm environment, economy, and society than they did. Simply introducing innovations for ideal conditions agreed upon in Europe and the United States would not work. With varying degrees of delay, white scientists, educators, and extension agents rebuilt and renegotiated extension with nonwhite farmers in the unfamiliar environments that their employing nation states aimed to dominate and reshape.[545]

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544 Zimmerman. This resource extraction bore similarities to the extraction of guano from Pacific islands as a revolutionary fertilizer beginning in the mid-nineteenth century, see Gregory T. Cushman, *Guano and the Opening of the Pacific World: A Global Ecological History* (New York: Cambridge University Press, 2013). For the unity of domestic and colonial American extension work, consider Frank Lamson-Scribner's career. He appeared in chapter 3, criticizing Wagner's flat pea. After his appointment as head of the USDA Agrostology Division, he became Chief of the Insular Bureau of Agriculture in the Philippines from 1901 to 1904. See, Hilty and Peterson Jr. Consider also: Jessica Wang, "Agricultural Expertise, Race, and Economic Development: Small Producer Ideology and Settler Colonialism in the Territory of Hawai'i, 1900–1917," *History and Technology* 36, no. 3–4 (October 1, 2020): 310–36.

545 See Ross, 307-341; Florian Wagner, "Inventing Colonial Agronomy: Buitenzorg and the Transition from the Western to the Eastern Model of Colonial Agriculture, 1880s–1930s," in *Environments of Empire: Networks and Agents of Ecological Change*, ed. Ulrike Kirchberger and Brett M. Bennett (University of North Carolina Press, 2020), 103–28; Kelly A. Minor, "'Justifiable Pride:' Negotiation and Collaboration in Florida African American Extension," in, *Beyond Forty Acres and a Mule: African American Landowning Families since Reconstruction,* ed.

My analysis of this negotiation process with German and American farmers recasts agricultural education of the colonized as a rerun rather than a premiere of development policy. The negotiation process with nonwhite farmers seems to have worked the same way, and to have been as geographically contingent, as with farmers in the Sauerland and western Maine. Scientists, extension agents, improvers, and market agents established their own expertise and acknowledged the expertise of some local farmers and improvers to negotiate agreement. Only then could extension and education collaborate with willing and able farmers in agricultural intensification. However, negotiation between white reformers and nonwhite farmers in the first half of the twentieth century included a much larger power differential and larger toolkit of strategies than with white domestic farmers. Some extension efforts aimed to replace nonwhite farmers with white settlers. Others used coercion and violence to force nonwhite farmers to follow extension instructions. Eventually the result was still agreement among the white scientists, educators, and extension agents and select nonwhite farmers. Even so, as several studies of colonial extension efforts suggest, the consensus between white reformers and nonwhite improvers and farmers was largely founded on racial hierarchy and coercion in addition to the economic pressures of global markets.[546]

Reimagining the history of agricultural change through the lens of knowledge negotiation enables one to see the global history of agricultural science, extension, and development in a new light. This study of challenging agricultural regions suggests several conclusions. First, a functional knowledge history of agriculture which combines comparison and entanglement enables a global history of agricultural knowledge. Through my study of what I argue was the pivotal period in two of the most historically significant countries for agricultural innovation, I have demonstrated that it is possible to balance the

Debra A. Reid and Evan P. Bennett (Gainesville: University Press of Florida, 2012), 205-228; Zimmerman. The examples from Ethiopia and the Kazakh Steppe were discussed at the session "Modernizations Adjusted? Agrarian Development from Planning to Practice" at the meeting of the Agricultural History Society on June 4, 2021. The following publications then only begin to explore these processes: Michele Sollai, "Microcosms of Colonial Development. Italian and Ethiopian Farmers at the Crossroads of Fascist Empire Building (1937-1941)," *Contemporanea*, 24, no. 1, 2021, 79-101; Jack Seitz, "Steppe School: The Late Russian Empire and Kazakh Agriculture," *NYU Jordan Center* (blog), March 25, 2021, https://jordanrussiacenter.org/news/steppe-school/.

[546] See especially Ross, 307-341; but also Droessler.

particularities with the similarities of case studies in agricultural history. I am not the first to do so, of course. Where Peter Moser and Juri Auderset are very careful in suggesting that their framework of the agrarian-industrial knowledge society applies beyond the case of Switzerland or even European countries, I have shown that enlarging their approach with the analysis of knowledge systems makes their framework the most promising narrative for a global history of agricultural change from the mid-nineteenth to the mid-twentieth century and beyond. Moser with his co-authors have suggested an even longer historical arc from around 1750 to today. While agricultural historians may disagree with such sweeping frameworks, I have shown it to be a good starting point for negotiating a consensus about the global history of agricultural knowledge.[547]

Second, an integrated history of the agrarian-industrial knowledge society which includes the agency and perspective of farmers is possible. I do not argue that my case studies of actors on the farmer-improver continuum in Westphalia and Maine are representative of knowledge systems beyond the confines of the United States and Germany. Yet they suggest an analytical method which puts farmers – numerically the largest group of people involved with the change of agriculture – back into the history of agricultural knowledge. I found insights by replacing the common narrative of agricultural "modernization." Scientists' "discoveries" were not just "disseminated," and innovations of "progressive" agriculture did not just "diffuse" among farmers until they had "caught up" with how "modern" agriculture should be. Rather, a fuller narrative understands that agricultural innovation and change was always coproduced, negotiated, and excluding. The constellation and functions of actor groups were the same within the agrarian-industrial knowledge society spanning the United States and Germany, but their conflicts, negotiations, and results in the particular and for individual actors was contingent on time and place. The ways the agrarian-industrial knowledge society agreed to respond to the economic pressures of globalizing markets eventually displaced the majority of farmers in the twentieth century. Rather than

[547] See e.g. Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*; Auderset, Bächi, Moser, "Die agrarisch-industrielle Wissensgesellschaft im 19./20. Jahrhundert: Akteure, Diskurse, Praktiken;" Moser and Varley, "The state and agricultural modernization in the nineteenth and twentieth centuries in Europe."

pointing fingers at any one actor group or factor, this history of agricultural innovation suggests reexamining the ways human societies have produced and communicated the knowledge to grow food and agricultural commodities in the past and today.

Third, combining the economic and knowledge history of agriculture provides a new perspective on the environmental history of agriculture. Seeing the negotiation of agricultural knowledge in response to globalizing markets sheds light on how agriculture came to damage its own foundation. The environment was part of the negotiations of agricultural knowledge but it did not get a seat at the table, no matter how much it resisted. I have begun to show why that was so. The agrarian-industrial knowledge society spanning Germany and the United States designed innovation to address immediate economic problems. To solve them, the resistance of nonhuman organisms, the limits of biological reproduction cycles, and the specificities of place were obstacles to overcome rather than a line that should not be crossed. Placeless knowledge of scientists, developed in and for ideal conditions, fit shared visions of placeless industrial production that controlled all conditions. The best innovation was the one every actor group could adapt to their own needs, that could win over a critical mass of actors, and that allowed making a living in the immediate future. It was telling that Wilhelm Wagner promoted his fodder cultivation and his flat pea variety as economic solutions. They would save farmers money in the long run and ensure the economic survival of farmers in challenging environments. He did not tout his ideas of environmental limits and ecological management. Where Wagner aimed to negotiate agriculture in every place anew to ensure sustainable profits for many, the agrarian-industrial knowledge society agreed on standardizing agriculture and the environment in the image of industry as the most profitable short-term solution for the few. With the intention to save farming and farmers, the agrarian-industrial knowledge society made unsustainable agriculture.

The consensus of the agrarian-industrial knowledge society shaped the development of farming in the twentieth century: fitting productive environments into global market niches, suspending limits of organic resources as much and as long as possible, and excluding those farmers who were unwilling or unable to negotiate the innovation to achieve these goals. In this perspective, the problem of farmers in challenging regions was that they were farmers in the first place. In the twentieth century, the niche in the world market for places with mountainous landscapes, poor soils, and colder, wetter climates, such as in the Sauerland and western Maine, would not be dairy or livestock products but timber. Closely managed spruce monocultures on Sauerland hillsides and soft wood forests for clear-cut logging in large parts of Maine became the dominant working landscapes. Trees replaced meadows, because growing trees on remote hillsides returned a profit in competition to other environments around the globe for large parts of the twentieth century. State policies which either established tariff barriers around domestic farmers or subsidized them did not halt this trend in challenging regions. The functional workings of the agrarian-industrial knowledge society produced blooming and booming farm regions to feed the world population, always needing the next industrial fix to displace the ever-resurging resistance of organisms, environments, and people. Elsewhere, profitable farming became a distant memory for all but a few locals. The hands and minds of scientists, improvers, market agents, farmers, extension agents, and state agents worked together, against, and without each other in many ways to know the promise of the land. But in the end, they were unable and unwilling to know the limits of the land.

To explain the unsustainable development of agriculture ever since the nineteenth century, we must understand this consensus. The question is not: What happened to farming knowledge of ecological limits? Rather, we have to ask: Why could all groups concerned with farming not agree on the inclusion of ecological limits in the development and negotiation of agricultural innovation? Their exclusion was not dictated by markets or environments but negotiated by humans. So, after more than a century, putting limits back into farming is difficult, but possible.

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