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<CN>Chapter Six<CN>

<CT>Ignorance Is Strength<CT>

<CST>Science-based Agriculture and the Merits of Incomplete Knowledge<CST>

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In his novel *1984*, George Orwell describes a system of totalitarian suppression in terrifying detail. Mass events and omnipresent television screens make for constant indoctrination, while cameras leave no part of the public and private spheres uncontrolled; a ruthless secret police weeds out dissidents for re-education, torture, and worse. But totalitarian control not only pertains to supervision and violence. At the time when the novel takes places, the rulers are about to introduce Newspeak, an artificial language that seeks to make oppositional thoughts intellectually impossible. For the moment, the system sticks to a method called Doublethink, which annihilates dissent by reconciling ideas that stand in contrast to each other. With that, ideas that could undermine the hegemonic system of thinking are neutralized because citizens can no longer draw inconvenient conclusions from them. The novel presents three slogans that epitomize the philosophy of Doublethink: War is peace. Freedom is slavery. And ignorance is strength.[i]

On first glance, it might appear as a far stretch to bring an idea from Orwell’s dystopia to the farming world of Western Europe. After all, farming was one of the least regulated trades in many countries until the late twentieth century, when consumer demands and environmentalism called for more stringent controls. As a matter of fact, the farmers’ liberty was an ideologically charged issue, as agriculturalists juxtaposed Western Europe’s family farmers to the collectives behind the Iron Curtain. However, freedom on the farm was merely a matter of perspective:

while farmers were legally free to do as they pleased, more subtle forces came to constrain their range of options. Knowledge played a crucial role in this process. In the post-war years, scientists and advisors came to favor only one approach to farming, namely specialized, industrial-style farming with a huge energy and chemistry input. In other words, farmers could do as they pleased, but if they sought alternatives to the dominant approach, they were essentially on their own—there simply were no experts that they could consult with. As a result, most farmers either went out of business or followed the hegemonic path, thus heeding a system of thought that was indeed totalitarian in its own way.

Ignorance is not an unexplored theme when it comes to industrial agriculture. Other scholars have described how experts used claims of ignorance in order to bolster the case for development policies and science-based agriculture and marginalize indigenous and peasant knowledge.[ii] However, this essay explores a different path towards the overall topic. It describes a situation where experts were unable to define standards of proper knowledge in their own right, and actually had to make significant concessions with a view to their status. In the following case study, scientific experts became subject to a general discourse with multiple stakeholders that allowed ignorance to flourish. This chapter views ignorance as the result of long-term trends in European farming, with the interaction between researchers, advisors, administrators, and farm practitioners producing a "proper farming code of conduct" over time: all parties had an impact on it, but none could determine this code in its own right. In order to analyze this ongoing process of negotiations, this chapter takes a long view, tracing the development of knowledge about soil fertility from the mid nineteenth century to the present. The production of ignorance as discussed in the following is a process that extended over several generations: it took a lot of time to develop a knowledge base that relied not only on scientific research but also on a readiness to blank out certain issues and perspectives. No thought police forced the farmers into believing that ignorance was strength—they simply got used to it over time.

It is worth pointing out that in the following story, ignorance is not simply the absence of knowledge. The erosion of knowledge about soil fertility was not a science-driven process and actually took place in the presence of a substantial body of scientific knowledge. The industrialization of agriculture went along with constant warnings about its impact on the soil, and these warnings did not come from some obscure fringe figures but from respected experts within the agricultural science community. At its core, ignorance was a transfer and contextualization problem: it was not difficult for a farmer to find expert warnings—after all, they often stood in their own farm journals—but it was nearly impossible to incorporate these warnings into a hegemonic discourse that relied solely on agrochemistry, conceiving the soil as merely a storage space for nutrients on the way from the chemical factory to the crop. From a twenty-first-century viewpoint, it is by all means clear that this path implied an enormous environmental toll: if it had not been for the enormous resilience of central European soils, which tolerate even grave forms of abuse without a sudden collapse of fertility for some time, the industrialization of agriculture would have ended in an ecological disaster.

<PT><A>In the Land of Liebig<PT><A>

It is by all means fitting that the following discussion centers on experts and farmers in Germany. Scholars agree that Germany's system of agricultural research was in the vanguard internationally, at least on a par with parallel trends in countries like France and the United States.[iii] The choice is even more convincing when it comes to the issue of soil fertility, as solving the mysteries of plant nutrition was to a great extent the work of German scientists. The most prominent name is that of Justus von Liebig, who won international acclaim for his role in the rise of agricultural chemistry. His "Law of the Minimum," which asserts that plant growth is determined by the least plentiful nutrient, stands in handbooks for fertilizer use all over the world, and it only adds to the importance of Germany's agricultural science in the nineteenth century that Liebig drew heavily on previous work by another German scientist, Carl Sprengel.[iv] A third famous name is that of Hermann Hellriegel, who investigated nitrogen fixation in plants from the legume family and showed that nitrogen fixing bacteria played a crucial role in the process.[v]

As a result, chemical expertise played a powerful role in agricultural research institutions of the nineteenth century. Out of the 65 agricultural experiment stations that Germany had in 1913, a full 50 were headed by a chemist.[vi] In fact, agrochemistry was frequently cited in the farming community as evidence for the professional credentials of science-based agriculture; but that said more about agriculture than about science. After all, the scientists were generally unabashed in conceding the limits of their knowledge. For example, Carl Sprengel wrote in 1839 that plants form "their organic body in a way that will eternally escape our understanding."[vii] Some six decades later, Hellriegel noted matter-of-factly that "we are still lacking a rational theory of plant nutrition and fertilizing."[viii] To be sure, the more boisterous Liebig often presented agrochemistry as a rock-solid science devoid of painful uncertainties, but it is easy to see through this rhetoric; his famous reversal on the issue of nitrogen in the seventh edition of his *Die Chemie in ihrer Anwendung auf Agricultur und Physiologie* in 1862 is perhaps the most obvious example.[ix] In late-nineteenth and early-twentieth-century publications, Liebig frequently came across as a hothead who exceedingly stressed chemical expertise, and some even charged him of "dilettantism" because he ignored the complexity of agriculture.[x]

The limits of agrochemical knowledge were not difficult to conceive. It was sufficient to ask one simple question: how much fertilizer of what kind should farmers use for their fields? Agrochemical texts were usually expansive about the different nutrients and their effects, but when it came to specific instructions for use, narratives became insecure and evasive: in the early 1900s, the standard response was that it all depended on the specifics of the individual case and that farmers would basically have to see for themselves. For example, the renowned head of the agricultural experiment station in Darmstadt, Paul Wagner, emphatically denied any ambition to give quantitative advice: "you will not bother me with such a silly request," he declared, calling on farmers to fertilize "according to circumstances."[xi] It was thus quite a stretch to speak of science-based agriculture: agrochemistry could provide some general information about mineral fertilizers and their merits, but it was in no position to define patterns of best use.

Furthermore, it is important to realize the limited role that mineral fertilizers played in late-nineteenth-century agriculture. They were not the only, or even the most important contribution to soil fertility. On most German farms, the role of artificial nutrients paled in comparison with that of animal manure. Combining livestock and plant production had been a key theme of agrarian reformers around 1800, and most farmers devoted much energy to perfecting the cycle of nutrients. The general idea was that plants would grow more bountiful with manure, thus boosting the production of animal feed, which in turn allowed the farmer to raise more animals which would deliver even more manure.[xii] The use of feces did by no means decline towards the end of the nineteenth century, as many German farmers came to rely on imported feed for livestock, and some calculations indicate that the *growth* of the nutrient input from manure was bigger than the *total amount* of nutrients from mineral fertilizer.[xiii] Finally, it is important to note that artificial fertilizers were used in farming long before Liebig. In 1800, an allegedly “complete” list of artificial fertilizers carried 45 entries, and products like fish wastes remained in use far into the twentieth century.[xiv]

All in all, soil fertility was still a broad concept in the late nineteenth century. Agrochemistry had left its mark on the ideas within the farming community, but it was by no means running the show. After all, soil fertility was about more than nutrients: manure was cherished for its chemical as well as its biological properties. Bacteria and organic matter would help in the preparation of the seedbed, as decomposition made the soil brittle and lofty in the spring. However, achieving the perfect seedbed required constant attention and care, and farmers took great pride in their skills. As late as 1949, a farming textbook stressed that correct treatment of the soil and seedbed preparation were “the supreme art of the farmer.”[xv] In short, managing soil fertility required a delicate interplay of chemical, physical and biological forces, and no scientist claimed that he or she understood it better than a seasoned practitioner. The general line was that experts were there to help the farmer make more informed decisions, and ideas about an ascendant hegemony of scientific specialists were still beyond the horizon. But that was about to change.

<PT><A>Going Chemical<PT><A>

One of the drawbacks for mineral fertilizer use in the nineteenth century was the scarcity of raw material. The guano trade provides a perfect illustration: Western nations would never have put up with the hassle of transporting bird droppings for thousands of miles if they had had a substitute at home. However, the resource problem was changing its character shortly before World War I when Fritz Haber and Carl Bosch invented a method to produce ammonium from atmospheric nitrogen.[xvi] Soon baptized the “Haber-Bosch process,” it allowed the production of practically unlimited quantities of the one nutrient that boosted plant growth like no other. To be sure, the process required a lot of energy, making synthetic ammonium a rather expensive type of fertilizer, but within the agricultural expert network, that mattered less than the sheer amounts that suddenly became available. For a fertilizer community that had lived with chronic problems of scarcity, the Haber-Bosch process was bursting the horizons.

However, the new quantities were not the only thing that made the invention of the Haber-Bosch process a watershed in German agricultural history. Before 1914, the fertilizer market had been the province of small and medium-sized companies. However, producing ammonium from atmospheric nitrogen was a classic endeavor of big, industrial chemistry. The patent holder, the BASF, soon merged into the giant IG Farben which comprised the lion's share of Germany's chemical industry, making it one of the most powerful companies in German history. As if to illustrate that it planned to move into the fertilizer business in a big way, the BASF founded its own agricultural experiment station in 1914, the Limburgerhof, which soon became one of the most important research centers of its kind.[xvii] To be sure, the ammonium did not go into agricultural use initially: during the war, the military claimed the production for explosives, and the Haber-Bosch process essentially kept the German army firing throughout World War I. But that made the entrée of synthetic nitrogen even more bold: the demands of the war economy had led to huge production capacities which were now waiting for a non-military use, while Germany's fields were devastated after four years of emergency production. The solution seemed obvious: bring excess ammonium to the impoverished fields.

As a result, experts, advisors, industrialists and officials came together in a joint endeavor to preach fertilizer use on an unprecedented scale. It all sounded like a very simple affair: "We have the necessary amounts of fertilizer, and we can bring them to the fields. If that does not happen, we will starve," a 1920 memorandum for the Prussian prime minister declared.[xviii] Some experts even fantasized about legal action to force farmers into mineral fertilization.[xix] However, the combination of massive propaganda, government subsidies and a galloping inflation rate were reason enough to go for massive, unprecedented doses. However, the simple equation did not work out: per-acre yields stayed below pre-war levels until far into the 1920s. To give just one example, the average yield of wheat for 1925–1927 was only 82 percent of what it had been during 1911–1913.[xx] What had been promised as the panacea for war-ravaged fields suddenly turned out to be a massive malinvestment, and that mattered a lot as farmers were struggling with debt in the late 1920s.[xxi] Furthermore, the approach was showing unexpected side effects: burdened with high doses of ammonium, many fields showed severe signs of acidification.

It is a bit difficult to define the precise extent of the acidification crisis. Soil types differ enormously in resilience and natural pH, and the level fluctuates throughout the season. However, when the Prussian ministry of agriculture sent out a circular in 1926, virtually all provinces were reporting difficulties.[xxii] The one clear thing was that acidification was dangerous to soil life. "Acid soils are dead soils, and it takes an artificial boost for microbiotic activity to revive them," Hubert Kappen, professor of agrochemistry at the Agricultural College of Bonn-Poppelsdorf, noted in a book of 1929.[xxiii] Kappen had noted as early as 1922 that the problem "was starting to look worrisome" and ultimately made acidification the topic of his life.[xxiv] The problem had caught Germany's mighty agrochemical establishment off guard, as researchers "had rarely, or even never paid attention to the chemical reactivity of the soil when they made fertilizer experiments."[xxv]

The acidification crisis encouraged widely different readings. For many chemists, the remedy was lime, which neutralized acids after two or three years. However, many farmers were skeptical, and for good reasons: weren't these the same people who had encouraged the massive doses of ammonium in the first place? Remarkably, the use of lime remained below pre-war levels, indicating that the agrochemical propaganda was increasingly falling on deaf ears.[xxvi] Furthermore, wasn't the idea to use lime coming from the same constrained perspective—from people who saw the soil simply as a storage place for chemicals, rather than a living entity? Of course, those in the employ of fertilizer manufacturers rarely raised these concerns, but independent observers were pointedly asking some basic questions. For Friedrich Merkenschlager, a government scientist in the employ of the *Biologische Reichsanstalt* (the federal agency for agricultural affairs), the real issue was specialization: he argued that researchers had studied the soil, and agricultural issues generally, in an exceedingly narrow way, and as a result, "specialism had destroyed the biological eyesight in and of itself."[xxvii]

In the interwar years, there was no scarcity of options for those who wanted to move beyond chemical perspectives. Soil science was burgeoning, with the German Society for Soil Science (*Deutsche Bodenkundliche Gesellschaft*) being founded in 1926.[xxviii] The previous year, Felix Löhnis accepted a chair at Leipzig University. The best-known soil microbiologist of his time, Löhnis had in vain tried to obtain a professorship in Germany in the early 1900s, prompting him to accept a position with the United States Department of Agriculture in 1914, and his return to Germany inspired high hopes for an invigoration of research on the biology of the soil.[xxix] Meanwhile, the founder of anthroposophy Rudolf Steiner taught a "course in agriculture" in 1924, inspiring a farming practice that refrained from mineral fertilizer use altogether.[xxx] Few farmers had a firm grasp of anthroposophical teachings, but the "bio-dynamic" approach to agriculture proved hugely popular. For practitioners, "bio-dynamic" farming was not an issue of dogmatism, and not even something unfamiliar, as fertilizing with manure was old school in farming. At a farmer's meeting in Westphalia in 1931, an estate owner touted the merits of bio-dynamic farming by noting "that the method does not offer something new in general, but merely resorts to the procedures of our forefathers."[xxxi] Furthermore, the "bio-dynamic" approach offered an escape from the dreaded dependence on the fertilizer industry.[xxxii]

<PT><A>Narrow but Strong: The Strange Career of Agrochemistry<PT><A>

The stage was set for a showdown, and things did not look good for agrochemistry. It obviously had deficient methods that offered an exceedingly narrow perspective on the living soil. It suffered from distrust among farmers, who were naturally hesitant to believe in an expert system with strong ties, including financial ones, to the fertilizer industry. Finally, it was facing competition from several sides, both as cognitive alternatives and as groups that were received with a great deal of sympathy within the farming community. For Merkenschlager, the situation was clear: "agricultural chemistry has lost credit in large segments of the population," he noted in an article of 1933.[xxxiii] But in the end, agrochemistry rebounded and emerged stronger than before, in a hegemonic position that had previously been unthinkable. It was a remarkable recovery, even more so since it relied on the systematic production of ignorance.

For a discipline under pressure, attacks on competitors were a natural first line of resort. In the case of agrochemistry, it was an almost inevitable path: thanks to its many friends in the fertilizer business, it commanded resources that soil microbiologists and bio-dynamic farmers could only dream of. Furthermore, the competitors made it relatively easy. Under Löhnis's guidance, soil microbiology aimed for basic research, seeking a comprehensive understanding of biological processes in the soil. Given the inherent complexity of the topic, that made for a gigantic endeavor, and when German soil microbiologists published a synthesis of their field in the late

1930s, the discussion was scattered with regretful remarks that there was “still not sufficient clarity” on numerous questions.[xxxiv] To be sure, soil microbiology remained a busy science that way, and a synthesis of 1968 estimated that some 15,000 books and articles had been published in the previous thirty years.[xxxv] But at the same time, the discipline provided little that farmers could actually use, and that spelled trouble in the form of competition with a fertilizer network with hundreds of farm advisors at its disposal. In an essay of 1926, Löhnis urged farmers to identify by themselves the right approach to tillage from a microbiological standpoint “and then wait patiently until scientific research has found an explanation for their practical successes.”[xxxvi] But why should farmers support a discipline that offered only explanations after the fact, and even advertised that broadly?

The situation was different with alternative farming. Bio-dynamic agriculture was eager to win converts in the farming community and even sought to reach consumers with its publicity. Bio-dynamic food was supposed to be more healthy; in fact, some proponents argued that mineral fertilizer was causing cancer. Needless to say, that would have angered the fertilizer industry even if the bio-dynamic farming community had offered some substantial evidence, and in the absence of scientific proof, the chemists resorted to drastic words. “From the viewpoint of serious cancer research, we categorically refute unfounded assertions about a link between potash fertilizer and cancer,” the Federal Institute of Health (*Reichsgesundheitsamt*) declared in its bulletin in 1933.[xxxvii] In 1931, a joint experimentation program collapsed when the fertilizer division of the German Society for Agriculture (*Deutsche Landwirtschafts-Gesellschaft, or DLG*) passed a resolution declaring that bio-dynamic farming was “dubious, and indeed dangerous.”[xxxviii] An editorial of the *Chemiker-Zeitung* charged the anthroposophists of cultivating “a fanaticism that evokes memories of the dark ages of medieval ignorance.”[xxxix]

After the Nazis' seizure of power, some authors explicitly called on the new leaders to crack down on these "charlatans."[xl]

However, strong words were only part of agrochemistry's response. After all, vigorous attacks easily backfired for a discipline under pressure, giving the impression of a panicked discipline without credibility. In any case, it quickly dawned on experts and advisors within the agrochemistry network that they would need to come up with a positive message. Given the defects of soil microbiology and alternative farming, what was their advice when it came to maintaining soil fertility? After the soil acidification debacle, farmers were more insistent than ever on clear advice so that they could later check the validity and, by extension, the trustworthiness of the advisor. For a discipline in trouble, it was unwise to evade requests for precise instructions in the manner of Paul Wagner.

Ironically, the acidification crisis pointed to a clever escape: soil testing. In 1926, the government started a program to subsidize tests in order to identify those fields that were in need of lime.[xli] It was a matter of common sense to add tests for other nutrients, most notably for potash and phosphorus—after all, if the farmer had made an effort to take a sample and send it to the laboratory, why not screen it more comprehensively and inform the farmer about the chemical potential of his land? Furthermore, if one knew about the nutrients in the soil, it was tempting to go all the way and instruct the farmers right away on how much fertilizer he should give. Observers had noted for a long time that it would be welcome "if we could provide the farmer with a quick and reliable procedure to check the fertilizer need of his soil with some certainty," and the agrochemical establishment became ever more willing to supply the farmers with precise numerical information in this way.[xlii] In his *Trust in Numbers,* Theodore Porter argued that "the drive to supplant personal judgment by quantitative rules reflects weakness and vulnerability" and that quantification develops in science "as a response to conditions of distrust attending the absence of a secure and autonomous community," and the present story provides a perfect illustration of his thesis.[xliii] Lack of legitimacy, rather than the opposite, was what brought the agrochemical expert network into the business of quantitative information.

It would have been a great response indeed—if agrochemistry had had reliable testing methods. However, the opposite was true: "For once we need to be clear that we are unable at this point to tell the farmer, based on any available procedure, how much fertilizer he should use on his field in the upcoming year," Max Gerlach, the former head of the renown Kaiser Wilhelm Institute for Agriculture, declared in 1926.[xliv] Others agreed: in a report for the Prussian ministry of agriculture, Otto Lemmermann, professor of agrochemistry at Berlin's Agricultural College (*Landwirtschaftliche Hochschule Berlin*) urged "upmost caution" in soil testing: "Consciously or subconsciously, we find erroneous ideas as to the reliability of laboratory methods in many circles."[xlv] However, these doubts remained mostly an internal affair: to the outside world, experts and advisors were preaching the gospel of soil testing as a trustworthy way to learn about the chemical properties of fields. After all, there was a way to adjust for the uncertainties in an inconspicuous way when making fertilizing proposals: if in doubt, give more. In an article of 1929, Paul Wagner proposed the following rule of thumb: "rather a bit too much than not enough."[xlvi] Under pressure from the need for precise instructions, experts gradually came to embrace testing methods in spite of scientific doubts, and over time, they became increasingly unembarrassed about it: in 1934, an article noted that experts were talking about methods "where the farmer does not need to spend any effort towards getting to know them."[xlvii]

The experts' boldness met with the viewpoint of the farmers: in retrospect, their wish for simple solutions, including quick and dirty ones, is clear. A good indicator is the farmers' penchant for patent fertilizers, i.e., mixtures of mineral fertilizers with several nutrients. Patent fertilizers had originally been unpopular because they were prone to manipulation and because the fixed ratio implied a significant waste. However, when the IG Farben introduced its "Nitrophoska" brand in 1927, offering a fertilizer that included nitrogen, potash, and phosphorus, the product became hugely popular with amazing speed.[xlviii] From a scientific viewpoint, it was easy to dismiss the approach: "We need to distinguish between 'Nitrophoskans' and intelligent farmers," a fertilizer expert said in a committee meeting in 1928, and the chairman concurred: "The lazy ones use Nitrophoska, the clever ones don't."[xlix] Farm practitioner were obviously favoring fool-proof recipes: no one argued that Nitrophoska would provide the perfect mix of nutrients, but it rarely provided a completely false or destructive dose, and that ultimately carried the day. It was a victory of a "simple and dubious" approach over a "correct but complicated" one, and it was a choice that no expert or advisor could mandate—it was the result of everyday purchasing decisions in thousands of stores all across Germany.

<PT><A>Ignorance Is Strength<PT><A>

After 1945, German agriculture changed more dramatically than ever before. Within one generation, a new industrial style pushed previous modes of production to the margins, making for the most dramatic shift in agriculture since the Neolithic Revolution. Food became abundant in Germany and Western Europe; at the same time, many farmers moved from full-time to part-time production or abandoned agricultural production altogether. Given the drastic nature of change in the post-war years, it is difficult to imagine that the transition was generally unexpected: there was no blueprint for change, and not even an expectation that productivity would soon go through the roof. In 1955, an article in the influential *Mitteilungen der DLG* argued with a view to per-acre yields that "it is unlikely that the general trajectory will continue its upward trend as dramatically as it has in the past."[l]

What looks like foolish caution in retrospect was scientifically proper in the contemporary context: there was no way to know that the combination of massive doses of nutrients with new seeds would lead to the biggest jump in per-acre yields in history. In fact, there was good reason to doubt that this jump was sustainable, as it is not difficult to find worries that presage numerous themes of today's environmental critique. For example, the West German Ministry of Agriculture took a strategic environmental initiative when it created an expert group for soil conservation in 1950.[li] With federal funding, a group of about a dozen soil specialists discussed a broad range of issues, including erosion, loss of organic matter in the soil, and other hazards of industrial-style farming. In 1957, the group produced a memorandum which warned, among other things, that "all monoculture is breeding dangers."[lii] At a meeting in 1962, a speaker noted that it is "necessary to pay more attention to natural limits, and to gain a deeper understanding of causes and effects."[liii]

The techno-scientific revolution of the post-war years began with halting steps, mindful of the constant calls for caution. However, as per-acre yields were growing, the challengers sounded mostly like naughty children who simply did not understand the trend of the time. Disciplinary boundaries made blanking out these warnings easy, and the chemical approach was reaching the apogee of its power: no other approach could challenge its jurisdiction on soil fertility matters. As a result, issues that had been causing headaches in previous generations were now dealt with in a matter-of-fact way. For example, the traditional field tests were now brusquely declared obsolete: "It takes way too long to conduct scientific fertilizer experiments to identify the needs for nutrients, and it is barely possible to make these experiments in everyday practice," an article of 1965 argued.[liv] In 1970, a handbook dismissed a popular soil testing method with the laconic remark that it was "too complicated for serial investigations."[lv] As to the issue of multi-nutrient fertilizers, nobody found it objectionable any more that even progressive farmers used them "because they save time."[lvi] And yet for all the power of the chemical approach, it is crucial to recognize that agrochemistry could not operate out of a position of *scientific* strength. None of its cognitive problems were solved: soil tests were still deficient, and soil life still escaped its attention. Agrochemistry ruled without providing a broad understanding, and when it came to soil fertility, agriculture was essentially flying blind through its industrial revolution.

In order to understand the status of science in the heat of the agro-industrial revolution, it is rewarding to look into an issue more closely that may seem like a trivial topic at first glance: the use of straw as fertilizer. Traditionally, straw had been the standard cushioning of stables, where it mixed with the animals' feces. However, with the introduction of combines in the 1950s, threshing took place right on the field, and that gave birth to a new idea: why not leave the straw right there, rather than transport it to the stable and back to the field with great effort? Experts were quickly called upon to comment on the labor-saving idea from a soil fertility standpoint, and their response was hesitant: one of the federal soil specialists called for caution because "we do not have any conclusive experience on the issue of straw fertilization, and we cannot have those because soil fertility processes are dependent on many factors, which means that it will take decades until we have a clear picture."[lvii] Of course, in the heat of the post-war agricultural revolution, it was illusionary to wait many years for results, and Eduard von Boguslawski, one of the more independent-minded university professors of the time, noted regretfully that "the teachings of science so far have been overwhelmed by the measures of farm practitioners."[lviii] In the end, the experts had no choice but to give their nod to the new labor-saving practice.

Sometimes they added a few caveats and conditions, but no one could check whether farmers were heeding their advice.

The straw story shows that in the post-war years, the key driving force was outside of laboratories and administrations. Farmers were searching for quick ways to save labor and boost productivity, giving researchers scant time to inquire for follow-up problems, let alone investigate those problems thoroughly. Machines were the hallmark of the new industrial mode of production, and many of them could only be used for one specific commodity; specialization thus became the rallying cry, as farmers produced a narrowing range of products, and ideally only one, on ever greater units of production. The advisory literature soon took on an apodictic stance when it came to specialization: "We have deleted the word 'and' from the textbook of farm production," a journal article proudly declared in 1965.[lix] "With all due respect to tradition: the new, quick-paced times need flexible farmers who go with the trend. That includes a renunciation of diverse use of farmland in small units," another one noted in 1960.[lx] The trend towards industrial, capital-intensive production came from below, from the fields and stables out in the countryside, leaving experts no choice but to forget their doubts and jump on the bandwagon.

With that, erosion of knowledge was the order of the day. For those who wanted to survive the cost-prize squeeze, time was scarce: modern production methods were raising all sorts of questions and issues, but farmers were increasingly unable to devote attention to them. The reaction was plain: farmers were demanding simple recipes and rules of thumb as long as they boosted productivity in the short term. Even the soil specialists talked about the need for "fool-proof crop rotations" at a meeting in 1959.[lxi] A decade later, a Westphalian official sarcastically noted that "according to conventional wisdom, we are living in a permanent state of Cardinal sin when it comes to crop rotation."[lxii] In order to understand the significance of these statements, one must keep in mind that crop rotations were the key theme of agrarian reformers around 1800, and essentially the crucial difference between medieval and modern farming. In the agricultural history of Central Europe, sacrificing crop rotation was the end of an era.

The second pet theme of agrarian reformers around 1800 was the aforementioned nutrient cycle, and once more, the idea was under pressure—not as a scientific concept but as an everyday farming practice. As stables were expanding, they produced huge amounts of animal feces, and using them wisely was often an intractable challenge. Most farmers were glad if they somehow got rid of what they increasingly saw as liquid waste; whether dumping nutrients on the fields made sense for production became an issue of secondary importance. Some farmers did not even account for the nutrients in animal feces when they defined the amount of mineral fertilizer, resulting in massive overdoses—yet another sign of how much scientific expertise was under pressure in the post-war years.[lxiii] It is no coincidence that corn became popular since about 1960, as corn is one of the few plants that do not suffer under excessive fertilization.[lxiv]

However, in spite of all simplifications in the wake of specialization and farm growth, agriculture was still a complex interplay of biological forces. As a result, industrial-style farming became notorious for its environmental impact: for example, the excess nutrients from manure quickly showed up in the groundwater, and nitrate levels were increasingly giving waterworks headaches. Therefore, it is insufficient to see the environmental repercussions of industrialized farming as mere by-products of the new production methods: the environmental excess was an indispensable part of the project. In a nutshell, the innovation of industrial-style farming was to supplant knowledge with resources: rather than reflect on how to perfect the nutrient cycle or learn the precise needs of the plants, farmers embraced the simple notion that "a lot helps a lot" and flooded the fields with fertilizer. Whereas microbes and organic matter had formerly helped in seedbed preparation, gas-guzzling tractors were now doing the job mechanically. Instead of wasting ideas, farmers were wasting resources.

<PT><A>The Costs of Ignorance<PT><A>

In a letter of 1964, a soil specialist described a dramatic scenario for the future. He argued that "due to the primacy of economics, we are paying less and less attention to the soil. With that, the soil is often treated in a way that is essentially rape, and it will surely get its revenge one day."[lxv] For a society where soil disasters like the Dust Bowl were still living memory, such a prophecy was certainly troubling. However, if the author had hoped to change the general trend of agriculture with a drastic warning, his hope was certainly illusionary. The agricultural revolution of the post-war years had a momentum of its own, and scientific experts were confined to a minor role on the sidelines. The situation might have been better if the soil conservation community had made some inroads in the interwar years, as it is clear in retrospect that the general trajectory of agricultural knowledge was defined in the 1920s and 1930s. But things being as they were, the network of experts, farmers, and advisors settled on a narrow reliance on chemical approaches, blanking out ideas from alternative farming, soil science, and soil microbiology. In the post-war years, the agricultural knowledge society was following this set course, and the doubts and worries of experts were nothing but an ephemeral phenomenon. It would have taken a major disaster to shift the course of development.

In a way, a disaster did happen; but it did not have the spectacular outlook of the Dust Bowl. Rather, the soil problems were of a silent type: soil compaction, loss of organic material, erosion.[lxvi] Unbeknown to the protagonists, the agricultural revolution of the post-war years was drawing on the enormous tolerance of Central European soils for abuse, and it is important to note that no one had a clear understanding of how long this tolerance would last—though warnings are proof of an ill feeling. It was a daring endeavor to ignore these warnings, but also one that was indispensable for the transformation to take place: if farmers, experts, and advisors had not agreed on a very narrow and very risky view of the soil, there would have been no narrow specialization, no abandonment of crop rotation, and no overfertilization in the "a lot helps a lot" fashion. With that, one may argue indeed that, in a perverted way, ignorance was strength.

Of course, it remains a matter of debate whether Orwell's notion of Doublethink is helpful here. However, if one tries to imagine the farmers' state of mind during the post-war agricultural revolution, the result does look familiar for readers of *1984*. On one level, the contradiction between the best available science and the code of conduct for practical farming was apparent, but on another one, it was hard to draw conclusions.[lxvii] Furthermore, chances are that the age of ignorance is by no means over in modern, industrial-style agriculture. To be sure, the management of soil fertility has improved notably in sophistication over the last three decades as environmental regulation has put some obstacles to some of the more destructive processes.[lxviii] However, it only takes a look at the current buzz over genetically modified plants to notice a familiar ring: the hope for simple solutions has not died, but merely shifted towards other topics. In a statement frequently quoted by biotechnology lobbyists, the Kenyan biologist Florence Wambugu argued for genetically modified crops by noting, "The great potential of biotechnology to increase agriculture in Africa lies in its 'packaged technology in the seed,' which ensures technology benefits without changing local cultural practices."[lxix] However, chances are that this kind of ignorance will cost the farmers dearly. In fact, if we look at genetically modified cotton in India, ignorance about the new plants' propensities is already leading to risky behavior without the farmers' knowing.[lxx] After all, agriculture remains a complex interplay of biological, chemical, and physical forces. The question is whether, and when, people take note of that.

<N>Notes<N>

i. George Orwell, *Nineteen Eighty-Four. With a Critical Introduction and Annotations by Bernard Crick* (Oxford and New York, 1984).

ii. Jan Douwe van der Ploeg, "Potatoes and Knowledge," *An Anthropological Critique of Development. The Growth of Ignorance*, ed. Mark Hobart (New York, 1993), 209–227. See also Bill Vitek and Wes Jackson, eds., *The Virtues of Ignorance. Complexity, Sustainability, and the Limits of Knowledge* (Lexington, 2008).

iii. Cf. Mark R. Finlay, "The German Agricultural Experiment Stations and the Beginnings of American Agricultural Research," *Agricultural History* 62, no. 2 (1988): 41–50; Nathalie Jas, *Au carrefour de la chimie et de l'agriculture. Les sciences agronomiques en France et en Allemagne, 1840–1914* (Paris, 2000). For an institutional overview, see Jonathan Harwood, *Technology's Dilemma. Agricultural Colleges between Science and Practice in Germany, 1860–1934* (Bern, 2005).

iv. Cf. William Hodson Brock, *Justus von Liebig. The Chemical Gatekeeper* (Cambridge, 2002).

v. Wolfgang Böhm, "Die Stickstoff-Frage in der Landbauwissenschaft im 19. Jahrhundert," *Zeitschrift für Agrargeschichte und Agrarsoziologie* 34 (1986): 31–54.

vi. Susanne Reichrath, *Entstehung, Entwicklung und Stand der Agrarwissenschaften in Deutschland und Frankreich* (Frankfurt, 1991), 118.

vii. Carl Sprengel, *Die Lehre vom Dünger oder Beschreibung aller bei der Landwirthschaft gebräuchlicher vegetabilischer, animalischer und mineralischer Düngermaterialien, nebst Erklärung ihrer Wirkungsart* (Leipzig, 1839), 48.

viii. Hermann Hellriegel, *Düngungsversuch und Vegetationsversuch. Eine Plauderei über Forschungs-Methoden* (Berlin, 1897), 15.

ix. For details, see Böhm, "Stickstoff-Frage", 31, 34, 36, and Brock, *Liebig*, 166–179.

x. Richard Krzymowski, *Philosophie der Landwirtschaftslehre* (Stuttgart, 1919), 27.

xi. Paul Wagner, *Stickstoffdüngung und Reingewinn* (Berlin, 1906), 24.

xii. Cf. Stefan Brakensiek, "Das Feld der Agrarreformen um 1800," *Figurationen des Experten. Ambivalenzen der wissenschaftlichen Expertise im ausgehenden 18. und frühen 19. Jahrhundert*, ed. Eric J. Engstrom, Volker Hess, Ulrike Thoms (Frankfurt, 2004), 101–122.

xiii. Friedrich-Wilhelm Henning, *Handbuch der Wirtschafts- und Sozialgeschichte Deutschlands. Vol. 2: Deutsche Wirtschafts- und Sozialgeschichte im 19. Jahrhundert* (Paderborn, 1996), 917.

xiv. Robert Somerville, *Vollständige Uebersicht der gewöhnlichen, und mehrerer bisher minder bekannten Dünge-Mittel und deren Würksamkeit* (Leipzig, 1800).

xv. Johannes Knecht, *Das Jahr des jungen Landwirts. Ein Lehr- und Handbuch für den landwirtschaftlichen Berufsschüler und Landwirtschaftslehrling*, 2d ed. (Stuttgart and Ludwigsburg, 1949), 26.

xvi. Margit Szöllösi-Janze, *Fritz Haber 1868–1934. Eine Biographie* (Munich, 1998), 179–181. For the global significance, see Hugh S. Gorman's chapter in the present volume.

xvii. Badische Anilin- und Soda-Fabrik, *Die Landwirtschaftliche Versuchsstation Limburgerhof 1914–1964. 50 Jahre landwirtschaftliche Forschung in der BASF* (Frankfurt, [1964]).

xviii. Bundesarchiv Berlin-Lichterfelde R 3602 no. 606, Denkschrift des preußischen Landwirtschaftsministers zur Frage der Volksernährung, Berlin, January 11, 1920, 1.

xix. Max Hoffmann, *Beispieldüngungen, Statistische und Exakte Felddüngungsversuche von 1903-1918. Ein Tätigkeits- und Rechenschaftsbericht; zugleich ein experimenteller Beitrag zur Kunstdünger-Frage* (Berlin, 1919), VII.

xx. Max Hoffmann, Otto Nolte, *Düngerfibel. Ein Leitfaden zu der Düngertafel der D.L.G.* (Berlin, 1929), 144.

xxi. Ulrich Kluge, *Agrarwirtschaft und ländliche Gesellschaft im 20. Jahrhundert* (Munich, 2005), 20–23.

xxii. Geheimes Staatsarchiv Preußischer Kulturbesitz Berlin I. HA Rep. 87 B no. 10557 p. 305-403.

xxiii. Hubert Kappen, *Die Bodenazidität nach agrikulturchemischen Gesichtspunkten dargestellt* (Berlin, 1929), 195.

xxiv. Hubert Kappen, "Bodenazidität und Kalkdüngung," *Mitteilungen der Deutschen Landwirtschafts-Gesellschaft* 37 (1922): 660.

xxv. Ibid., 663.

xxvi. Siegfried Gericke, "Trotz stärkerer Düngung schlechtere Ernten," *Die Umschau. Illustrierte Wochenschrift über die Fortschritte in Wissenschaft und Technik* 36 (1932): 662.

xxvii. Friedrich Merkenschlager, "Zeitkrise und die sogenannte 'Biologisch-dynamische Düngung,'" *Natur und Kultur. Monatsschrift für Naturwissenschaft und ihre Grenzgebiete* 30 (1933): 123.

xxviii. Cf. Hans-Peter Blume, ed., *75 Jahre Deutsche Bodenkundliche Gesellschaft* (n.l., 2001). For a more extensive discussion of these alternatives, and the general background of this essay, see Frank Uekötter, *Die Wahrheit ist auf dem Feld. Eine Wissensgeschichte der deutschen Landwirtschaft* (Göttingen, 2010).

xxix. Ernst Zander, "Neubesetzung des Lehrstuhles für Bodenbakteriologie," *Die Technik in der Landwirtschaft* 6 (1925): 247.

xxx. On the development of bio-dynamic farming, see Gunter Vogt, *Entstehung und Entwicklung des ökologischen Landbaus* (Bad Dürkheim, 2000), and Helmut Zander, *Anthroposophie in Deutschland. Theosophische Weltanschauung und gesellschaftliche Praxis 1884–1945*, 2 vols. (Göttingen, 2007).

xxxi. Staatsarchiv Münster Landwirtschaftliche Kreisstellen, no. 698, newspaper article of January 12, 1931.

xxxii. Hugo Neubauer, "Über die biologisch-dynamische Wirtschaftsweise," *Mitteilungen der Deutschen Landwirtschafts-Gesellschaft* 46 (1931): 634.

xxxiii. Merkenschlager, "Zeitkrise," 123.

xxxiv. Gerhard Ruschmann, "Vorkommen und Tätigkeit von Mikroorganismen im Stalldünger," *Handbuch der landwirtschaftlichen Bakteriologie. Vol. 2: Dünger- und Bodenbakteriologie*, 2d ed., ed. Felix Löhnis et al. (Berlin, 1935), 13, 20n, 87 (quotation), 130n, 150.

xxxv. Theodor Beck, *Mikrobiologie des Bodens* (Munich, 1968), 18.

xxxvi. Felix Löhnis, "Bodenbakterien und Bodenfruchtbarkeit," *Die Technik in der Landwirtschaft* 7 (1926): 251.

xxxvii. *Reichs-Gesundheitsblatt* 8, 1933, 813.

xxxviii. Geheimes Staatsarchiv Preußischer Kulturbesitz Berlin I. HA Rep. 87 B no. 10547, 69.

xxxix. *Chemiker-Zeitung* 58 (1934): 245.

xl. O. Flieg, "Hände weg von unseren bewährten Düngemethoden!" *Umschau. Illustrierte*

Wochenschrift über die Fortschritte in Wissenschaft und Technik 37 (1933): 715.

xli. Geheimes Staatsarchiv Preußischer Kulturbesitz Berlin I. HA Rep. 87 B no. 10421, 29–31.

xlii. Hoffmann, *Beispieldüngungen*, 275.

xliii. Theodore M. Porter, *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life* (Princeton, 1995), xi.

xliv. Max Gerlach, "Die Bestimmung des Düngerbedürfnisses der Böden," *Landwirtschaftliche Jahrbücher* 63 (1926): 368.

xlv. Geheimes Staatsarchiv Preußischer Kulturbesitz Berlin I. HA Rep. 87 B no. 10423, Institut für Agrikulturchemie und Bakteriologie der Landwirtschaftlichen Hochschule to the Ministerium für Landwirtschaft, Domänen und Forsten, October 10, 1931, 2.

xlvi. Paul Wagner, "Das Thomasmehl als Frühjahrsdünger," Verein der Thomasmehlerzeuger ed., *Unseren Freunden vom Thomasmehl* (Berlin, 1929), 4.

xlvii. Kurt Maiwald, "Ermittlung der Düngebedürftigkeit des Bodens," *Mitteilungen für die Landwirtschaft* 49 (1934): 994.

xlviii. BASF AG, ed., *50 Jahre Nitrophoska* (Ludwigshafen, 1977), 8.

xlix. Bundesarchiv Berlin-Lichterfelde R 3602 Nr. 606, Niederschrift der 74. Sitzung über allgemeine Düngerangelegenheiten im Preußischen Landwirtschaftsministerium on February 10, 1928, 14, 16.

l. Walther Reich, "Können unsere Getreideerträge weiter erhöht werden?" *Mitteilungen der Deutschen Landwirtschafts-Gesellschaft* 70 (1955): 397.

li. Bundesarchiv Koblenz B 116/3240, Kurzprotokoll über die Besprechung von Fragen der Erhaltung und Mehrung der Bodenfruchtbarkeit on July 13, 1950 beim Bundesministerium für Ernährung, Landwirtschaft und Forsten, 1.

lii. Bundesarchiv Koblenz B 116/3239, Denkschrift des Verbandes Deutscher Landw. Untersuchungs- u. Forschungsanstalten über die Erhaltung und Mehrung der Fruchtbarkeit deutscher Böden, 1.

liii. Bundesarchiv Koblenz B 116/18257, Niederschrift über die Arbeitstagung der Bodenspezialisten in Göttingen on March 22–23, 1962, 4.

liv. W. Petersen, "Betriebe mit hoher Bodenleistung: Wie machen sie es?" *Deutsche Landwirtschaftliche Presse* 88 (1965): 474.

lv. Ruhr-Stickstoff Aktiengesellschaft ed., *Faustzahlen für die Landwirtschaft*, 6th ed. (Hiltrup and Munich, 1970), 193.

lvi. Staatsarchiv Würzburg Landwirtschaftsamt Würzburg no. 20, 4. Vierteljahresarbeit des Landwirtschaftsreferendars Max Gutmair, Richtige Anwendung der Handelsdünger, der erfolgreichste Weg zur Ertragssteigerung, 18.

lvii. Gerhard Spannagel, "Strohdüngung und Bodenfruchtbarkeit," *Landwirtschaftliches Wochenblatt für Westfalen und Lippe* 117 (1960): 563.

lviii. Eduard von Boguslawski, J. Debruck, "Die Verwertung der Strohernten als Strohdüngung," *Bodenfruchtbarkeit ohne Stallmist?*, ed. Ruhr-Stickstoff AG (Bochum, 1965), 9.

lix. W. Thalen, "'Große Serien' mit ernstem Hintergrund," *Deutsche Landwirtschaftliche Presse* 88 (1965): 381.

lx. Schmah, "Ist Vielseitigkeit im Ackerbau noch berechtigt?" *Landwirtschaftliches Wochenblatt für Westfalen und Lippe* 117 (1960): 1862.

lxi. Bundesarchiv Koblenz B 116/3240, Bericht über die Exkursionstagung der Bodenspezialisten der Länder on July 2–4, 1959 in Hesse, 3.

lxii. F. Stobbe, "Erfahrungen zwischen Theorie und Praxis," *Landwirtschaftliches Wochenblatt*

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lxiii. Jürgen Rimpau, “Düngung und ökologische Auswirkungen. Berichterstattung,” *Mit welcher Düngungsintensität in die 90er Jahre? Vorträge und Ergebnisse des DLG-Kolloquiums am 13. und 14. Dezember 1988 in Bad Nauheim* (Frankfurt, 1989): 56.

lxiv. On the post-war boom of corn, see Frank Uekötter, “Mutmaßungen über Mais. Anmerkungen zu Westfalens erfolgreichstem Neophyten,” *Westfälische Forschungen* 57 (2007): 151–171.

lxv. Bundesarchiv Koblenz B 116/18258, Spannagel to Schmitz, July 13, 1964, 2.

lxvi. For a popular presentation of soil problems in contemporary Germany, see *Politische Ökologie* 119 (2010): *Peak Soil. Die unterschätzte Krise der Böden.*

lxvii. Once more, the remark illustrates that the project of agnotology will need some kind of interaction with psychology and brain science if we want to gain a more theoretically satisfying understanding of the cognitive structure of ignorance.

lxviii. On the challenge of regulating the nitrogen cycle, see Hugh S. Gorman’s chapter.

lxix. Florence Wambuga, “Why Africa Needs Agricultural Biotech,” *Nature* 400 (1999): 16.

lxx. Cf. Glenn Davis Stone, “Biotechnology and the Political Ecology of Information in India,” *Human Organization* 6, no. 2 (2004): 127–140.