

## **The Visible Hand and the New American Biology: Toward an Integrated Historiography of Railroad-Supported Agricultural Research**

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*In the early twentieth century, American railroad companies faced new challenges. The railroad network had developed fully, broad political opposition was gaining teeth in new, enforceable federal legislation, and financial markets-first established to support railroad expansion- had begun to move beyond railroads. Railroad companies answered with a wide range of new managerial and scientific practices. Recent scholarship that goes beyond the traditional disciplinary separation of technological, political, managerial, economic, and scientific concerns has enabled historians to recognize that agricultural research pursued in concert with other institutions empowered railroads to address all of these challenges in the period between 1900 and 1930.*

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At the broadest level, participation in agricultural research brought railroads into the sphere of the biological sciences, which at the turn of the twentieth century held out the promise of a new and effective unity of knowledge production, political action, and economic productivity. During the biological moment between 1900 and the Great Depression, railroad support of agricultural research provided a means of linking abstract, basic investigational practices to Progressive ideals of national wellbeing and of addressing perceived weaknesses in a branch of

the economy that provided much railroad traffic. The broad collaboration between railroads and land-grant colleges in this period significantly concreted the institutional form of this concert of interests. This linkage became sufficiently diffuse by the time of the Great Depression that the biological moment in railroad practice had passed, and agricultural research lost its once compelling allure for railroad managers. For a few short decades, however, the "visible hand" in American railroad management was not only that of the accountant, the scientific manager, and the engineer; it was the hand of the biologist as well.

In 1938 the management of the Illinois Central Railroad (IC) charged the railroad's own Research and Development Bureau with compiling a set of essays drawn from internal training programs that could offer a systematic representation of the "*Organization and Traffic of the Illinois Central System*." The Bureau resonantly summarized its guiding principle: "Good research moves someone to *act*." Furthermore, research should follow "the method employed by the natural scientist." In economic terms it would be easy enough to imagine that the company desired to maintain competitive advantage by keeping the benefits of its research clearly within its own boundaries. Accordingly, the bureau set forth its program:

It should be borne in mind that there are two principal kinds of railroad research. First, there is mechanical and chemical research which develops improvements in equipment, materials, fabrics, paints and even such wonders as modern streamlined trains. Second there is commercial or traffic research which develops improvements in freight and passenger rates and service and studies natural resources, population and industry to find a ready market for the best transportation that can be produced.

Indeed, the benefits of the bureau's work seemed to be limited to the firm itself. The chapter concluded with this vision reduced to a cliché: "Our competitive position is also improved simply

because knowledge is power." It would therefore seem that the IC left the question of the benefit of its research policies to entities not represented on the corporate balance sheet exclusively in the care of Adam Smith's invisible hand.<sup>1</sup>

The Association of American Railroads (AAR), the industry's primary lobbying and public relations group, shared such an internalist vision of railroad research practice when it chose some ten years later to produce a pamphlet for dissemination to schools entitled *The Railroad Story: Science, Research, and Railroad Progress*. The pamphlet's metaphorical vision of science as the source of all railroad technology and practice took form in a cover photomontage of a two-hundred-forty-ton locomotive emerging fully formed and in builder's-photograph matte paint from a hand-held test tube (Figure 1). The pamphlet argued in several chapters that "research brings steady improvements." A second photomontage represented this vision by surrounding both the face of "experimental" company-built Norfolk and Western Railway Class A locomotive number 1200 and a serious, white-coated chemical researcher with vignettes of railroad operations and management (Figure 2). Nonetheless, Smith's hand was not so invisible here, for the railroad industry's trade group could not privilege the narrow interests of one firm over another. The entire railroad industry was in play and the pamphlet encouraged readers to perceive that railroad research benefits the public and the nation. "Science and many thousands of people keep the railroads working constantly for us," and, inexorably then, "railroads bring modern progress," so much so that "the railroads' future is our future." The AAR's pamphlet, however, notably failed entirely to mention a once-significant aspect of railroad-supported research that directly focused railroad resources on practices external to the companies' own technical and managerial systems: agricultural research.<sup>2</sup>

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**Figure 1**

The IC's self-assessment also displayed complex issues of corporate, public, and regional benefit associated with railroad support of agricultural research and development. The chapter entitled "Agricultural Development" sat in close proximity to the chapter on the practices of the Research and Development. The company's choice to separate research from development revealed the unstable position of agricultural research within the company's practices. In fact, the chapter on agricultural development never once included the term "research," although it described the IC's energetic support--from the moment of its corporate inception in 1850--for the investigation and propagation of better drainage, crop diversification, farm machinery, fruit and vegetable varieties, refrigeration, dairying methods, agricultural marketing, pest control, erosion control, seed oil varieties, and livestock husbandry. Nonetheless, in 1938 the IC described these practices not as research, but only as development.<sup>3</sup>

By the late 1930s railroad companies and their advocates understood "research" to refer only to the improvement of the railroads' own internal technical and managerial practices. "Development," on the other hand, represented inquiry into practices beyond those of the firm itself that might lead to the improvement of their traffic base. Nonetheless, a survey of the literature on railroad research and development revealed that such an interpretation failed to account for the diversity of practices through which railroad companies supported agricultural research in the earlier part of the twentieth century. [Between the turn of the century and the Great Depression (punctuated by the US Railroad Administration federalization during the First World War), the representatives of almost all larger American railroad companies, with the exception of the major Eastern trunk lines, saw agricultural research as an integral element in their strategies of corporate growth, public and government relations, and capital restructuring [KA: Please provide a citation for this]. Such research expanded railroad practice in ways

that appeared to benefit both the corporations and their broader constituencies, it provided a means of addressing the political pressures brought to bear on railroads, and it held the potential to demonstrate to the capital markets, which were emerging from their formative period of railroad dominance, that railroads offered good opportunities for returns.<sup>4</sup>

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## Figure 2

The IC, in fact, provided the records and materials that enabled a number of path-breaking scholars to first establish the historical significance of railroad-supported agricultural research. The two most important such studies are Paul Wallace Gates's *The Illinois Central Railroad and Its Colonization Work*, itself an important source for the railroad's 1938 self-study, and the only attempt at a comprehensive treatment of railroad agricultural "development," Roy V. Scott's *Railroad Development Programs in the Twentieth Century*. Several recent major studies from a range of historical subfields on business culture, railroad politics and practice, and agricultural practice--each of which addresses in some depth the workings of a single railroad company--have now revealed sufficient details about railroad companies' interest in agricultural research to enable the development of an integrated historiographical approach to the issue's many complexities. These studies include Olivier Zunz's *Making America Corporate, 1870--1920*, Gerald Berk's *Alternative Tracks: The Constitution of the American Industrial Order, 1865--1917*, Steven Usselman's *Regulating Railroad Innovation: Business, Technology, and Politics in America, 1840--1920*, Claire Strom's *Profiting from the Plains: The Great Northern Railway and Corporate Development of the American West*, Deborah Fitzgerald's *Every Farm a Factory: The Industrial Ideal in American Agriculture*, and Richard Orsi's *Sunset Limited: The Southern Pacific Railroad and the Development of the American West, 1850--1930*.<sup>5</sup>

Around 1900 and after, railroads and farmers entered together into the spheres of investigation and persuasion associated with a rapidly and powerfully expanding field of science: biology. Both farmers and scientists showed some resistance to this shift, but by the early twentieth century, biologists--a highly diverse group with fluid disciplinary identifications--had accepted that agricultural research was biological in character. The historiography of biology, and especially American biology after 1890, also focused on a significant shift in practice that correlated with the new investigational interests that railroads held in agriculture: the rise of experimental methods. For most of the nineteenth century, historical, anatomical, and morphological evidence--none of it derived from experimental observation under controlled conditions--had dominated biology. The late nineteenth century, however, witnessed the rise of investigational techniques that could relate conceptual phenomena like hereditary transmission to specific physiological processes in cells and organs.<sup>6</sup>

American biologists made this shift to experimental methods such a significant element of their practices around 1900 that many historians have accepted Garland Allen's suggestion that the shift represents a "New American Biology." Some biologists argued that sophisticated experimental practice meant that biology had finally become an autonomous science, independent of interests or investments in political, social, or cultural issues. Far more biologists, however, recognized that the exciting new results provided by experimentation could provide the basis for an invigorated kind of advocacy that made biology the basis for claims about the social, political, and moral good. Biology quickly became rooted in support of discourses of progress in scientific knowledge, political organization, and social advocacy. The classical Progressive "search for order" emerged wherever this network of scientific investigation and social and political valences of persuasion encountered the technical practices of institutions like the railroad.<sup>7</sup>

The search for order in agriculture in the early twentieth century therefore became biological in three ways. At the simplest level, research on crop varieties was increasingly subject to controlled and institutionalized experimental processes after 1900, which interested and scientifically inclined farmers could pursue. Nonetheless, the professionalization of crop improvement meant that agricultural inputs like hybrid seeds increasingly came not from farmers themselves, but from research pursued in land-grant colleges, government experiment stations, and specialized industrial corporations. Thus, agricultural processes predicated on biological knowledge supported the development of a capital-intensive new industry. Finally, this new and contentious complex of farming and capital accreted a wide set of claims about social good and political rationalization. In the early twentieth century, all of these discourses fell within the sphere of biological knowledge: the specific attributes of crop plants, the development of industrial-scale hybridization with its attendant production and distribution processes, and arguments about the social benefit of scientifically derived products. Railroad companies all over the United States rapidly came to understand that they could benefit from all of these. Improved crops translated into better harvests to deliver to faraway markets. Increasing capital intensity in agriculture meant that railroads had the opportunity to not only haul the products of agricultural production, but its inputs as well. They were therefore able to link themselves to new industrial spaces of capital investment at a time when the financial markets began to look beyond railroads for returns. Finally, railroads could counter political criticism of their treatment of their agricultural constituents by connecting themselves to biologically marked discourses of social improvement.<sup>8</sup>

After 1900 the expansion of the scale of the railroad network gave way to a new focus on scope: effective management, capacity improvement, and regulation of existing infrastructure. This brought a shift within railroads' investigational goals from engineering, with

its dominance of the technical, to science, which could be tied much more clearly both to management and to questions of investigation and persuasion that had impact outside the business firm itself. Experimentally structured investigation of agricultural processes was the most important sphere of science to which railroads turned in their attempts to expand the scope of their practices and persuasive claims. Some companies developed their own means of funding experimental farms and propagating the results of their research in order to generate traffic and positive public relations. Many more companies, however, linked their research efforts directly to a relatively new set of institutions charged by law with disseminating improvement in agricultural practices: land-grant colleges and agricultural experiment stations.<sup>9</sup>

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### **Figure 3**

The complex relationships between railroads and the constituencies with whom they were in positions of mutual dependence in the early twentieth century have made it exceedingly difficult for scholars to approach railroad practice with an integrated vision. Maury Klein, for example, has stated that "railroad history has never had a clear central theme or overview for new information and insights to demolish." Nonetheless, scholars seeking thorough readings of the effects of railroad technology and practice have helped to define entire subfields of American history. The relationships between railroads and their agricultural constituencies undoubtedly rank among the most difficult to narrate with coherence. There is no shortage of scholarly and popular historical literature on railroad exploitation of farmers, nor about railroads as engines of regional growth and development. James Vance's effusive language in the introductory chapter to his economic geography of North American railroads expresses both the significance of the railroad-agriculture relationship and the historian's difficulty in representing that significance with adequate precision:

the world's most effulgent agricultural region grew up "on the railroad," stretching uninterrupted from the backslope of the Appalachians in Québec, Vermont, and upstate New York to the edge of the Great North at Fort Vermillion . . . and to the Great West in the Rockies at the spine of the continent. This simultaneous shaping of the world's most extensive integrated railroad system . . . and its greatest of all agricultural realms shows most conclusively that the North American railroad served as the instrument of geographical development of a previously inconceivable scale.

However, there exists no recent general study of opposition to railroads and their practices among agricultural constituencies. Most of the literature on these issues found its documents in the political and legal arenas, where so many wronged parties on both sides of such debates sought their recourse.<sup>10</sup>

The infinite variety of railroad activities evinced in interaction with agricultural interests can best be conceptualized as three classes of practice: technical, investigational, and persuasive. Such a practical analysis reveals that in the early twentieth century, at the time that railroads supported agricultural research most widely, their character as technological systems expanded outward from the internally oriented "engineering ideal" of the maximally efficient and well-managed machine toward a scientific conception of investigation that could benefit firms and their constituencies together in an ongoing process of change and improvement. Railroads at the time are therefore best understood as networks of the mediation and propagation of knowledge. Investigational practices reveal this knowledge, technical practices apply it to the machinery and management of the railroad, and persuasive practices spread it recursively both within and beyond railroad institutions into the spheres of politics and finance.<sup>11</sup>

From their earliest period of growth in the early and mid-nineteenth century, American railroads had always balanced investigational, technical, and persuasive practices within their own institutional structures. Investigation quickly made its utility obvious: from early developments in scheduling to telegraphic dispatching and from innovations in locomotive construction to new developments in accounting practices, the mounting complexity of railroad construction and operations demanded new forms of knowledge production. Into the late nineteenth century, however, this knowledge production was directed largely toward the solution of specific problems of technical practice, and was therefore ad hoc and unsystematic, even within individual firms. Usselman chooses a vivid metaphor to describe this situation, one that focuses attention on investigational practice: "The early lines were essentially grand experiments." What his metaphor risks obscuring is that early railroad investigation did not apply systematic experimentation on the model of scientific inquiry, but focused rather on specific technical issues. Usselman nonetheless recognizes this when he dubs the pattern of these practices "insider innovation," which emphasizes that they were simply structured and applied internally.<sup>12</sup>

By the late nineteenth century, however, railroad investigational practice began to grow systematically and its methods expanded to incorporate patterns of scientific research, including controlled experimentation and comparison. Zunz expresses this by arguing that the "tinkerers" who pursued ad hoc innovation in technical practice during the nineteenth century in fact cannot be seen separately from the professionalization of scientific investigation:

While the tinkerer and the scientist could heretofore coexist and largely ignore each other, the institutional and technological changes of late-nineteenth-century America made this mutual avoidance more and more difficult. Tinkering had to compromise with science and continue under a larger cognitive scheme.

Investigational practice on the scientific model had a difficulty, however, one common to all private firms including railroads: as the knowledge derived from investigation came uncoupled from specific technical challenges internal to the firm, its benefits might no longer be easily limited to the firm itself. The profits that the firm might hope to achieve from its investigational results would be based on knowledge that other firms could easily exploit if they had access to it. Railroad research thus developed in two directions--technical and agricultural--both of which addressed the problem of benefit to entities external to the firm. Both forms also allowed railroad companies to develop partnerships with other institutions, including locomotive builders, engineering firms, and universities. These partnerships allowed the railroad companies to spread both the risk and the expense of investigational practice, and to benefit individually and collectively as an industry.<sup>13</sup>

The first of these investigational directions remained closely linked to technical practice, and focused on experimental investigation into the physics and chemistry of the materials and machines central to railroad operations. Major railroads with substantial cash flow and access to capital occasionally chose to develop internal institutions dedicated to technical research. The Pennsylvania Railroad's (PRR) research, experimentation, and testing facilities attached to its Juniata Shops complex in Altoona, Pennsylvania, represent the most extensive such attempt. Usselman's study of the practices pursued by the PRR and the Chicago, Burlington, and Quincy (CB&Q) reveals that they emerged ad hoc from particular requirements of technical practice. A few major railroads with powerful and persuasive superintendents of motive power experimented with locomotive and boiler design in their own internal shop facilities. Private locomotive builders and equipment firms also explored the development of experimental methods. Like the managers of the IC in 1938, historians of business and technology have

generally limited their understanding of the forms of research pursued by railroad companies and their supplier firms to this variety of technically driven investigation.<sup>14</sup>

The other major form of investigational practice pursued by railroad companies--the promotion of experimental approaches to the improvement of agricultural products and practices--brought railroad companies into much closer contact and conflict with their constituents, and is therefore potentially both more difficult and more rewarding to explore than technically derived research. The potential of the railroads' encounter with biology through agricultural research went well beyond traffic development, support for shippers, and public relations. It provided the firms with a response to two dynamic moments in early twentieth-century America: [the political pressure brought effectively to bear on large firms by Progressive elites and the economic pressures of railroads' loss of their position as the constitutive and dominant element in American (and even international) financial markets **[KA: Please provide a citation for this]**.<sup>15</sup>

Historians have already widely explored the political aspects of these pressures on railroads. However, the relationship between politics and investigational practice is much less clear. Usselman relates them successfully to change in technically oriented investigational practice. He argues that after 1900, the "engineering ideal" that had come to dominate railroad management and technical practice in the later nineteenth century was turned against the railroads by partisans of regulation like Louis D. Brandeis, who accused the companies of failing to apply the new techniques of "scientific management." The extensive work done by business historians on managerial innovation and corporate structure also addresses these political moments. Alfred Chandler's narrative emphasizes that railroads instantiated a trajectory of innovation in managerial technique and technology that spanned the period between 1850 and 1900. Nonetheless, their innovations insufficiently prepared them for the political and economic

challenges of the new century. "The railroad was . . . in every way the pioneer in modern business administration," Chandler insists, though he emphasizes that "as the new century opened, patterns of success and failure were only just beginning to appear."<sup>16</sup>

Economic developments, which left railroads contemplating the loss of their leading position in the financial markets that had grown up through the nineteenth century to serve them, complicated the pursuit of knowledge through investigational practice. While there is little evidence to suggest that railroad executives and managers themselves perceived of any greater difficulty in raising capital (at least between the economic recovery of the late 1890s and the Panic of 1907), actors in American financial markets increasingly sought to diversify their activities beyond the railroad sphere. In 1932 Winthrop M. Daniels, a former member of the Interstate Commerce Commission and Culyer Professor of Transportation at Yale, reflected upon railroads' dominance of financial markets into the early twentieth century: "As late as 1906, almost eighty-five per cent of the bonds, and fully half of the stocks listed on the New York Stock Exchange, were those of railroad companies." The situation was already changing, though. With a range of evidence from both railroads and early integrated industrial firms, Chandler reveals how financial and industrial actors grew aware of the increasing diversification of the financial markets while they remained convinced of the central position of railroads in both financial and managerial innovation.<sup>17</sup>

Caught between political and economic pressures, railroads could no longer turn only to internal engineering solutions and their attendant rhetoric of efficiency. Albro Martin's claim that the Panic of 1907 "revealed the inadequacy of America's economic institutions and of its understanding of the forces that were at work" provides perhaps the most appropriate heuristic marker of the beginnings of the movement of capital away from railroads. Railroad interests had to respond persuasively to a new form of opposition. They had long faced arguments that

their leaders were not interested in the wellbeing of their customers and constituents, but rather only in the manipulation of securities for personal gain. Increasingly, however, they faced skepticism from the very financial markets and leaders who had always been seen as subservient to them. The rapid changes in regulatory structures in the first two decades of the twentieth century, most significantly represented in the establishment of the Interstate Commerce Commission's power to set maximum freight rates without court confirmation through the Hepburn Act of 1906, further complicated the railroads' calculations of their interests. Where agriculture formed a primary focus of railroad interest and source of traffic-- that is almost everywhere outside the corporate suites of the major Eastern trunk lines-- agricultural research constituted their most important answer.<sup>18</sup>

Independent of direct railroad support, investigational practice marked as agricultural science brought vast changes to American agricultural life after 1870. Scott's study of railroad agricultural development work supports this trajectory of change in institutional practices. He argues that railroad support of development--a category in which he includes research, but also broader aspects of land use and settlement--"tended to be opportunistic and sporadic" before 1900. Such work was often either a response to local interests or a result of the personal preferences of powerful individuals. In the 1870s and 1880s, at the same time that railroads were reaping the greatest benefits from federal railroad land-grant policies, agricultural scientists began to garner widespread state and federal government support for their work. This support took two forms: first the expansion of federal land-grant policies to benefit state colleges of agriculture and mechanic arts following the Morrill Act of 1862, and then direct federal subsidy of agricultural experiment stations following the Hatch Act of 1887. Alan Marcus summarizes these arguments in his study of agricultural experimentation in the late nineteenth century: "promoters reminded their audiences that each farmer operated a laboratory, his farm,

and suggested that all could devote a small portion of their efforts to experimental farming.” Marcus further describes how “scientific farmers” and “agricultural scientists” often disagreed because of the varying sources of their personal and institutional commitments--for farmers these were technical and economic concerns and for the professional scientist they were investigational and philosophical--but that both groups sought a “union of science and farming.” Both farmers and scientists also perceived and responded to the economic pressures of investment in agriculture by capital interests pursuing profit. The Hatch Act did not resolve such conflicts among agricultural interest groups about the proper scope and setting of experimentation, but it gave agricultural experiment stations the imprimatur of direct federal funding, and thereby accelerated the propagation of investigational practice in agriculture through professionalization.<sup>19</sup>

Marcus's conclusion reveals a further moment of significance within the developing concert of interests between agricultural science and railroads: he emphasizes that the Office of Experiment Stations within the new USDA “adopted a managerial spirit, seeking to systematize American agricultural science.” Thus, between 1900 and the Great Depression, professional scientific investigators interested in agriculture met professionalized railroad managers in a new symbiosis. Railroads across the country--from the Long Island Rail Road to the Southern Pacific in California and from the Northern Pacific to the Central of Georgia--pursued a double-pronged policy of collaboration with professional agricultural scientists from land-grant colleges, experiment stations, and state extension programs. Railroad companies both supported the work of academic investigators with resources like demonstration trains and also set up their own experimental and demonstration farms, often staffed by graduates of the land-grant colleges. Railroads exploited this merger of institutional research and corporate interests in ways contingent upon local and regional economies, both to support the expansion of their

business and to develop new arguments to defend their activity as serving the public, localities and regions, and the nation as a whole. The high point of this symphony of interests and conflicts came in the federal government's passage of the Smith-Lever Act in 1914, which established federal support for a nationwide system of county agricultural extension agents. Revealingly, the act specifically forbade the use of federal extension monies for the support of agricultural demonstration trains in order to prevent the appearance of a new form of federal subsidy to railroad companies. Most railroads nonetheless strongly supported the act, because it strengthened the expansion of the biological knowledge network that benefited both the firms and their many constituents.<sup>20</sup>

In the early development of the American railroad network between 1830 and 1850, the commercial interests of growing urban centers determined the economic geography of railroad growth. Agriculture was important to railroad strategy, politics, and operations only as one of many potential sources of business that could be efficiently gathered and transported into urban centers by rail. By 1860, however, and with accelerating though intermittent vigor throughout the later nineteenth century, railroads were growing outward beyond urban centers into sparsely populated and developed regions all over the continent. As Scott has argued, railroads therefore began in that period to explore agricultural innovation as a means of expanding their traffic base. It was not until around 1900, though, that the rise of experimental methods in biology, the changes in the structure of American financial markets, the establishment of agricultural science in land-grant colleges, and the political atmosphere of the Progressive Era precipitated the concert of interests that made the first three decades of the twentieth century the biological era in railroad research policy.<sup>21</sup>

Individual railroad companies developed a range of responses to these many factors. Across the agricultural Midwest and West, and with some examples in the Northeast and the

South, companies and their leadership perceived that agricultural research could potentially provide an integrated set of answers to the economic, financial, and political challenges of the new century. Seven companies whose archival and documentary materials have been mined recently **[KA: Please provide a citation for these]** by scholars of business, agricultural, and technological history demonstrate the significance of these developments. They are the Illinois Central (IC); the Southern Pacific (SP); the Chicago, Burlington, and Quincy (CB&Q); the Great Northern (GN); the Northern Pacific (NP); the Delaware, Lackawanna and Western (DL&W); and the Chicago Great Western (CGW).<sup>22</sup>

This list of railroad companies--with the exception of the last two, which are the smallest, regionally based firms, and also the least thoroughly researched--will immediately raise the question of the significance of managerial leadership in corporate policy toward research. At the beginning of the twentieth century, the IC and the SP were closely associated with the leadership of Edward Harriman; the CB&Q, NP, and GN were the three railroads linked to James J. Hill. It is therefore tempting to seek a potentially simplest explanation of the biological moment in railroad agricultural research primarily in the personal preferences of such powerful executives. Indeed, both Harriman and Hill showed themselves to be personally interested in agricultural (Hill) and biological (Harriman) research in the first decade of the century. Furthermore, much historical work on railroad executives emphasizes what Chandler calls the "truncated" qualities of their management structure: that railroad companies, because of their quasi-monopolistic position in transportation around 1900, could be managed in an almost exclusively top-down fashion by powerful executives. Nonetheless, an evaluation of the significance of these seven representative firms gives support to Zunz's contention that railroad companies, like other technologically sophisticated large firms of the day, were not simply fiefdoms of their great leading figures. Rather, they were dynamic entities with growing

knowledge-based structures that linked center and periphery, the local and the regional, the executive in the metropolis with the operating and managerial staff at the far reaches of the system. For the many railroad companies with large agricultural traffic bases around and after 1900, agricultural research made sense from the perspective of all of the nodes of this knowledge network. Not only could it represent the railroads' interest in the wellbeing of their constituent shippers and customers, but it could serve the interests of all of the members of the growing managerial bureaucracy.<sup>23</sup>

The Illinois Central Railroad has provided a substantial fraction of the archival and documentary material available to scholars of railroad innovation in management, technology and agriculture. The company's long history of financial strength, managerial innovation (not always successful or systematic), and interest in local traffic development, together with its participation in a diverse range of regional economies in the industrial and agricultural Midwest and Mid-South, make it perhaps the best representative of the railroad as knowledge network in the early twentieth century. The roots of the IC's extensive and differentiated support of agricultural research reach well back into the nineteenth century. John F. Stover's history of the IC and the company's own 1938 self-study pursue this point. Nonetheless Stover's narrative also clearly evinces a shift in the scope of the IC's investigational practice after 1900: "After 1900 there had been a definite increase in agricultural promotion throughout all sections of the country served by the railroad." The IC was also closely involved in the development and success of the University of Illinois at Champaign, one of the earliest of the land-grant colleges that would form the centers of much agricultural science. It also worked with the Extension Department of the Louisiana State University and with Professor P. G. Holden of the Iowa State College. No other single railroad provides more evidence in Scott's analysis of railroad development programs. Though he recognizes that the IC did not necessarily originate all of the

many research and development programs that it pursued, its policies promoting the colonization of land grants, the propagation of new and improved crops, and even innovations like better wagon road surfaces and coal prospecting techniques were “so successful that they were subsequently adopted by other roads.”<sup>24</sup>

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#### **Figure 4**

The presence in the IC’s knowledge network both of very powerful executive figures and of a longstanding policy of regional differentiation in support of research and development means that it was in fact a difficult example through which to demonstrate the set of financial, political, and scientific factors that precipitated the biological moment in railroad research after 1900. Stover’s exhaustive narrative history, however, provides evidence sufficient to tease these factors out of the dominant story of executive entrepreneurship. The IC was indeed an extraordinarily financially secure firm at the turn of the twentieth century, and this gave it the opportunity to pursue the systematic improvements in technical standards with which Harriman is so closely associated. One specific choice by the company’s management, however, reveals that it valued highly the potentially intangible benefits to be gained from corporate association with the vision of a scientifically ordered society. The IC provided not only substantial financial and logistical support, but also major organizational talent for the 1893 World’s Columbian Exposition in Chicago. The IC maintained its vigorous interest in agricultural research through the 1920s. Despite the fact that agricultural products as a fraction of the firm’s traffic revenue had fallen from almost one-half in the 1890s to only one-sixth in the 1920s, the company and its executives never wavered in their ongoing, regionally differentiated policy of support for agricultural research and development. The severe retrenchment of the Great Depression put an end to this policy, however.<sup>25</sup>

The Southern Pacific Railroad, another corporation closely associated with E. H. Harriman after 1901, pursued policies similar to those of the IC. Richard Orsi has recently provided an extraordinarily thorough and perspicacious history of the company in its economic, social, and political guises, a history in which the company's varied investments and interests in agricultural research, pursued vigorously in concert with land-grant colleges and even independent agricultural researchers like Luther Burbank, play a central role. Orsi clearly demonstrates the inadequacy of the traditional narrative of the SP-"Octopus" exploitation of farmers and resistance to political interventions. His arguments also lend strong support to the concept of the railroad as knowledge network:

Not only was the ostensible villain [the SP] providing expensive assistance to farmers, a group whose welfare it was charged with ignoring, the company was also engaged with western land-grant universities in promoting the modern ideal of scientific efficiency, held by many historians to be a unifying principle of the Progressive movement. . . [T]he story . . . suggests that the Southern Pacific was not as hostile toward farmers' interests and Progressivism itself as historians have traditionally maintained. It also illustrates the ways in which railroad and university were similar and inter-related types of organizations that shared problems, values, relationships, and roles in the modernization of western agriculture.

A particularly notable aspect of the SP's investigational practices is that it pursued scientific means of gathering information that affected company traffic and operations, including of agricultural practices, crop and soil conditions, and weather patterns, and disseminated them widely both within the firm and to outside constituents including farmers, shippers, and state and federal government agencies. Another important moment in Orsi's analysis pursues the

similar patterns of public opposition both to the SP and to the University of California despite their extensive collaborative work in support of agricultural research and practice.<sup>26</sup>

The Chicago, Burlington and Quincy Railroad, another firm with a particularly accessible and well-preserved set of corporate archival records, provides a hybrid case. Constituent interests driven by the traffic base led the company to support agricultural development, but managerial policy favored varieties of investigational practice more narrowly targeted toward internal benefit through the improvement of technical practice. Both Zunz and Usselman extensively address the CB&Q's policies in their work, but neither focuses on its agricultural interests. Zunz sees the firm as "a representative case study of the making of a managerial workforce," and he uses this as a basis for his arguments that corporate change originated both with executives and middle-level managers. He concludes from his CB&Q evidence that the new managerial culture fashioned a differentiated understanding of the distribution of the benefits of the firm's activities from its new means of knowledge generation, for "managers invented a new work culture within the larger corporations, a culture that balanced order and rule with competition and a search for profits and that sought to resolve large problems with increasingly specialized knowledge." Usselman extensively explores the CB&Q's leadership in the pursuit of engineering solutions to a wide range of technical problems of operation including signaling, rail metallurgy, and air brake technology. At the same time, however, Usselman points to ways in which this "engineering ideal" could itself motivate the firm's managers to support agricultural science as a means of expanding the benefits of systematic investigation beyond the bounds of the firm itself. And indeed the CB&Q participated vigorously in the biological moment. It had a number of its own experimental farms beginning in the 1890s, published several freely distributed periodicals on farming methods, and operated numerous agricultural education trains as late as 1940 in concert with land-grant colleges and other institutions. In 1913 it

opened its own Agricultural Department under the leadership of the University of Minnesota agronomist John B. Lamson.<sup>27</sup>

The two great transcontinental railroads of the northern tier, the Northern Pacific Railway and the Great Northern Railway (which were united but not merged through the Northern Securities Company in 1901), display the most dramatic case of conflict between the will of powerful executives (James J. Hill and his second son Louis, themselves personally interested in scientific farming) and the goals of agricultural scientists affiliated with educational and scientific institutions. Claire Strom emphasizes this point in her history of the GN's development policy and demonstrates how the contested field of financial and political interests among railroads, railroad leaders, and their constituents meant that railroad policy could appear both to serve and to undercut Progressive political goals. She argues that

[James J. Hill] concurred with the Progressive belief that agriculture needed to be more scientific and businesslike, and he supported the need for experts to establish fundamental agrarian principles. At the same time . . . he believed that expertise could be established through means other than formal education.

Hill's personal vision of himself as railroad executive and scientific farmer led to a string of personal failures in his own farming ventures and to recurrent breakdowns in the relationships between the GN and the government and university institutions with which it began collaborative initiatives. Thus, "by 1916 university experts had clearly gained ascendancy."

Deborah Fitzgerald's work, which focuses on developments in Montana, complements Strom's. Her subtle analysis extends the vision of large-scale industry as knowledge network to the rise of "industrial" agriculture in the 1920s and 1930s. While observing the contingency of local developments, she argues that

an agricultural leadership emerged in the 1920s--composed of business leaders, government agents, agricultural college professors, demonstration agents, and bankers--and . . . this leadership developed an industrial logic for agriculture. This logic functioned as a matrix of ideas, practices, and relationships that persuaded farmers to change the way they did things.

Unsurprisingly, she discovers that the GN and NP shared a "sudden enthusiasm" for highly mechanized, industrial-scale wheat farming in Montana in the mid-1920s.<sup>28</sup>

The two remaining representative cases are smaller railroads that both responded to the biological moment, but whose response was more limited. The first is the Delaware, Lackawanna and Western Railroad, which linked the New York/New Jersey waterfront with Buffalo via Scranton, Pennsylvania. The DL&W demonstrates that the biological moment was a national phenomenon (though many other Eastern railroads including the Lehigh Valley, Erie, Delaware and Hudson, New York Central, Baltimore and Ohio, and Pennsylvania also pursued limited agricultural research in this period). More importantly, it shows that both the rise and decline of the biological moment were contingent upon corporate financial performance, and upon political and economic factors at the local level and beyond. Scott recounts a revealing moment in 1910 and 1911 when the DL&W "approached the [New York] state department of agriculture and the agricultural college at Cornell, offering to purchase two farms and turn them over to the state for demonstration purposes." This suggestion resulted not in new demonstration farms, however, but in the DL&W's support of a generous expansion of the state's county extension agent program. Nonetheless the railroad had specifically done so "hoping to halt the decay in agriculture in southern New York State." By the end of the decade, however, the DL&W was spending its capital resources not on agricultural research, but on a

huge rebuilding of its line in the mountains of New Jersey and Pennsylvania to facilitate high-speed through freight and coal traffic.<sup>29</sup>

The final case is the Chicago Great Western, a system that tied together Chicago, Omaha, Kansas City, and Minneapolis through a hub at Oelwein, Iowa, and which existed constantly in the shadow of several much larger competitors in all of its markets. Gerald Berk uses the CGW as a case study in support of a large-scale attempt to reread American business history in which he argues for a vision of “regional republicanism” rather than one of “corporate capitalism.” Though Berk focuses on management practice and the concept of a “viable regional carrier” rather than on research and development, he could not have chosen better evidence for his thesis than the attempts by an undercapitalized railroad company dependent upon agricultural traffic to link itself to the biological knowledge network of the early twentieth century. He notes the CGW’s attempts to pursue technological innovations in locomotive design, operation, and maintenance managed from its Oelwein shops complex, and also its experiments around 1900 with a flat managerial structure in which local station agents reported directly to the general superintendent in Oelwein. But he does not miss the agricultural analogue of these practices, which meant that as early as the 1870s, the company was encouraging agricultural diversification in local and regional markets. Bucking the trend away from railroad-employed agricultural educators and agents after the passage of the Smith-Lever Act, in the 1920s the CGW (like the DL&W, another railroad with strong regional interests) pursued a particularly vigorous “personal service campaign,” which included both individualized assistance and group meetings at which constituents were invited to address both agricultural and railroad service issues.<sup>30</sup>

The cultural and political determinants of railroads’ turn to agricultural research after 1900 were always mediated through the not yet fully professionalized corporate leadership.

Corporate strategies, therefore, still reflected the personalities and proclivities of leading figures like the Harriman and Hill. The 1920s represented the last phase of strategic investment by railroads in general research goals, and thereafter such investment was mostly limited to public relations. During the biological moment between 1900 and the Great Depression, however, railroad support of agricultural research provided a means of linking abstract, basic investigational practices to Progressive ideals of national well-being, and of addressing perceived weaknesses in a branch of the economy that provided much railroad traffic. The broad collaboration between railroads and land-grant colleges in this period was the most significant and concrete institutional form of this concert of interests. Much future research will be needed to clarify the dynamics of this knowledge network, especially to enable clear links to be drawn between the local and regional factors that drove railroad investment in agricultural research and the larger-scale shifts in economic conditions and financial markets that motivated the industry's consolidation and its ongoing interest in engineering improvements. Nonetheless, the biological moment left its mark both on railroad companies across the country and on the agricultural constituencies that they served.

1. The author wishes to thank Garland E. Allen, Tanya Zanish-Belcher, and several anonymous referees. Illinois Central Railroad Research and Development Bureau (hereafter IC), *Organization and Traffic of the Illinois Central System* (Chicago: Illinois Central Railroad, 1938), 269, 272, 274=-75. Emphasis is in original.

2. Association of American Railroads (hereafter AAR), *The Railroad Story: Science, Research, and Railroad Progress* (New York: American Education Press, 1948), 3, 9, 12, 31; George H. Drury, *Guide to North American Steam Locomotives: History and Development of Steam Power Since 1900* (Waukesha, Wisc.: Kalmbach, 1993), 300.

3. IC, *Organization and Traffic of the Illinois Central System*.

4. **[Please provide a citation]**.

5. Paul Wallace Gates, *The Illinois Central Railroad and Its Colonization Work* (Cambridge: Harvard University Press, 1934); Roy V. Scott's *Railroad Development Programs in the Twentieth Century* (Ames: Iowa State University Press, 1985); Olivier Zunz, *Making America Corporate, 1870=-1920* (Chicago: University of Chicago Press, 1990); Gerald Berk, *Alternative Tracks: The Constitution of the American Industrial Order, 1865=-1917* (Baltimore: Johns Hopkins University Press, 1994); Steven Usselman, *Regulating Railroad Innovation: Business, Technology, and Politics in America, 1840=-1920* (New York: Cambridge University Press, 2002); Claire Strom, *Profiting from the Plains: The Great Northern Railway and Corporate Development of the American West* (Seattle: University of Washington Press, 2003); Deborah Fitzgerald, *Every Farm a Factory: The Industrial Ideal in American Agriculture* (New Haven: Yale University Press, 2003); Richard Orsi, *Sunset Limited: The Southern Pacific Railroad and the Development of the American West, 1850=-1930* (Berkeley: University of California Press, 2005).

6. See, Philip J. Pauly, *Biologists and the Promise of American Life: From Meriwether Lewis to Alfred Kinsey* (Princeton: Princeton University Press, 2000), 73–88. The vitalistic philosophies that also flourished between 1890 and 1910 represent the most significant form of resistance to the rise of the reductionistic forms of experimentalism in biology. See, Anne Harrington, *Reenchanted Science: Holism in German Culture from Wilhelm II to Hitler* (Princeton: Princeton University Press, 1996), 48–54; Ernst Mayr, *The Growth of Biological Thought: Diversity, Evolution, and Inheritance* (Cambridge, Mass.: Belknap Press, 1982), 51–52.

7. See, Garland E. Allen, "Thomas Hunt Morgan and the Emergence of a New American Biology" *Quarterly Review of Biology* 44 (June 1969): 168–88; Jane Maienschein, *Transforming Traditions in American Biology, 1880–1915* (Baltimore: Johns Hopkins University Press, 1991); Vassiliki Betty Smocovitis, *Unifying Biology: The Evolutionary Synthesis and Evolutionary Biology* (Princeton: Princeton University Press, 1996). For an analysis of the English case of the relationships between biological inquiry, agricultural research, and politics, see, Alison Kraft, "Pragmatism, Patronage and Politics in English Biology: The Rise and Fall of Economic Biology 1904–1920," *Journal of the History of Biology* 37 (June 2004): 213–58.

8. Garland E. Allen, "The Reception of Mendelism in the United States, 1900–1930," *Sciences de la vie/Life Sciences* 323 (Dec. 2000): 1081–88; Alan I. Marcus, *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870–1890* (Ames: Iowa State University Press, 1985), 59–69. Two recent articles describe case studies in this contested development: Laurie Carlson, "Forging His Own Path: William Jasper Spillman and Progressive Era Breeding and Genetics," *Agricultural History* 79 (Winter 2005): 50–73; Kathy J. Cooke, "Expertise, Book Farming, and Government Agriculture: The Origins of Agricultural Seed Certification in the United States," *Agricultural History* 76 (Summer

2002): 524-45; David Goodman, Bernardo Sorj, and John Wilkinson, *From Farming to Biotechnology: A Theory of Agro-Industrial Development* (Oxford: Basil Blackwell, 1987), 33-44; Richard Levins and Richard Lewontin, "The Political Economy of Agricultural Research," in *The Dialectical Biologist* (Cambridge: Harvard University Press, 1985), 209-24.

9. See, Alfred Dupont Chandler and Takashi Hikino, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass.: Belknap Press, 1990). For an application of these concepts to railroad issues, see, Berk, *Alternative Tracks*, 6-8, 124-29.

10. Maury Klein, "The Unfinished Business of American Railroad History," in *Unfinished Business: The Railroad in American Life* (Hanover, NH: University Press of New England, 1994), 177. For a subtle analysis of one of these foundational works in business history, see, Steven W. Usselman, "Still Visible: Alfred D. Chandler's *The Visible Hand*," *Technology and Culture* 47 (July 2006): 584-96. James E. Vance Jr., *The North American Railroad: Its Origin, Evolution, and Geography* (Baltimore: Johns Hopkins University Press, 1995), 11-12. A successful study limited to California is: William Francis Deverell, *Railroad Crossing: Californians and the Railroad, 1850-1910* (Berkeley: University of California Press, 1994). The best recent literature includes James W. Ely Jr., *Railroads and American Law* (Lawrence: University Press of Kansas, 2001); Barbara Young Welke, *Recasting American Liberty: Gender, Race, Law, and the Railroad Revolution, 1865-1920* (New York: Cambridge University Press, 2001).

11. The concept of the "engineering ideal" is used here with reference both to Usselman, *Regulating Railroad Innovation* and to Philip J. Pauly, *Controlling Life: Jacques Loeb and the Engineering Ideal in Biology* (New York: Oxford University Press, 1987). Olivier Zunz, "Producers, Brokers, and Users of Knowledge: The Institutional Matrix," in *Modernist Impulses in the Human Sciences, 1870-1930*, ed. Dorothy Ross (Baltimore: Johns Hopkins University Press, 1994), 290-307.

12. William D. Samson and Gary John Previts, "Reporting For Success: The Baltimore And Ohio Railroad and Management Information, 1827-1856," *Business and Economic History* 28 (Winter 1999): 235-48; Usselman, *Regulating Railroad Innovation*, 61-96.

13. Zunz, "Producers, Brokers, and Users of Knowledge," 296. Chandler notes the ways in which firms in many industries coupled their growing interest in investigational practice with increasing attention to patent laws and litigation practice and he emphasizes further the primacy of the investigational over the legal. Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass.: Belknap Press, 1977), 375.

14. Usselman, *Regulating Railroad Innovation*, 198. Zunz makes the PRR's investigational divisions a paradigmatic American example of German-style "*wissenschaftliche Massenarbeit* (scientific teamwork)." Zunz, "Producers, Brokers, and Users of Knowledge," 297; Drury, *Guide to North American Steam Locomotives*, 24-25, 44, 144, 201. See, John K. Brown, *The Baldwin Locomotive Works, 1831-1915: A Study in American Industrial Practice* (Baltimore: Johns Hopkins University Press, 1995); J. Parker Lamb, *Perfecting the American Steam Locomotive* (Bloomington: Indiana University Press, 2003), 83-91; Albert J. Churella, *From Steam to Diesel: Managerial Customs and Organizational Capabilities in the Twentieth-Century American Locomotive Industry* (Princeton: Princeton University Press, 1998), 25, 90.

**15. Please provide a citation for this.**

16. Usselman, *Regulating Railroad Innovation*, 327-30. For the most vigorous scholarly critique of the arguments about scientific management used by Brandeis and others against railroads around 1910, see, Albro Martin, *Enterprise Denied: Origins of the Decline of American Railroads, 1897-1917* (New York: Columbia University Press, 1971). For the most careful reflection on the varying significance of scientific management to railroad companies, see, Stephen Skowronek, *Building a New American State: The Expansion of National Administrative*

*Capacities, 1877-1920* (New York: Cambridge University Press 1982), 248-84. These challenges, and corporate responses to them, are the focus of Martin J. Sklar, *The Corporate Reconstruction of American Capitalism, 1890-1916: The Market, The Law, and Politics* (New York: Cambridge University Press, 1988). Chandler, *Visible Hand*, 204, 345.

17. Chandler argues that "by 1903 the market for industrial securities had become satiated." Chandler, *Visible Hand*, 333; Winthrop M. Daniels, *American Railroads: Four Phases of Their History* (Princeton: Princeton University Press, 1932), 26. See, also, Thomas K. McCraw, "American Capitalism," in *Creating Modern Capitalism: How Entrepreneurs, Companies, and Countries Triumphed in Three Industrial Revolutions*, ed. Thomas K. McCraw (Cambridge: Harvard University Press, 1997), 335; John Moody, *Moody's Analyses of Investments. Part I, Railroad Investment* (New York: Moody's Investors Service, 1920), 3. Chandler's case study of General Electric is most revealing: not only was "much of this [managerial] order . . . clearly borrowed from the railroads," but "the electrical manufacturers were the first American industrialists not intimately connected with railroads who found it necessary to go to the capital markets for funds in order to build their initial enterprise." Chandler, *Visible Hand*, 430, 426.

18. Martin, *Enterprise Denied*, 11. Maury Klein's two major scholarly biographies of railroad financier-executives have done the most to reanalyze the hypostasized narrative of the "robber barons" that long dominated the historiography of early American railroad capitalism. See, Maury Klein, *The Life and Legend of Jay Gould* (Baltimore: Johns Hopkins University Press, 1986) and Maury Klein, *The Life and Legend of E.H. Harriman* (Chapel Hill: University of North Carolina Press, 2000). Two widely divergent schools of thought remain in contention about whether ICC regulation in the early part of the century destroyed railroad initiative and returns on investment, or represented the capture of regulatory agencies by railroad interests seeking to limit competition and secure oligopoly. The anti-regulation argument is found in Martin,

*Enterprise Denied* and repeated in Albro Martin, *Railroads Triumphant: The Growth, Rejection, and Rebirth of a Vital American Force* (New York: Oxford University Press, 1992), and is the focus of a tract by the editor of the *Wall Street Journal* in the 1920s: William Peter Hamilton and Charles Henry Down, *The Stock Market Barometer: A Study of its Forecast Value Based on Charles H. Dow's Theory of the Price Movement* (New York: Harper & Bros., 1922). Regulatory capture is the central thesis of Gabriel Kolko, *Railroads and Regulation, 1877-1916* (Princeton: Princeton University Press, 1965), subtly informs Berk, *Alternative Tracks* and receives a post-socialist reading in Michael Perelman, *Railroading Economics: The Creation of the Free Market Mythology* (New York: Monthly Review Press, 2006).

19. Scott, *Railroad Development Programs*, 9; Marcus, *Agricultural Science*, 24, 27, 217-21; Charles E. Rosenberg, "Unintended Consequences: The Ideological Shaping of American Agricultural Research, 1875-1918," in *No Other Gods: Science and American Social Thought* (1976; repr., Baltimore: Johns Hopkins University Press, 1997), 198; Pauly, *Biologists and the Promise of American Life*, 77, 117.

20. Marcus, *Agricultural Science*, 218; Scott, *Railroad Development Programs*, 4, 37, 51, 55, 90-94.

21. Vance, *North American Railroad*, 21-31.

**22. Please provide citations.**

23. See, Klein, *Harriman*, 308-20; Ely, *Railroads and American Law*, 235-36; Martin, *Enterprise Denied*, 79-93, 100-101. "By sheer force of example, Harriman dragged the railroad industry into the new era of high-volume traffic carried at low rates." Klein argues that "Harriman's keen interest in technology did not extend to science." Nonetheless he explores Harriman's interest and participation in an extensive scientific survey of Alaska in 1899. Klein, *Harriman*, 445, 183. See, Chandler, *Visible Hand*, 186. The classic treatment of the top-down

practice of the nineteenth-century railroad executive as “entrepreneur” is: Thomas C. Cochran, *Railroad Leaders 1845-1890: The Business Mind in Action* (Cambridge: Harvard University Press, 1953). Oliver Zunz, *Making American Corporate, 1870-1920* (Chicago: University of Chicago Press, 1990), 39-40. The railroad accounting rules developed by industry groups during the early twentieth century in response to Interstate Commerce Commission rulings rules itself complicates study of these issues. There was no specific provision for marking expenditures on research and development, which were subsumed under “traffic” or “general” expenses and amounted only to a small fraction of expenditure. See, Joseph L. White, *Analysis of Railroad Operations* (New York: Simmons-Boardman Pub. Corp., 1946), 53, 231.

24. JoAnne Yates credits IC executive policy with “using statistical reports as the basis for monitoring and evaluating the company [which] systematized and depersonalized relations with employees” [and] points to a relative improvement in the Illinois Central’s performance. JoAnne Yates, *Control Through Communication: The Rise of System in American Management* (Baltimore: Johns Hopkins University Press, 1989), 157-58; IC, *Organization and Traffic*, 237-38, 241, 244-45; John F. Stover, *History of the Illinois Central Railroad* (New York: Macmillan, 1975), 72, 121, 306; Gates, *The Illinois Central Railroad*, 135-36, 280-302; Scott, *Railroad Development Programs*, 5, 42-43, 96-97, 128-29.

25. Stover, *Illinois Central*, 217-21, 306-308. The exposition was thoroughly suffused with an ideal of a biologically ordered and classifiable world. Its organizational plan was prepared by George Brown Goode, assistant director of the Smithsonian’s National Museum (of natural history). Pauly, *Biologists and the Promise of American Life*, 69. The most subtle recent reading of the scientific vision of the exposition is Gail Bederman, *Manliness and Civilization: A Cultural History of Gender and Race in the United States, 1880-1917* (Chicago: University of Chicago Press, 1995).

26. Orsi, *Sunset Limited*, 280, 283-97, 309, 316.

27. Zunz, *Making American Corporate*, 40, 64; Usselman, *Regulating Railroad Innovation*, 262; Richard C. Overton, *Burlington West: A Colonization History of the Burlington Railroad* (Cambridge: Harvard University Press, 1941), 471-73, 483-88; Scott, *Railroad Development Programs*, 9.

28. Claire Strom, *Profiting from the Plains*, 11; Deborah Fitzgerald, *Every Farm a Factory*, 8, 70.

29. The best recent treatment of the twentieth century significance of the DL&W is H. Roger Grant, *Erie Lackawanna: Death of an American Railroad, 1938-1992* (Stanford: Stanford University Press, 1994). Scott, *Railroad Development Programs*, 52-53.

30. The CGW's corporate records are very fragmentary. The best monographic treatment is: H. Roger Grant, *The Corn Belt Route: A History of the Chicago Great Western Railroad Company* (DeKalb: Northern Illinois University Press, 1984). Berk, *Alternative Tracks*, 121-23; Scott, *Railroad Development Programs*, 91-92.