Article

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WATERWHEELS AND STEAM ENGINES IN ONTARIO: INDUSTRIAL POWER REPORTED IN THE 1871 MANUSCRIPT CENSUS

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ABSTRACT

The transition from water to steam power has long been an interesting issue in the history of technology. Newly created data for the 1871 manuscript census are used to examine features of the transition in Ontario. Industrial characteristics and geographical variations of each power source are discussed. Questions and implications for further research are explored in relation to contemporary work environments and power technology.

RESUME

La question de la substitution de la vapeur à l'eau comme source de puissance motrice a depuis longtemps attiré l'attention des historiens de la technologie. De nouvelles données provenant du recensement de 1871 nous permettent d'étudier comment cette transition s'est produite en Ontario. Pour chacune de ces deux sources d'énergie nous présenterons les caractéristiques des industries impliquées et les variations géographiques de leur localisation. Nous explorerons également de nouvelles avenues de recherche en relation avec les environnements de travail et les technologies de puissance contemporains.

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Introduction

The central role of power in industrial development has long been recognized in Britain and the United States. Detailed studies by Hunter, Musson, von Tunzelmann and Hills have examined the technological and economic significance of water and steam power in the critical stages of industrialization.[2] At a finer scale, much of the research in industrial archaeology in the past two decades has been concerned with powered industrial sites, mainly those using water power.[3] Apparently little attention has been given to the development of industrial power in Canada, and there seems to be a sizeable gap between recognition of the pioneer water mills of the 1820s and 1830s and the large hydro-electric projects begun in the late 1890s.[4]

How significant were the various forms of industrial power in nineteenth-century Canada? What were the geographical variations and concentrations in industrial production associated with water, steam, horse and hand power? What factors influenced entrepreneurs to replace hand power with inanimate forms of power or to retain cheap hand labour in some trades? How were industrial work environments and workers affected by the increasing use of steam power in mills and factories? How did nineteenth-century Canada compare with other industrialized

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2 Louis C. Hunter, *A History of Industrial Power in the United States, 1780-1930*, Vol.1: *Waterpower in the Century of the Steam Engine*; Vol.2: *Steam Power* (Charlottesville, 1979 and 1985); A.E. Musson, 'Industrial Motive Power in the United Kingdom, 1800-1870,' *Economic History Review* 2nd series, 29 (1976), 415-39; G.N. von Tunzelmann, *Steam Power and British Industrialization to 1860* (Oxford, 1978); G.N. Von Tunzelmann, 'Coal and Steam Power,' in John Langton and R.J. Morris, eds., *Atlas of Industrializing Britain 1780-1914* (London, 1986), 72-9; Richard L. Hills, 'Steam and Waterpower - Differences in Transatlantic Approach,' in Robert Weible, ed., *The World of the Industrial Revolution: Comparative and International Aspects of Industrialization* (North Andover, MA, 1986), 35-53.

3 See papers published in *IA: The Journal of the Society for Industrial Archeology*, I-(1975-) for USA; *Industrial Archaeology Review*, I-(1976-) for the UK.

4 William Fox, Bill Brooks and Janice Tyrwhitt, *The Mill* (Toronto, 1976); J.H. Dales, *Hydroelectricity and Industrial Development in Quebec 1898-1940* (Cambridge, MA, 1957); Felicity L. Leung, *Grist and Flour Mills in Ontario* (Ottawa, 1981), esp 45-53, 83-9.

countries in the transitions from hand to inanimate forms of power and from water to steam?

A new source now allows us to address the topic of industrial power in Canada. Databases derived from the manuscript schedules of industrial establishments recorded for the 1871 Census of Canada offer considerable promise for various fields of historical research, including the history of science and technology and industrial archaeology. Since mid-1982, a project to make this material machine-readable has been sheltered by the Department of Geography, University of Guelph. Assisted by a grant from the Social Sciences and Humanities Research Council, an intensive phase of activity in 1985-6 captured all the industrial establishments in Ontario urban centres and all powered industrial establishments in rural Ontario by August 1986.[5] In a linked project led by Professors Inwood and Chamard at St Mary's University, data for all establishments in New Brunswick and Nova Scotia were made machine-readable. They have now been made consistent with the Ontario database at Guelph. New funds from the SSHRC in 1988-9 are enabling the project team to complete the data for rural Ontario, to integrate the various segments of Ontario data on the mainframe computer, and to extend the project to the province of Quebec. When all these phases have been completed, basic details of the 1870 operations of about 45,000 industrial concerns will be accessible. We expect that the final version of the whole database will be available for others to use in January 1991.

This paper is based mainly on the data for all urban industrial units and all rural powered establishments in Ontario, as they had been entered and edited by the end of 1986, with some updating to early 1989. We report on the new machine-readable source, present some of the patterns that may be drawn from the data and raise some of the interesting questions that may be addressed with the help of this material. The term 'power' is used

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5 Various aspects of the project are described in articles and reports such as the following: E. Bloomfield et al., *Industry in Ontario Urban Centres, 1870: Accessing the Manuscript Census* (University of Guelph, Department of Geography, 1986); E. Bloomfield, 'Using the 1871 Census Manuscript Industrial Schedules: A Machine-Readable Source for Social Historians,' *Histoire sociale/Social History* 19 (1986), 427-41; E. Bloomfield, 'Manuscript Industrial Schedules of the 1871 Census of Canada: A Source for Labour Historians,' *Labour/Le Travail* 19 (1987), 125-31; E. Bloomfield, ' "As accurate as is humanly possible": Accessing the Manuscript Schedules of the 1871 Census of Canada,' *Archivaria* 23 (1986-7), 185-92; E. Bloomfield and G.T. Bloomfield, 'Mills, Factories and Craftshops of Ontario, 1870: A Machine-Readable Source for Material Historians,' *Material History Bulletin* 25 (1987), 35-47.

to describe the motive force derived from primary energy. The emphasis in this paper is on inanimate power, though power derived from horse-windlasses and hand or manual power are compared with water and steam power at various points. The term 'powered establishment' refers to an industrial firm using power other than hand or manual power. The significance of the various forms of power is set out in Table 1 (see tables at end of article).

Data Source

The manuscript schedules for industrial establishments, recently made available on microfilm as part of the whole 1871 manuscript census by the National Archives, constitute a uniquely valuable source for Canada.[6] Although similar details were collected in the censuses of 1881, 1891, 1901 and 1911, none of the manuscript schedules for those years have survived. While the 1851 and 1861 census manuscripts are extant, their format is much more awkward to use, the more limited industrial details being scattered through the household schedules. Moreover, the 1871 schedules contain a wealth of information which was not published at the time. In the United States, equivalent manuscripts have survived from the 1850, 1860, 1870 and 1880 censuses. Their data have been partially exploited during the past fifteen years by the Bateman-Weiss-Atack team at Indiana University, whose purposes and methodology may be compared with our own.[7]

It is important to note that the 1871 Canadian census manuscript schedules were intended to record 'all industry of any importance which is conducted in separate establishments or workshops.' An industrial establishment was defined as 'a place where one or several people are

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6 T.A. Hillman, *Catalogue of Census Returns on Microfilm, 1666-1881* (Ottawa, 1981).

7 The US data source and the Indiana University project procedures are discussed in Fred Bateman and Thomas Weiss, *A Deplorable Scarcity: The Failure of Industrialization in the Slave Economy* (Chapel Hill, 1981), 23-6 and Appendix A; Jeremy Atack, *Estimates of Economies of Scale in Nineteenth-Century United States Manufacturing* (New York and London, 1985), 40-81. The Philadelphia Social History Project has used all the manuscript industrial data for that city from the 1850 through 1880 censuses, as reported in Henry Williams, 'Data Description,' in *Philadelphia: Work, Space, Family and Group Experience in the 19th Century,* edited by Theodore Hershberg (New York, 1981), Appendix II.

employed in manufacturing, altering, making up or changing from one shape into another, materials for sale, use or consumption, quite irrespectively of the amount of capital employed or of the products turned out."[8] No minimum value of output was set, in contrast to the United States, where only establishments with at least $500 worth were included. All repairs, mending and custom work done by industrial establishments were to be included.

The 1871 census enumerators recorded the following details of activity in the twelve months ending on 31 March 1871 for each industrial enterprise that they included:

* Name of proprietor(s),
* Statement of type of establishment by nature of product/service,
* Values of fixed and floating (working) capital,
* Number of working months in the year,
* Average numbers employed, distinguished into males females over 16 years, boys and girls under 16 years,
* Aggregate wages of all employees,
* Type of motive power other than manual (water, steam, horse, wind or some combination of these) with the nominal force stated in units of horse power,
* Types, quantities, units of measurement and values of specified raw materials,
* Types, quantities, units of measurement and values of manufactured products.

For some firms, further remarks or comments were added. Information for each of about 45,000 industrial establishments was handwritten on

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8 'Manual Containing the Census Act and Instructions to Officers Employed in the Taking of the First Census of Canada, 1871,' Canada, *Sessional Papers*, No. 64 (1871), 138.

'Schedule 6' forms, with five establishments to the page (see sample schedule in Figure 1 at end of article).[9]

Only a very limited amount of this material was published in the official census volumes of the 1870s. The published statistics were organized primarily by various industrial types, which were defined pragmatically rather than systematically. For each industry type, whether as specialized as whip making or as ubiquitous as blacksmithing, figures were published for numbers of establishments, hands employed, yearly wages, value of raw materials and value of products. The published statistics in the 1871 census report were primarily organized by such industrial types through the four provinces. Summary data only were published for each of the 206 census districts (90 in Ontario). No industrial data at all were published for smaller areal units, either as summaries of total industrial activity or for specific types of industry. Thus the only 1871 industrial information published for urban centres was for the six cities, the boundaries of which coincided with those of one or more census districts. These were Montreal, Toronto, Hamilton, Ottawa, London and Kingston. No details were made available for individual establishments, and the material collected on the non-manual forms of power (water, steam, water/steam, horse and wind) was not released in any form. Furthermore, the published totals seem to have understated the real extent and values of industrial activity as these may be reconstituted from the manuscript census schedules. The 1871 manuscript census data for industrial activity thus have great value in substantially supplementing the published census record. This is especially true for the topic of industrial power.

How good were the data of industrial activity in 1870? The census organizers declared that they were 'as accurate as is humanly possible,' but questions inevitably arise. Small proportions of the establishment records have missing data. For a small percentage of powered establishments, only one per cent of those powered by steam in Ontario but eleven per

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9 The range of variables is similar to that in the US censuses for 1850-1870, except that Canada recorded 'floating' or working capital in addition to 'fixed' capital (real and personal estate), the number of working months in the year and the number of girls employed as well as of men, women and boys. On the other hand, the Canadian data do not permit a separation of the wage costs of men, women and youths.

cent of water-powered establishments, the number of units of horse power was not stated. In some cases (about one per cent of the urban Ontario records) no figures are given for employees. Presumably these were one-person craftshops in which the proprietor did not reckon to be an employee. In other cases, there are no entries for cost of raw materials; this can often be interpreted as custom work in which the clients brought the materials to be processed or made up. Census enumerators undercounted industrial activity to some extent, presumably with the smaller units and more informal types of industrial activity.[10]

Much more common are problems relating to quantities of raw materials or products. The 1871 census schedules allowed space for enumerators to complete details of the quantities as well as the dollar values of raw materials and of manufactured products. The 1871 census organizers anticipated problems with the returns for these measures, stating in the 'Instructions to Officers' that 'in many instances the raw materials or articles manufactured are of such a multifarious character that they must be lumped together and entered by the value.'[11] Census enumerators differed in their recording of raw materials and products, some making considerable efforts to ascertain and record the types, quantities and values of component raw materials and manufactured products, others perhaps naming several materials or products but not specifying separate quantities or values. Generally, more detail of raw materials and products tended to be provided for smaller and rural establishments than for larger and urban ones. Deficiencies in the data for quantities and values of raw materials handicap us in some research into industrial power – the extent to which coal was used as an energy source, for example.

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10 Undercounting was most common with the smaller artisanal businesses, as has been noted for the US manuscript census in John B. Jentz, 'A Note on Evaluating the Error in the Gilded Age Manufacturing Census: The Problem of the Hand Trades,' *Historical Methods Newsletter* 15 (1982), 79-81.

11 'Manual,' Canada, *Sessional Papers* (1871), 139.

General Dimensions and Characteristics of Industrial Power in 1870

In this section we present a summary of the main features of power reported by Ontario industrial establishments in 1870, in order to provide a basis for our discussion of some research questions and implications in the rest of the paper. Table 1 summarizes the use of various forms of power by Ontario industrial enterprises. The term waterwheel is used generally here (as it was in the early 1870s) to include not only the traditional overshot and undershot wheels but also the more modern breast wheels and turbines. Census data do not distinguish between the various types of water wheel.[12] The water/steam type noted in Table 1 and elsewhere refers to older water-powered establishments with a steam engine to supplement the usual power source in periods of low water flow. The significance of this type of mixed power source is very evident in Guelph (Figures 3 and 4) where the Speed River flow was declining.

Under one quarter of Ontario's 21,729 industrial establishments in April 1871 reported using water or steam power. But such firms were disproportionately significant in terms of employment, investment and production. Water- and steam-powered enterprises employed just over half of all industrial workers, reported well over three-quarters of fixed capital invested in industry and accounted for over 77 per cent of the value added in the processes of industrial production.

Establishments with the largest nominal capacity were mainly powered by waterwheels. Sixty-seven water-powered establishments were reported as having a force of at least 100 horse power, and sixteen of these had at least 250 horse power. Only twenty-five steam-powered enterprises reported 100 horse-power or more, and only two of these reported at least 250 horse power. Industrial firms reporting at least 150 horse power are listed in Figure 2. In contrast, the great majority of businesses reporting use of live horses were one- or two-horse units, only fourteen per cent using three or more animals.

The most common power capacity for both water- and steam-powered firms was 20 hp units, accounting for 15 per cent of water-powered and 12

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12 See also: Arnold Pacey, *The Maze of Ingenuity: Ideas and Idealism in the Development of Technology* (London, 1974), 209-11; Terry S. Reynolds, *Stronger than a Hundred Men: A History of the Vertical Water Wheel* (Baltimore, 1983); Terry S. Reynolds, 'The Emergence of the Breast Wheel and its Adoption in the United States,' in Robert Weible, ed., *The World of the Industrial Revolution*, 55-8.

per cent of steam-powered businesses. The next most common were 25 hp units for steam, accounting for 8 per cent (this was also most common for establishments using a combination of water and steam power) and 30 hp units for water, accounting for 8 per cent of such establishments. Other common capacities for steam, each accounting for at least 5 per cent of the total number of steam-powered businesses, were 6, 8, 10, 12, 15 and 30 horse-power units. For water-powered businesses, 10, 12, 15, 25 and 40 horse-power units each accounted for at least 5 per cent of the total.

Industrial Power by Major Industry Groups

Industrial power may be analyzed by industrial sector or major industry group, using the Standard Industrial Classification coding that has been assigned for each establishment record (see Table 4). By far the largest number of enterprises powered by water or steam were in food and beverages (especially flour and grist mills) and wood processing (saw mills), followed by textiles (mainly woollen cloth mills). Non-metallic minerals (brick and pottery making) and leather (tanneries) firms used mainly horses. But a large proportion of industrial activity in several sectors still depended on manual power. Over half the establishments making boots and shoes, tobacco products, textiles, knitted goods and clothing, furniture, metal fabricated goods, printing and publishing, transportation (mainly carriages and wagons), miscellaneous manufactures, and primary processing, construction, utilities, trade and services depended on hand

power alone, and were not assisted by waterwheels, steam engines or horses. A closer look at several of these sectors provides evidence of a dual technology or a dichotomy between a small group of mechanized enterprises using inanimate power and operating on a relatively large scale and the great mass of artisanal enterprises working on small scales and using hand power alone.

The same data may also be calculated to show the relative importance of particular sectors or major industry groups to each type of power source. Horses were used mainly in establishments processing non-metallic minerals such as brickyards and pottery (37 per cent of all firms reporting

horses), or in food processing (12 per cent) and tanneries (10 per cent). The largest proportion of steam-powered enterprises were saw mills (46 per cent of firms and 54 per cent of horse power units reported)[13] and grist and flour mills (13 per cent of firms and 15 per cent of horse power). Over half of all water-powered establishments were in the wood processing sector, and 29 per cent (35 per cent of horse power) were in food processing, particularly grist and flour mills.

Steam power was associated with a more diverse range of industrial types than was water power, as is evident in the sample of all industrial establishments reporting 20 horse-power capacity presented in Table 5. Three of every five enterprises in this size class reported water power, and 84 per cent of these were either saw mills or flour/grist mills. Only 24 per cent of the steam-powered businesses with this capacity were saw mills or grist mills, and the great variety of other industrial types included gold crushers, breweries, oil refineries, and establishments making sewing machines, measuring scales, and musical instruments.

Geographical Variations in Industrial Power

It is equally easy to illustrate and analyze the geographical patterns of industrial use of various types of power, at every scale from individual units in a locality up to whole counties or larger regions. This capability depends on the careful geographical coding of all records, so that they may be aggregated and disaggregated by territorial units from the basic census enumerator's division, through the census subdivision to whole counties or regional groups of counties. Geographical location is illustrated here at two different scales. The microscale maps of individual units in and around the town of Guelph show the concentration of water-powered sites along the Speed and Eramosa Rivers and the development of additional steam power mainly within Guelph (Figures 3 and 4). At the other extreme, reported totals for industrial water-power and steam-power are mapped for the ninety census districts of Ontario, illustrating the greater endowment of water-power in the eastern and northern areas, and

13 The substantial use of steam power in Ontario sawmills may be contrasted with the situation in Nova Scotia, where only 1.4 per cent of all sawmills were steam-powered. See Barbara R. Robertson, *Sawpower: Making Lumber in the Sawmills of Nova Scotia* (Halifax, 1986). This study is one of the few to have utilized the 1871 manuscript census data in a comprehensive manner.

its scarcity in the southwest (Figure 5). It would be possible to show more subtle variations by aggregating the power data for the intermediate census subdistrict units. The large sawmills at the Chaudiere Falls on the Ottawa River and the Rideau Falls contributed to Ottawa's impressive total of reported water-power.[14] The total power capacity of 4,490 hp in Ottawa was considerably larger than in the other large urban centres of Toronto (2500 hp), Hamilton (1216), London (530) and Kingston (220), which all depended overwhelmingly on steam power. There were notable differences between urban and rural areas in the use of power for industry in 1870. Over two-thirds of all powered establishments were in rural Ontario and hand labour persisted strongly in urban places. However, steam power was more common in urban centres than in rural areas, and urban powered enterprises were generally larger and more productive than rural ones (Table 8). They also had a far wider range of industrial types than rural powered establishments. If we consider only establishments reporting 25 or more horse-power capacity, nearly half of those in Ontario used steam power compared with only 17 percent of the rural establishments.

Steam power outweighed water power in the industrial establishments of urban places, the output of steam-powered factories being nearly twice that of water-powered enterprises. Steam power was especially significant in the largest urban centres, contributing 95 per cent of all non-manual power in Toronto and 98 per cent in Hamilton. The notable concentration of steam-powered industry in urban areas reminds one of Adna Weber's conjecture in 1899 that, in answer to the question, 'What now are the economic forces that have caused the massing of people in large communities? ... the business man's answer would probably be short and trenchant, "Steam".'[15]

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14 A clear visual sense of lumber milling activity in Ottawa is conveyed by the photographs in John H. Taylor, *Ottawa: An Illustrated History* (Toronto, 1986).

15 Adna F. Weber, *Growth of Cities in the Nineteenth Century* (New York, 1899), 158. See also Asa Biggs, *The Power of Steam: An Illustrated History of the World's Steam Age* (London, 1982).

The database can be used not only for creating new statistical aggregations, as in earlier tables, but also in linking the evidence of individual establishments into the larger context. Thus the clustering of water-powered industry around the navigation canals, such as the Lachine, Cornwall, Trent and Welland, can be examined in more detail and related to the larger patterns of industrial development and location.[16]

By linking the census establishment data with contemporary photographs or illustrations published in the 1870s, we can add another dimension to our knowledge of nineteenth-century factories and work environments.[17] Industrial views published in the Ontario county atlases of the 1870s can be linked with the census data to provide additional details for analysis, generally and more particularly. Plates 1 to 4 (at end of article) show a variety of powered establishments in rural and urban areas of southern Ontario.

Research Questions and Implications

The database may be analyzed and interpreted by scholars in various fields to address various research questions. Some of these relate to the significance of industrial power in 1870 and its interrelationships with other factors at that time. Other questions are concerned with longitudinal processes spanning the nineteenth century and with Ontario's status in comparison with other industrializing regions. Several possible lines of research are introduced here.

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16 See for example: Larry S. McNally, *Water Power on the Lachine Canal 1846-1900* (Ottawa: Parks Canada, Microfiche Report Series MRS54, 1983); Elinor Kyte Senior, *From Royal Township to Industrial City: Cornwall 1784-1984* (Belleville, 1983); James T. Angus, *A Respectable Ditch: A History of the Trent-Severn Waterway 1833-1920* (Montreal, 1988); J.N. Jackson and F.A. Addis, *The Welland Canals: A Comprehensive Guide* (St Catharines, 1982).

17 Francine Brousseau and Line Chabot, *Architecture in "Canadian Illustrated News" and "L'Opinion publique"* (Ottawa, 1984).

Work Environments

The 1870 database can provide a context for more qualitative research on work environments and the variable patterns of persistence or replacement of hand labour in particular industrial trades, to explore the Canadian equivalents of Raphael Samuel's findings in mid-Victorian Britain.[18] Following the Philadelphia work of Laurie and Schmitz, we defined work environments that combine measures of size of unit with the extent to which non-manual power was used. Laurie and Schmitz distinguished five types of work environment: factories as all powered establishments, manufactories as non-powered workplaces with more than twenty-five workers, and artisanal craftshops as non-powered units with five or fewer workers. Middle-sized establishments, without power and employing between six and twenty-five workers, they distinguished as sweatshops, while acknowledging that these 'presented nagging definitional problems.' They also identified outworkers who toiled at home under the putting-out system, though admitting the difficulty of distinguishing these from artisans on census manuscript evidence alone.[19] We might quibble with the designation of all powered establishments as 'factories,' when fewer than twenty-five, and certainly when fewer than five workers, were employed. Many of the grist and wood-processing mills in village and small-town Ontario, with their small numbers of workers, should not really be described as factories. It is also misleading for oil refineries and tanneries, which used inanimate energy but lacked the work discipline and complex organization connoted by the term 'factory.' Powered establishments with twenty-five or fewer workers might usefully be distinguished from the larger factories. Sweatshop and outwork settings present definitional problems in Ontario, too, which can probably not be resolved using the manuscript census source alone.

Work environment data for Ontario are summarized in Tables 9 and 10. Table 9 presents the proportions of all Ontario workers in each major industrial sector by each of the eight work environments. Just over half of Ontario's workers were in powered establishments and just under half worked entirely with hand labour. The most common work environment

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18 Raphael Samuel, 'Workshop of the World: Steam Power and Hand Technology in Mid-Victorian Britain,' *History Workshop Journal* 3 (1977), 6-72.

19 B. Laurie and M. Schmitz, 'Manufacture and Productivity: The Making of an Industrial Base, Philadelphia, 1850-1880,' in T. Hershberg, ed. *Philadelphia: Work, Space, Family, and Group Experience in the Nineteenth Century* (New York, 1981), 53-66.

was the small artisanal establishment using only hand power and accounting for 29 per cent of all workers. Next was the largest size of powered factory or mill in which 19 per cent of all workers were recorded. Table 10 enables us to compare the proportions of workers in each work environment in rural Ontario and urban Ontario and also in the two largest urban centres of Toronto and Hamilton.

With its rich detail on the size and scale of operation and use of power of individual firms, our database contributes good evidence of the concurrent co-existence and 'combined and uneven development'[20] of very different modes and scales of operation between and within industrial sectors. Artisanal craftshops, manufactories and factories can be identified in virtually all industry groups, but in varying proportions. Woollen, cotton and knitting mills clearly conform to the textile paradigm. As with primary metals and machinery, each of these industry-groups had over 90 per cent of its workers in powered establishments, and at least 60 per cent in factories of over twenty-six workers. Wood-processing (mainly saw and shingle mills) and paper mills had proportions which were nearly as high. The dominance of large, powered establishments in these sectors may be contrasted with the mix of non-powered work settings in the clothing industry especially, but also such sectors as leather, non-metallic minerals, chemicals, tobacco, miscellaneous manufacturing, transportation equipment and printing, as well as the activities of trade, services, construction and utilities. The furniture industry illustrates the co-existence of several scales of operation in a single industry, with only three factories, a handful of smaller businesses and a host of artisanal cabinet-makers. Toronto and Hamilton, as the largest centres, had much the same proportion of workers in powered establishments as the aggregate of all Ontario urban centres, but their workers were in larger workplaces, whether powered or not, than was the case in smaller urban centres. The map of central Guelph (Figure 4) shows the concentration of hand-powered manufactories and artisan shops in the central business district, flanked by water-powered mills at dam-sites along the rivers and by steam-powered factories, some of them along the railway line.

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20 Samuel, 'Workshop of the World', 60.

Water and Steam Power Technology

A focus on industrial uses of power can help in re-examining the relationships between water power resources and local settlement and development. Potential water power sites were noted by surveyors and sometimes reserved for town locations since the land and water rights commanded a premium price.[21] What is known of the work of Ontario's millwrights? What were their main reference works, and what sort of adaptations did they make for Ontario conditions? Some small town foundries and machine shops already specialized in the mill work associated with water power. William Kennedy and Sons, of Owen Sound, for example, was manufacturing waterwheel turbines from the 1850s. In 1871 the firm employed twenty-one and used a 10 hp steam engine. Such firms also provided training for young men who, after completing their apprenticeships, would set up in business elsewhere. Charles Barber began to specialize in hydraulic turbines shortly after establishing the Georgian Foundry at Meaford in 1867. By 1871 Barber & Harris employed ten men and utilized a 10 hp steam engine.[22]

To what extent did waterwheels utilize the full potential water-power resources of Ontario? In Paris, Hiram Capron's dam and water race on the Nith River was supplying 87 hp to local industries in 1849. Within a decade Capron's new development on the Grand River was capable of

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21 The early water-power sites of Guelph were noted by the town's founder, John Galt, who described the great advantages of seventeen mill-sites on either side of the Speed River, in a letter dated 30 April 1827. Canada Company, Commissioners' Letters and Reports, 1826-1828. Archives of Ontario, Canada Company Records, Series A-6-2.

22 See also: Joseph D. Lindsey, ' "Water and Blood." The Georgian Foundry: Hydraulic Technology and the Rise and Fall of a Family Firm in Small Town Ontario,' *Ontario History* 75:3 (1983), 244-65.

supplying 800 hp. The 1871 census manuscript data reveal that only 282 hp were actually being used.[23] Under-utilization of water resources was common on the Ottawa and Trent rivers and, of course, at Niagara. The 1871 data for industrial water power might be related to the Commission of Conservation's assessment of water power resources in 1911, and the various Conservation Authority river basin surveys of the 1950s.[24]

The rise of steam power prompts further questions. How was this innovation diffused through Ontario? How does the Ontario experience compare with that in the United States?[25] The benefits of steam were recognized by the Colonial Advocate as early as 1833, which noted that the steam engine was not:

> ... subject to the casualties of broken dams, stoppages by drought and frost, to say nothing of the unhealthiness of large ponds of stagnant water generating pestilential miasma and causing thereby an unhealthy state of atmospheric air throughout the surrounding neighbourhoods where such mills are situated.[26]

Once steam was adopted on a substantial scale, it gave a new unity to the factory system, increasing interdependence and tending to impose more general laws on industrial development. As Mantoux remarked in 1928:

> The industrial world came to resemble one huge factory, in which the acceleration, the slowing down and the stoppage of the main engine determines the activities of the workers and regulates the rates of production.[27]

What were the operating costs and efficiency levels of steam engines in mills and factories compared with water power? What kinds of engines

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23 Donald A. Smith, *At the Forks of the Grand* (Paris, Ont., 1967), 88.

24 Leo G. Dennis and Arthur V. White, *Water Powers of Canada* (Ottawa, 1911). The current statistics of water powers are presented in Ontario Ministry of Natural Resources, *Ontario's Water Power Sites* (Toronto, 1985).

25 Carroll W. Purcell, *Early Stationary Steam Engines in America: A Study in the Migration of a Technology* (Washington, DC, 1969); Jeremy Atack, Fred Bateman and Thomas Weiss, 'The Regional Diffusion and Adoption of the Steam Engine in American Manufacturing,' *Journal of Economic History* 40 (1980), 281-308.

26 Cited in B. Sinclair, N.R. Ball and J.O. Petersen, eds. *Let Us Be Honest and Modest: Technology and Society in Canadian History* (Toronto, 1974), 159.

27 Paul Mantoux, *The Industrial Revolution in the Eighteenth Century* (London, 1961), 338.

were in use? To what degree was the portable steam engine used? The 1871 manuscript census records some sixteen engine manufacturers located in eleven towns and cities in central and southwestern Ontario (Figure 6). But it is possible that other engineers and machine builders may have made limited numbers of engines for local use. Some of the firms making engines in 1870, such as John Inglis of Guelph and Goldie and McCulloch of Galt (later Babcock and Wilcox) are well known, others are now forgotten. The database does provide some perspective on business history and the firm which might be pursued in more detail through company records.

Steam engines were widely diffused throughout Ontario by 1871 as major prime movers or as supplementary power to the hand trades. The force of steam was clearly visible in the big engines used in rolling mills, sawmills and waterworks. Data in Figure 2 show that the two rolling mills in Hamilton and Toronto were the biggest steam-powered establishments. The 225 horsepower capacity at the Tecumseh Salt Works in Goderich was a traditional use of big steam engines for brine pumping and the evaporation process. Large steam-powered sawmills at Tay, Rama and Collingwood contributed to the large steam capacity of North Simcoe that may be noted in in Figure 5. The Rathbun Company's integrated sawmilling operations at Deseronto also appear in the listing.[28]

Steam engines were also used to pump water from mines and for high-pressure systems to supply water to cities. These activities were not strictly industrial and the manuscript census data for Ontario are somewhat inconsistent. Western Canada Mining (copper) at Bruce Mines is one of the few mines listed but there is no record of the power used.[29] Only a few urban waterworks are noted in the census record and the well-known

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28 D.M.Wilson, *Lost Horizons: The story of the Rathbun Company and the Bay of Quinte Railway* (Belleville, 1983).

29 Mining was also reported, if incompletely, in the Schedule 9 of the 1871 manuscript census. Many details of mining and oil wells at this time are discussed in Dianne Newell, *Technology on the Frontier: Mining in Old Ontario* (Vancouver, 1986).

Hamilton pump-house which was located outside the city in Saltfleet Township was not enumerated.[30]

As illustrated in Tables 2 and 3, it is the smaller capacity steam engines which were most important. Engines smaller than 25 hp were widely used in both urban and rural areas throughout the whole range of industry types from primary processing (sawmills) to planing and the fabricating of finished goods such as agricultural implements that are illustrated in the plates. Railway workshops were also significant users of steam power.[31]

The extensive use of small steam engines allowed flexibility in the location of industrial activities, permitting both decentralization in rural areas and concentration in cities, to sites which lacked immediate sources of water power. Examples of locational shift may be observed in many small river basins. The first industrial activity in the Spencer Creek watershed (Hamilton-Wentworth Region) began near the headwaters at Crook's Hollow and later growth developed downstream to Dundas.[32] By 1871, however, the steam-powered factories of Hamilton were far more significant.

To what extent did industrial steam engines use coal by 1870? Census manuscript details for raw materials could theoretically provide the evidence of actual use, though such data were often omitted for larger and more complex industrial establishments. Certainly, as Walker has suggested, the lake ports and areas served by railways by 1870 were able to draw on US coal sources which were a more efficient substitute for wood.[33]

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30 The Hamilton waterworks system was powered by two compound condensing rotative beam engines of 100 horsepower each. William James and Evenlyn M. James, *'A Sufficient Quantity of Pure and Wholesome Water': The Story of Hamilton's Old Pumphouse* (London, Ont., 1978).

31 Paul Craven and Tom Traves, 'Canadian Railways and Manufacturers 1850-1880,' *Canadian Historical Association, Historical Papers* (Ottawa, 1983), 254-81.

32 J.A. Blyth, 'The Development of the Paper Industry in Old Ontario 1824-1867,' *Ontario History 62* (1970), 119-33.

33 David F. Walker, 'Energy and Industrial Location in Southern Ontario 1871-1921,' in D.F. Walker and J.H. Bater, eds., *Industrial Development in Southern Ontario* (Waterloo, 1974), 41-68.

International Comparisons

How does Canada compare with the United States and with various European countries in the use of industrial power at this period? There is scope for more comparative and longitudinal research on work environments and the persistence of hand labour. What of the water-steam transition that has been documented by Hunter in the United States? While it is difficult to be definitive in the absence of earlier Canadian data, the extent to which steam power was used by 1870 may be related to its status in other and more industrially advanced countries. The dominance of steam in British industry and landscape is highlighted by some estimates provided by David Landes (Table 11) and others (Table 12) which provide a context for our Ontario data.[34]

It is possible to relate the status of industrial power in Ontario in 1870 to that thirty years later, when a small amount of information was included in the published census reports, though only at the provincial level. According to these data, the transition from dependence on water wheels to steam power was achieved in Ontario during these years. The number of units of industrial horsepower apparently increased 145 per cent in Ontario during these three decades, while the number of industrial workers rose only 72 per cent.[35] The average capacity of an Ontario industrial establishment using inanimate power in 1900 was 82 units of horse power, compared with just 20 units in 1870. Thus the phases of energy dominance, memorably described by Lewis Mumford as Eotechnic, Paleotechnic and Neotechnic, went through a speedy series of transitions in Ontario.[36] But if 'Carboniferous Capitalism' had been partially achieved in the province by 1900, it was vanquished by hydro-electricity by 1921.[37]

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34 David S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present* (Cambridge, 1969), 194.

35 We note the change in the official definition of an industrial establishment for the 1901 Census, to exclude units with fewer than five workers. See: Kris Inwood and John Chamard, 'Regional Industrial Growth during the 1890s: The Case of the Missing Artisans,' *Acadiensis 16 (1986), 101-116.*

36 Lewis Mumford, *Technics and Civilization* (New York, 1934; reprint, 1963).

37 Data in the *Canada Yearbook* (Ottawa, 1924), 416, show that in 1921 hydraulic power amounted to 78.9 per cent of total capacity of all industrial prime movers, reflecting the large-scale hydro-electric developments in Ontario over the previous twenty years.

Acknowledgments

The authors acknowledge the help of their research staff over several years, notably Janine Grant who coded and edited much of the manuscript census data analyzed in this paper, and Peter McCaskell who assisted with the computer calculations.

Gerald Bloomfield is Professor of Geography at the University of Guelph. **Elizabeth Bloomfield** is an historian who has been principal investigator in several stages of the project that has been making the 1871 census manuscript data machine-readable.

Table 1

Power used in Ontario Industry, 1870: Summary Data

Type of Power	Estabs	HP Force (percentages)	Employment	Fixed Capital $ value	Added Value
Waterwheels	11.9	58.2	16.3	26.0	18.2
Steam engines	9.8	36.4	32.0	48.9	41.5
Water/steam	0.6	4.0	1.8	2.7	1.8
Horses	3.3	1.4	2.8	1.5	2.0
Wind	(-)	(-)	(-)	(-)	(-)
Hand	74.4	-	47.1	20.9	36.4
Totals	100.0	100.0	100.0	100.0	100.0

Note: (-) under 0.1 per cent.

Table 2

Ontario Establishments Reporting Use of Water or Steam by Size Class, 1871

Size Class #hp	Steam #	Steam %	Water #	Water %	W/S #	W/S %	Total #	Total %
Over 100	25	1.2	67	2.6	4	3.3	96	2.0
50 - 99	65	3.1	196	7.6	31	25.2	292	6.0
25 - 49	484	22.7	625	24.1	48	39.0	1157	23.9
1 - 24	1534	72.0	1402	54.0	38	30.9	2974	61.3
n.a.	23	1.1	306	11.8	2	1.6	331	6.8
Total	2131	100.0	2596	100.0	123	100.0	4850	100.0

Note: All horse- and wind-powered establishments were in the 1-24 hp size range.

Table 3

Water and Steam Power used in Ontario Industry in Size CLasses, 1870

(horse power units)

Size Class	Steam		Water		W/S		Total	
#hp	#	%	#	%	#	%	#	%
Over 100	3550	8.4	15508	23.0	556	11.9	19614	17.2
50 - 99	3902	9.3	11791	17.5	1947	41.8	17640	15.5
25 - 49	15133	35.9	20243	30.0	1566	33.6	36942	32.4
1 - 24	19563	46.4	19825	29.4	586	12.6	39974	35.0
Total	42148	100.0	67367	100.0	4655	100.0	114170	100.0

Table 4

Ontario Establishments in Major Industry Groups by Type of Power, 1870-1

Major Industrial Group	Hand %	Horse %	Steam %	W/S %	Water %	Total %	#
1-4 Primary	44.4	8.3	44.4		8.8	100.0	36
5.01 Food,beverages	43.5	4.3	13.4	2.2	36.4	100.0	2053
5.02 Tobacco	78.6		19.0		2.4	100.0	42
5.04 Leather	91.8	2.5	4.6	0.1	0.1	100.0	3133
5.05 Textiles	83.6	0.2	4.5	1.2	10.5	100.0	2526
5.06 Knitting	94.7		1.8	0.9	2.7	100.0	113
5.07 Clothing	99.8		0.2			100.0	1523
5.08 Wood	30.1	0.9	28.8	0.7	39.4	100.0	3412
5.09 Furniture	66.3	10.8	13.5	0.7	8.4	100.0	585
5.10 Paper	30.4		13.0	4.3	52.2	100.0	23
5.11 Printing,publishing	88.5	0.9	10.6			100.0	218
5.12 Primary metals	9.6	7.7	75.0		7.7	100.0	52
5.13 Metal fabricating	84.1	1.7	8.9	0.4	4.9	100.0	698
5.14 Machinery	45.3	11.5	33.4	1.0	8.5	100.0	620
5.15 Transportation	91.6	3.5	3.6	0.1	1.2	100.0	1753
5.17 Non-metal.min.proc.	73.1	24.3	1.2		1.4	100.0	1075
5.18 Petroleum/coal prods	6.5	4.3	89.1			100.0	46
5.19 Chemicals	93.7	1.3	4.0	0.2	0.4	100.0	446
5.20 Miscellaneous	91.9	1.0	6.1		1.0	100.0	182
6 Construction	90.7	3.9	4.3	0.2	0.8	100.0	483
7 Utilities	75.0		6.3		6.3	100.0	16
8 Trade, repair	99.2	0.8				100.0	122
10 Services, notably blacksmiths	99.6	0.1	0.2			100.0	2555

Table 5

Range of Industry Types of Establishments Reporting 20 Horse-power

SEC	Steam	Water	Water/Steam
4	2 Salt works		
	2 Gold crushing		
5.01	24 Flour mills	96 Flour mills	2 Flour mills
	2 Breweries		
5.04	7 Tanneries/leather	6 Tanneries	
5.05	9 Wool cloth mills	24 Wool cloth mills	3 Wool cloth mills
	3 Flax mills	2 Flax mills	
	4 Carding mills	4 Carding mills	
5.06	1 Knitting mill	2 Knitting mills	
5.08	36 Saw mills	233 Saw mills	2 Saw mills
	17 Sash/door/window	4 Sash/door/window	
5.09	2 Cabinets/furniture	4 Cabinets/furniture	
5.11	1 Printing/publishing		
5.12	12 Foundries		
5.13	3 Metal fabr/hardware	2 Hardware	
5.14	5 Agric.implements	3 Agric.implements	
	2 Sewing machines		
	1 Scales		
5.15	2 Railway cars/wheels	1 Ship builder	
	4 Carriage/wagons	2 Carriage/wagons	1 Spoke/bending
5.17	1 Plaster mill	4 Plaster mills	
5.18	4 Oil refineries		
5.19	1 Paint/varnish		
	1 Glue		
5.20	2 Melodeons/organs		
6	2 Carpenters		

Table 6
Rural/Urban Distribution of Industrial Power, 1870

	Urban	Rural	Total	
	%	%	%	#
Water	28.3	71.7	100.0	67,367
Steam	43.7	56.3	100.0	42,148
Water/Steam	41.0	59.0	100.0	4,655
Other (horse,wind)	29.9	70.1	100.0	1,465
Totals	34.4	65.6	100.0	115,635

Table 7

Composition of Industrial Power in Rural and Urban Ontario, 1870

	Water %	Steam %	W/S %	Other %	Total %
Urban	48.0	46.2	4.8	1.0	100.0
Rural	63.7	31.3	3.6	1.4	100.0
Total	58.3	36.4	4.0	1.3	100.0

Table 8

Comparison of Steam-powered Establishments in Rural and Urban Ontario

Mean size of firms in urban and rural areas by selected variables

	Rural	Urban
Number of employees	7.6	22.2
Units of horse power	20.5	18.9
Fixed capital ($)	4,590	17,820
Value added in manufacturing ($)	5,750	15,820

TABLE 9

ONTARIO, 1870-1: DISTRIBUTION OF INDUSTRIAL WORKERS BY WORK ENVIRONMENT (percentages)

SECTOR	FIRM SIZE	NON-POWERED BY WATER/STEAM				SUB-TOTAL	POWERED BY WATER/STEAM				SUB-TOTAL
		1-5	6-25	26-50	51+		1-5	6-25	26-50	51+	
1-4	PRIMARY	4.4	5.5	-	59.1	69.1	2.0	24.0	4.9	-	30.9
5.01	FOOD etc.	28.0	11.7	1.7		41.4	28.4	19.9	6.7	3.6	58.6
5.02	TOBACCO	5.1	23.8	13.8	11.3	54.0	-	7.04	18.7	20.3	46.0
5.04	LEATHER	51.4	16.0	2.8	9.7	79.9	3.6	6.6	0.4	9.5	20.1
5.05	TEXTILES	35.0	1.1			36.1	7.0	24.3	11.4	21.2	63.9
5.06	KNITTING	20.0	6.4	8.2	-	34.6			6.8	58.6	65.4
5.07	CLOTHING	27.0	40.6	15.0	13.0	95.6	-	-	-	4.4	4.4
5.08	WOOD	7.7	3.0	0.6	-	11.3	20.2	33.1	10.6	25.0	88.7
5.09	FURNITURE	25.7	8.7			34.4	6.8	18.4	11.6	28.8	65.6
5.10	PAPER	3.1	3.6			6.7	1.2	34.6	18.5	38.9	93.3
5.11	PRINTING	17.6	23.2	5.5	9.7	56.0		4.5	8.1	31.4	44.0
5.12	PRIMARY METAL	1.7				1.7	7.7	20.4	26.3	44.0	98.3
5.13	METAL FABRICTG	28.8	13.0	0.8		42.6	2.5	11.5	16.0	27.4	57.4
5.14	MACHINERY	9.5	1.5			11.0	4.5	22.3	11.8	50.4	89.0
5.15	TRANSPORTATION	33.8	23.6	2.0	3.2	62.6	1.1	4.6	5.0	26.7	37.4
5.17	NON-MET. MINS	43.9	35.8	5.5	1.7	86.9	0.7	3.4		9.0	13.1
5.18	FUELS	2.8				2.8	12.2	54.1	30.9		97.2
5.19	CHEMICALS	69.3	13.0			82.3	1.4	13.8	2.5		17.7
5.20	MISCELL. MFG	28.3	33.7	8.1		70.1	0.8	4.3	8.7	16.0	29.9
6	CONSTRUCTION	36.5	40.7	4.1	5.5	86.8	1.3	8.8	3.1		13.2
7	UTILITIES	13.0	47.8			60.9	2.2		33.7		39.1
8	TRADE	96.1	3.9			100.0					-
10	SERVICES	97.2	2.1			99.3	0.1	0.6			0.7
TOTALS	#	27,762	13,683	2,806	3,306	47,557	7,959	14,973	6,749	18,155	47,836
	%	29.1	14.4	2.94	3.47	49.85	8.3	15.7	7.1	19.0	50.15

SOURCE: CANIND71 database, compiled from 1871 census manuscript schedules.

Table 10

Distribution of Workers by Work Environments, 1870

Work Environment	Rural Ont	Urban Ont	Hamilton	Toronto
Non-Powered	%	%	%	%
Artisans (1-5 emp)	45.4	17.8	7.5	6.1
Sweatshops (6-25 emp)	5.8	20.2	18.7	16.2
Manufactories (26-50 emp)	.0.3	4.8	6.0	6.6
Manufactories (>51 emp)	0.5	5.5	7.9	15.3
Sub-Total	52.0	48.3	40.1	44.2
Powered				
Small (1-5 emp)	15.8	3.2	0.5	0.5
Medium (6-25 emp)	19.6	13.0	6.0	5.4
Factories (26-50 emp)	5.4	8.3	6.6	7.2
Factories (>51 emp)	7.2	27.2	46.8	42.7
Sub-Total	48.0	51.7	59.9	55.8
TOTAL	100.0	100.0	100.0	100.0

Table 11

Steam Power Capacity (000 hp), 1869/1870

Great Britain	4,040
Germany	2,480
France	1,850
USA	1,216
Belgium	350
Ontario	42

Table 12

The Water-Steam Transition 1870: International Comparisons

percent of inanimate industrial horsepower

	Water	Steam	Source
United Kingdom	6.4	93.6	Musson (1976)
United States	48.2	51.8	1870 Census
Michigan	33.0	67.0	1870 Census
Ontario	61.8	38.2	1871 MS Census

Table 13

Ontario: Water-Steam Transition, 1870-1900

	1870		1900	
	hp	%	hp	%
Waterwheels	67,367	58.3	77,313	29.5
Steam engines	42,148	36.4	181,652	69.2
Water/steam	4,655	4.0	-	
Gas and gasoline	-		1,455	0.5
Other (horse and wind)	1,465	1.3	1,988	0.8
Totals	115,635	100.0	262,408	100.0

Sources: 1871 MS Census; 1901 published census returns

PLATE 1. The Barber Brothers' woollen mill at Streetsville was one of the largest integrated textile factories in Ontario (Figure 2). All processes from scouring, carding, spinning, dyeing, weaving to the final finishing of the tweed cloth took place in the mill complex. The mill was established in 1843 and rebuilt in stone after destruction by fire in 1861. A 20-foot fall on the Credit River provided water to the 16 foot diameter overshot waterwheel which powered all the machinery. Its capacity in 1871 was rated at 150 hp. The boiler house supplied steam for wool drying and space heating. A generator produced gas from gas-oil for lighting the building. In 1871, 129 persons were employed in the mill, 79 males and 50 females. Since the location was somewhat isolated, the mill was supported by its own machine shop, blacksmithy and carpenter's shop and a small sawmill. There was also a cluster of workers' housing around the mill complex. Source: *Illustrated Historical Atlas of the County of Peel* 1877 (Cumming reprint 1977), p. 37.

PLATE 1.

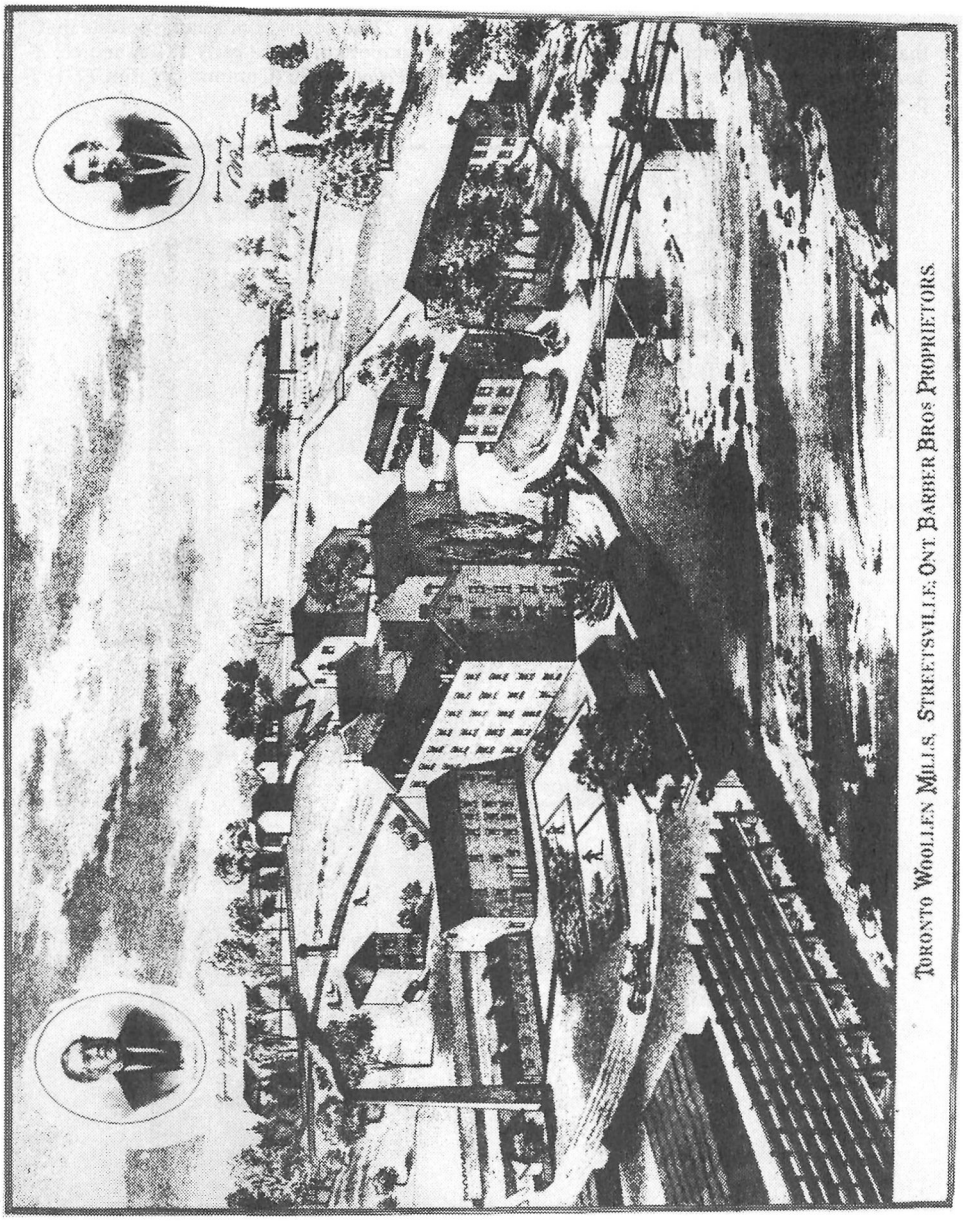

TORONTO WOOLLEN MILLS, STREETSVILLE, ONT. BARBER BROS PROPRIETORS.

PLATE 2. The agricultural implement works of L.D. Sawyer & Co. in Hamilton was wholly steam-powered when the plant was relocated by the main line of the Great Western Railway. In 1871 86 men and 4 boys were employed at making threshing machines, mowers, reapers and horse rakes. The reported capacity of only 22 horsepower of steam suggests that that hand shaping, forming and fitting were still very important in the early 1870s. Source: *Illustrated Historical Atlas of the Counties of Lincoln and Welland* 1876 (Cumming reprint 1971), p. 40.

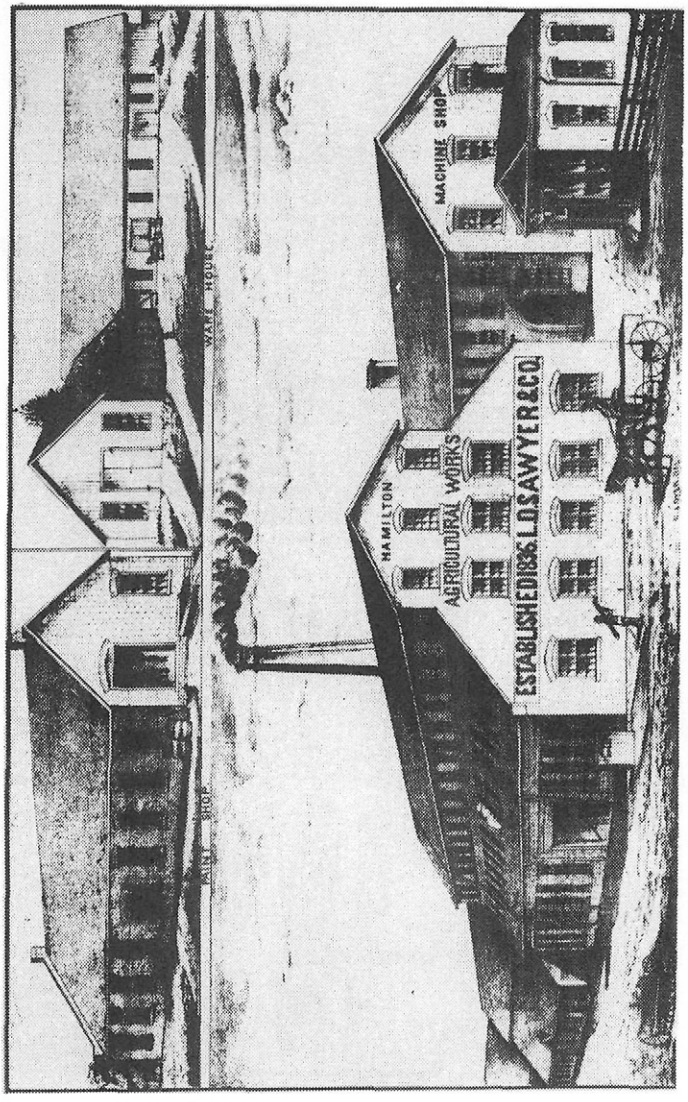
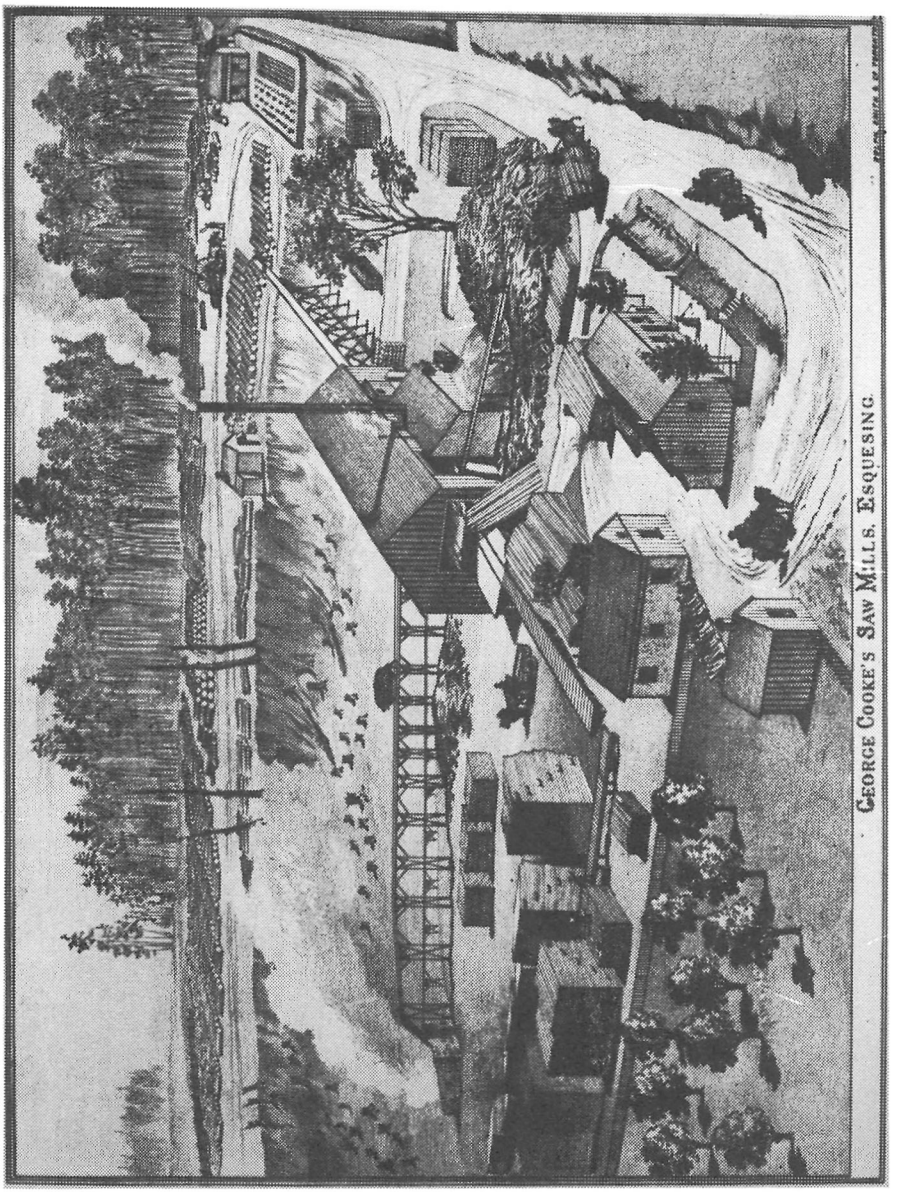


PLATE 3. George Cooke's sawmill at Concession 6, Lot 10 in Esquesing Township, Halton County, had been established in the 1860s to supply increasing local demands for building materials and to utilize wood from the final phase of land clearance. Cooke was described as a shrewd businessman who had made money in speculative ventures on the forest frontier in Michigan. In Esquesing he combined farming with sawmilling. The sawmill was powered by steam (25 hp) and employed 13 men and one woman producing 'inch' boards and shingles. Source: *Illustrated Historical Atlas of the County of Halton* 1877 (Cumming reprint 1971), p. 11.



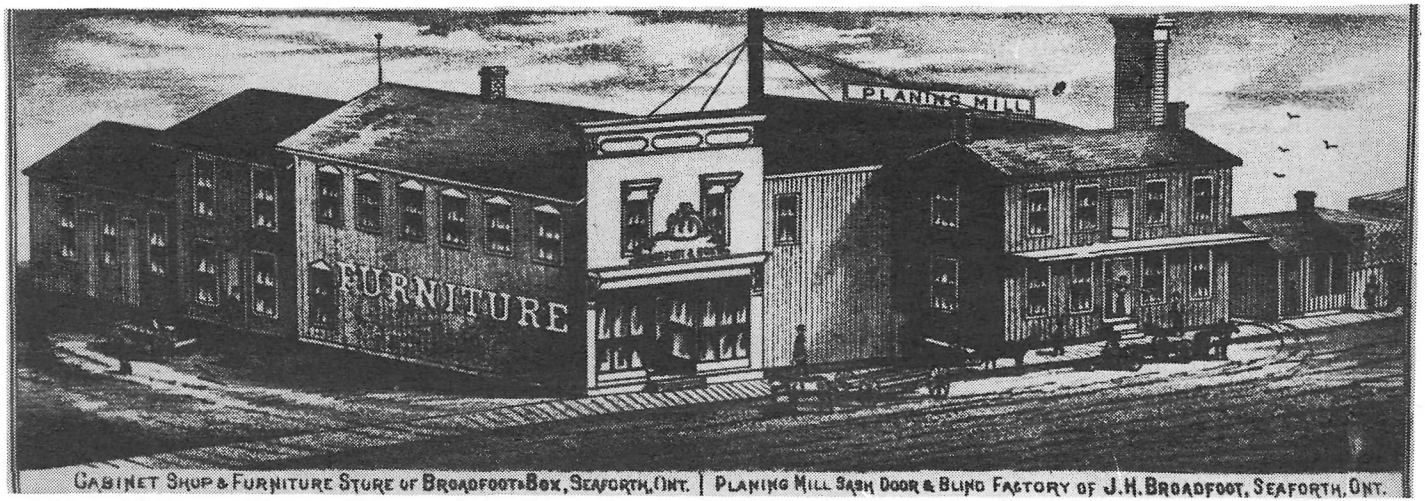


PLATE 4. Wood was still the most important industrial material in 1871 and this establishment at Seaforth, Huron County was typical of hundreds of similar urban planing mills making sashes, doors, blinds and mouldings for the building trades. A steam engine of 15 hp capacity provided the necessary power for the ten men employed in 1871. The value of output at $12,500 was similar to that of George Cooke's sawmill ($11,500). By the end of the 1870s when this sketch was made, a small cabinet shop and furniture store had been added next door to the planing mill. Such local business expansion reflected the growth of population at Seaforth from 1,368 in 1871 to 2,480 in 1881. Source: *Illustrated Historical Atlas of the County of Huron* 1879 (Cumming reprint 1972), p. 86.

FIGURE 1. Facsimile of an 1871 census manuscript schedule for part of Ottawa City. All the establishments in this sample were water-powered.

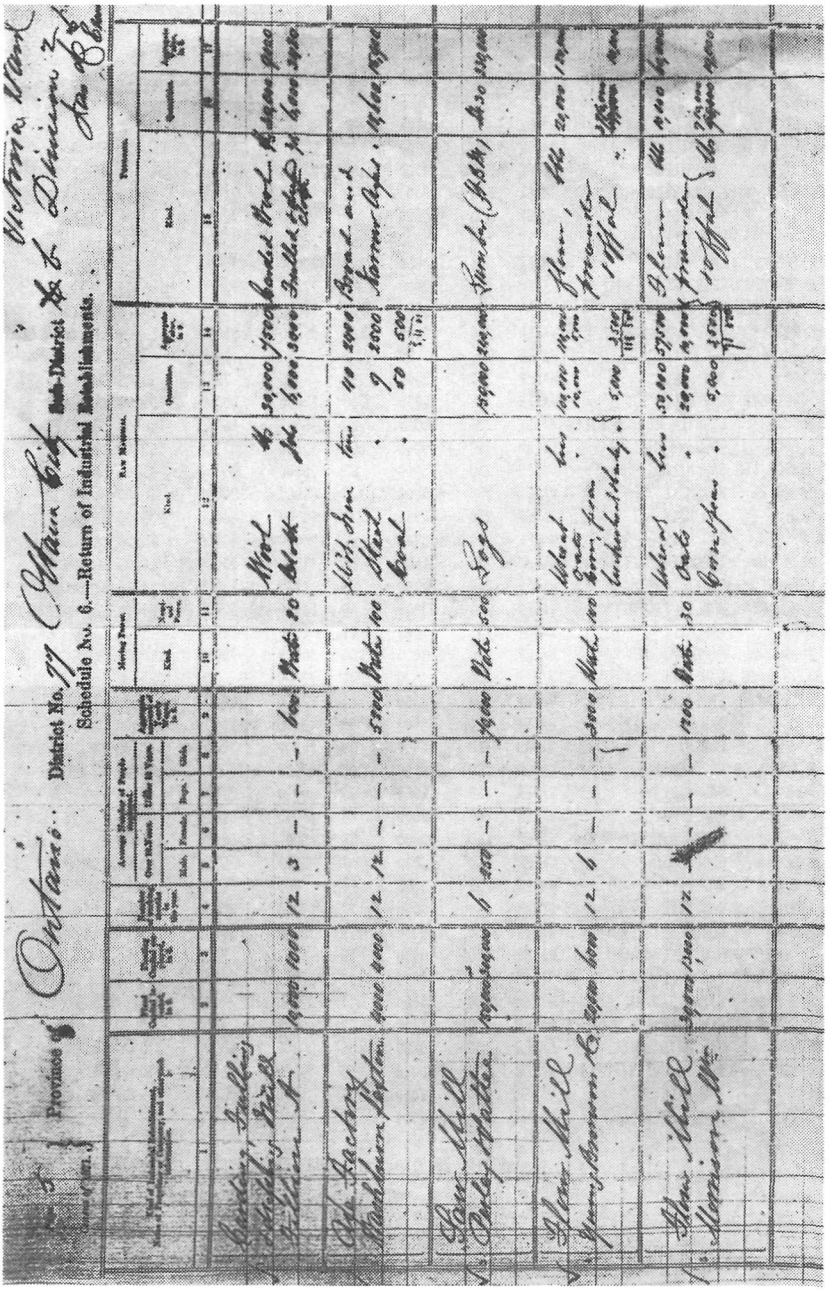


FIGURE 2. Printout of largest industrial users of inanimate power in Ontario in 1871 with a selection of some of the variables in the database.

LARGEST INDUSTRIAL USERS OF WATER AND STEAM POWER, 1870-1

PROPRIETOR	TYPE ESTABLISHMENT	POWER	FORCE	FIXCAP	TOTEMP	WAGES	RAWMAT	PRODUCTS	PLACE
BRONSON, WESTON & CO	SAW MILL	WATER	2500	350000	300	70000	240000	360000	OTTAWA
HAMILTON BROTHERS	SAW MILLS	WATER	1500	100000	168	27000	400000	540000	HAWKESBURY
MCVENE ALEXANDER	FLOUR/FEED MILL	WATER	500	8000	2	800	21000	24000	CAMDEN E
SMITH RC & CO	SAW MILLS	WATER	500	100000	110	14300	72000	90000	FENELON
HAGAR ALBERT	SAW MILL	WATER	500	25000	66	17500	25000	48000	PLANTAGENET N
PERLEY & PATTEE	SAW MILL	WATER	500	150000	250	70000	240000	330000	OTTAWA
MCQUARRIE & THORBURN	GRIST/FLOUR MILL	WATER	400	10000	5	2000	266500	266500	ONEIDA
HAMILTON ROLLING MLS	ROLLING MILLS	STEAM	400	70000	225	80000	410000	680000	HAMILTON
TUTTLE/DATE/RODDEN	AGRC HAND TOOLS	WATER	350	75000	120	55000	36000	137000	ST CATHARINES
LYMBURNER & LAFFERTY	SAW MILL	WATER	300	20	2	50	1500	2000	CAISTOR
PAWLEY WILLIAM	SAW MILL	WATER	300	2000	16	2000	2800	5600	PORTLAND
MCLAUGHLIN BROTHERS	SAW MILL	WATER	260	50000	100	15000	90000	110000	ARNPRIOR
GORDON & MACKAY	LYBSTER COTTON MILLS	WATER	250	150000	200	36000	66000	150000	MERRITTON
GZOWSKI C & CO	ROLLING MILL	STEAM	250	100000	200	72000	387000	500000	TORONTO
HOTCHKISS HEWSON &CO	SAW MILL	WATER	250	75000	82	25000	40000	85000	TAY
BOOTH JAMES R	SAW MILL	WATER	250	400000	200	60000	180000	250000	OTTAWA
BALDWIN A H	SAW MILL	WATER	250	90000	274	50000	180000	276000	OTTAWA
CHRISTIE A R	SAW MILL	WATER	250	100000	87	25000	40000	85000	TAY
PLATT MARY ANN	TECUMSEH SALT WORKS	STEAM	225	21500	19	7500	25000	40000	GODERICH
HESPELER GEORGE	DISTILLERY	WATER	200	22500	15	4775	15000	54760	HESPELER
BLACKBURN & MCLAREN	WOOLEN FACTORY	WATER	200	35000	58	14400	60000	80000	NEW EDINBURGH
CASSELMAN MARTIN	SAW MILL	WATER	200	10000	24	1500	12000	15000	CAMBRIDGE
RIORDAN JOHN	PAPER MILLS	WATER	200	156000	100	30000	70000	160000	MERRITTON
THOMPSON SMITH & CO	SAW MILL	W/S	200	0	240	72000	0	135000	TORONTO HQ
NEEDLER WILLIAM	GRIST MILL	WATER	180	24000	7	2800	120000	139996	LINDSAY
BOYD & MOSSUM	SAW MILL	WATER	180	33000	49	10100	15000	27000	HARVEY
DODGE & CO	SAW MILL	STEAM	160	25000	50	18000	30000	75000	TAY
ROSAMOND B & W & CO	WOOLLEN FCY	WATER	160	200000	209	48600	270000	350000	ALMONTE
MCDONOUGH JOHN	SAW MILL	WATER	160	12000	20	8000	27000	40000	THOROLD
BARBER JAMES	PAPER MILL	WATER	160	50000	46	11000	64000	90000	GEORGETOWN
GOLDIE JAMES	FLOUR MILL/COOPERAGE	WATER	160	30000	38	15000	260000	275000	GUELPH
BETHUNE ANGUS	FLOUR MILL	WATER	160	12000	7	2950	6250	10000	CORNWALL
NOXON S & T H	SAW MILL	WATER	155	5000	4	480	1300	3277	WALKERTON
THOMSON J & MILLER M	SAW MILL	STEAM	150	70000	72	13000	30000	60000	RAMA
BARBER & BROS	WOOL CLOTH FACTORY	WATER	150	150000	129	28000	90000	175000	TORONTO
REID OWEN	SAW MILL	WATER	150	10000	18	1882	7000	14000	THURLOW
HOTCHKISS/PECKHAM CO	SAW MILL	STEAM	150	30000	133	26000	54000	120000	COLLINGWOOD
RATHBUN H B & SON	STEAM SAW MILL	STEAM	150	50000	311	39250	77900	140754	DESERONTO
DICKINSON K	SAW MILL	WATER	150	1100	8	2000	4000	8000	OSGOODE
HILLIARD GEORGE	SAW/GRIST MILL	WATER	150	20000	96	30000	65000	110000	SMITH
JONES FORD CO	TOOL/SHOVELS/FORKS	WATER	150	50000	55	15000	55000	80000	GANANOQUE
ANGLIN ROBERT	SAW MILL	WATER	150	2000	6	1800	5000	8000	PITTSBURGH
NEELON SYLVESTER	FLOUR MILL	WATER	150	25000	20	8000	385000	447120	ST CATHARINES
*** Total ***			13710	2899120	4141	1033687	4446250	6597007	

FIGURE 3. Location of powered industrial establishments in Guelph and vicinity in 1871, showing type of power and capacity.

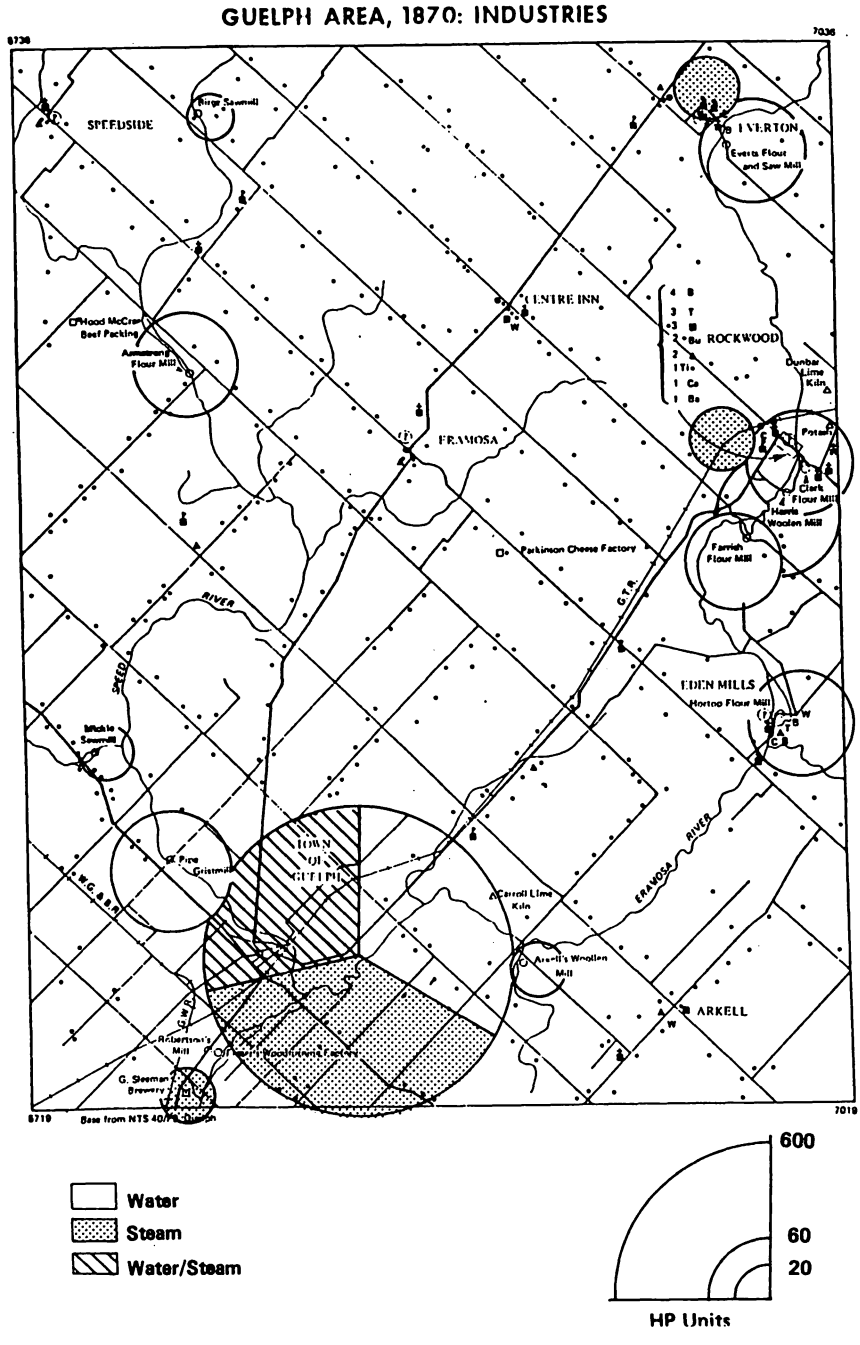


FIGURE 4. Industrial establishments in the town of Guelph in 1871, showing value of production and type of power.

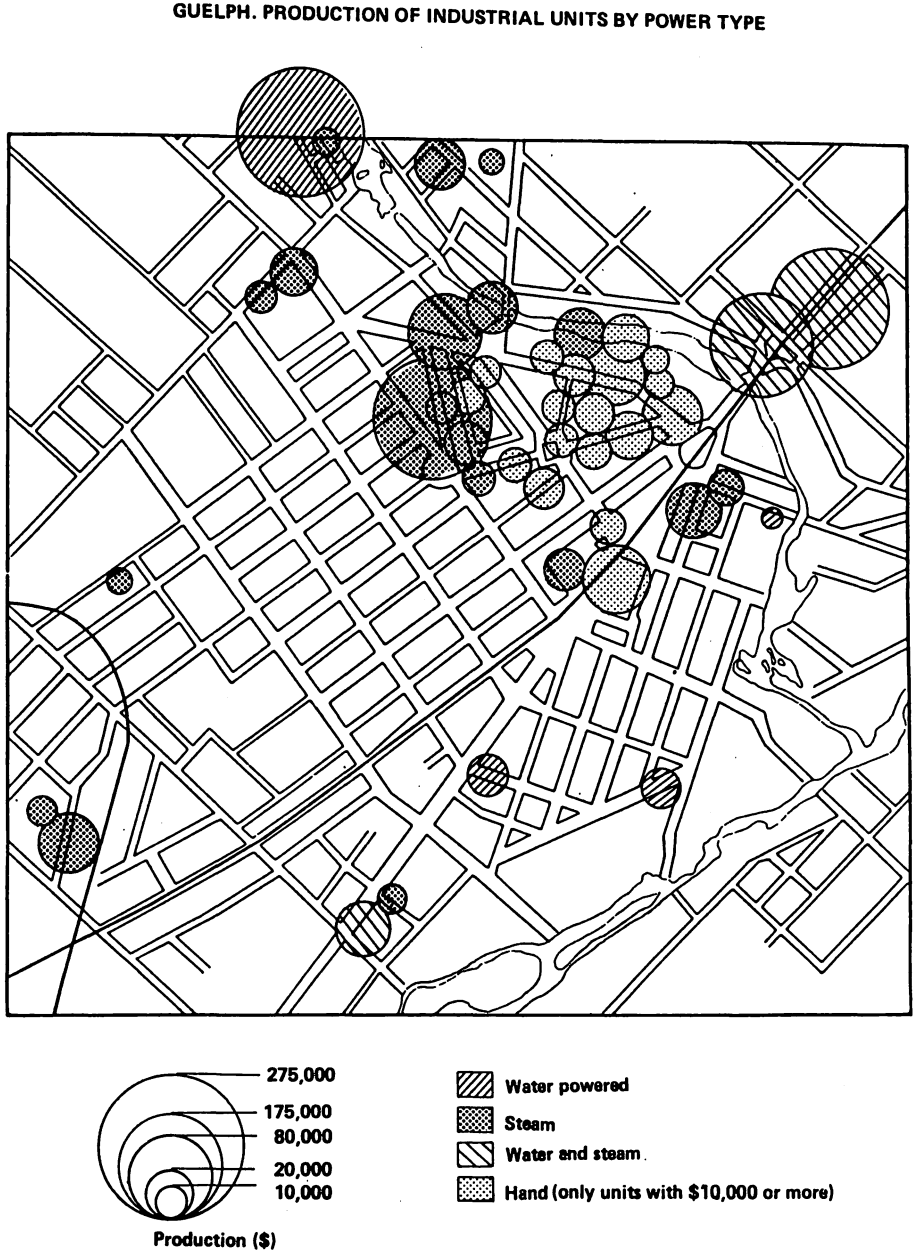
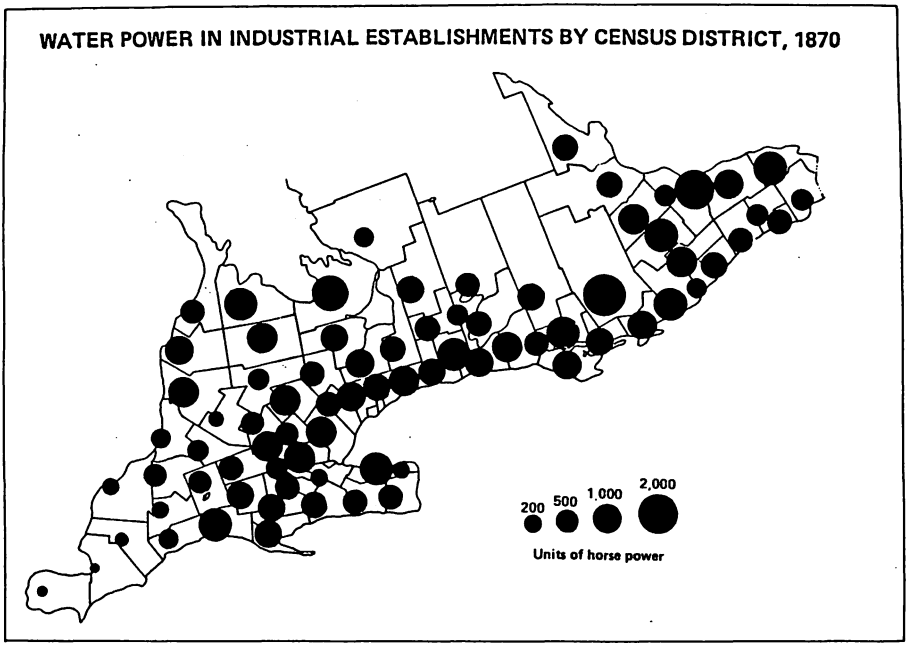


FIGURE 5. Distribution of industrial power capacity in Ontario census districts in 1871, showing proportions of steam and water power.



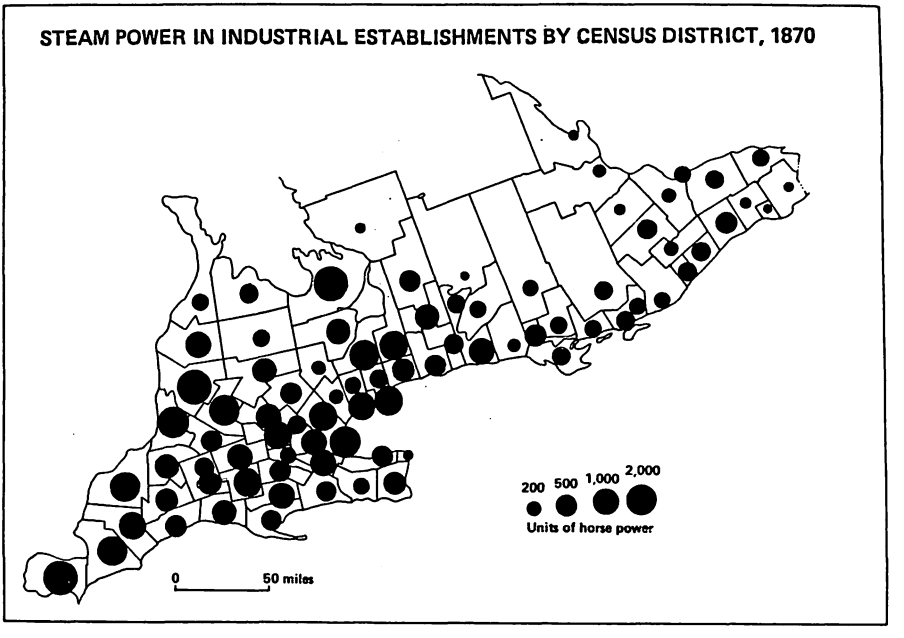


FIGURE 6. Location of steam engine manufacturers in Ontario in 1871.