Organizing a Rural Transformation: Contrasting Examples from the Industrialization of Tree Harvesting in North America

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Abstract: The transformation of work and the technological innovation that makes it possible usually doesn't "just happen". The greater the difficulty and cost of the tasks of innovation, the more likely successful innovation requires that innovation be deliberately organized and sustained. Few cases can be more illustrative of this than the industrialization of tree harvesting in North America after WWII. In this article we examine the processes by which the harvesting of pulpwood in two contrasting regions of North America, both highly dependent on the pulp and paper industry, were transformed in the post WWII era. We establish that Eastern Canada was a leading region in the mechanization of woods work and the American Southeast a laggard. We delineate what it took to create and lead in a sustained industrial revolution in the woods in Eastern Canada, and that this did not happen in the American Southeast. We then suggest why the powerful business interests in Canadian forestry took strong measures to promote innovation, and why the same interests in the United States were able to avoid strong involvement in the transformation of woods work.

Keywords: Social organization, innovation, industrialization, forest operations, Tree harvesting.

La organización de una transformación rural: Contraste de ejemplos de la industrialización de la tala de árboles en América del Norte

Resumen: La transformación del trabajo y la innovación tecnológica que la hace posible, no suceden generalmente porque sí. Cuanto mayor es la dificultad y el coste de las tareas de innovación, mayor será la exigencia de que esta, para tener éxito, sea deliberadamente organizada y sostenida. Pocos casos pueden ilustrar mejor este hecho que la industrialización de la tala de árboles en América del Norte tras la Segunda Guerra Mundial. En este artículo se examinan de forma comparada los procesos por los que la obtención de madera para pasta de papel en dos regiones de América del Norte, ambas muy dependientes de dicha industria, fue transformada en los años posteriores al conflicto mundial. Partimos de que el este de Canadá era una región líder en la mecanización del trabajo de la madera, mientras el sureste de Estados Unidos estaba más retrasado. Describimos lo que llevó a crear y dirigir una revolución industrial sostenida en los bosques orientales de Canadá, que no se dio en el sureste estadounidense. A continuación sugerimos por qué los poderosos intereses empresariales en el sector forestal canadiense adoptaron medidas enérgicas para promover la innovación, y por qué los mismos intereses en Estados Unidos fueron capaces de evitar una fuerte participación en la transformación del trabajo de la madera.

Keywords: Organización social, innovación, industrialización, trabajo forestal, tala de árboles.

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A Note on Theory and Methods

Forestry has been and continues to be one of the most important economic activities in much of rural North America. It consists of two usually quite separate production sectors: 1) the mills that manufacture a wide variety of wood products (of which the two best known are paper products and lumber) and 2) the forest operations that supply wood in various forms as inputs to the mills. In spite of the popularity of the romantic image of the lumberjack, forest operations have been hardly studied by historians and social scientists, even though forest operations have undergone a great measure of change since the end of World War II. We started studying the transformation of woods work from manual labour and draft animals to the modern array of tree harvesting systems in the early 1990s in Eastern Canada[1]. We extended our work to the American Southeast in 2003.

The research design of our study is a comparative case study using a mix of qualitative methods. We began our study of tree harvesting in a specific locale, The Miramichi Valley of New Brunswick. Following our preliminary discussions with Professor Tomas Bjerkelund of the Forest Engineering Programme of the University of

1• In forest parlance, Eastern Canada is most of the country – namely all the small-tree forest east of the Rockies.

New Brunswick, we interviewed[2] some forty workers, contractors and a mill woodlands manager on the Miramichi (Clow and MacDonald, 1996) using semi-structured open-ended interview techniques[3]. The structure of our interview questions developed as our knowledge of woods work increased, throughout our study.

The geographic scope of our study expanded outward from the Miramichi through our discovery of the forest engineers, and the resources and library, of the Forest Engineering Research Institute of Canada (FERIC). The FERIC library is a underutilized treasure trove of primary documents and research studies by forest engineers concerning forest operations and harvesting research in all of Eastern Canada extending back to the original work of the Woodlands Section of the Canadian Pulp and Paper Association, which began disseminating best practice and conducting forest operations research in the first few decades of the 20th century. We became aware of the pioneering historical work of Canadian forest engineer C.R. Silversides[4], of the Canadian forest and labour historian Ian Radforth (1982, 1987), and (when it appeared) of *Tracks in the Forest*, the only attempt to write a global history of the evolution of forest machinery (Drushka and Konttinen, 1997). The generous time and assistance of FERIC librarians and forest engineers Jean-Francois Gingras and Jean

2• A personal connection is necessary to gain access to people's work history and lives, and our student, Aloysius Hayes, was invaluable. In fact, he conducted many of the initial interviews under our direction.

3• We agree with Hiller and DiLuzio (2004) that interviews are complex 'research instruments' (Marshall and Rossman, 1995: 59). Our approach was to seek several kinds of information from our interviewees. First, we sought in the initial stage to have the interviewee present their perspective (Hiller and DiLuzio, 2004: 2) to the most general questions, that is to present their perspective on the industrialization of tree harvesting (or their part in it). We then asked more specific questions designed to test the accounts of other interviewees, arguments in the literature or our suppositions from our own theoretical resources — the sociology of work and critical political economy. Finally, we tended to return to general questions which allowed the interviewee to rework his initial arguments, if our second rank of questions has altered their original thinking. We thus subscribe to a constructionist interpretation (Hiller and DiLuzio, 2004: 3 and Holsteina and Gubrium, 1995), that the interview is a dialogue between interviewer and interviewee in which both contribute to an attempt to arrive at a sense of what happened and why in the process of the transformation of woods work. We interviewed approximately 50 woods workers, contractors, and woodlands managers for the pulp and paper companies in Canada, as well as half a dozen forest engineers. We interviewed twenty contractors, wood dealers, and woodlands managers as well as half a dozen forest engineers in the US Southeast.

4• For example, see: Silversides (undated manuscript), Silversides (1988), C.R. Silversides (1984) and Silversides (1997).

Berard deserves special recognition for their contribution to our understanding of the evolution of tree harvesting in Eastern Canada.

As in Canada, the primary research methods we employed in the South were semi-structured interviews and the reading of primary and secondary documents. Tracing the predominance of systems in use in the American Southeast was hindered by the lack of any regional or national equivalent to Canada's FERIC. Instead of regular surveys of machine use, we have had to rely on figures developed by other researchers with other purposes, at more infrequent points in time, and with differing geographic scope, as well as original documents, trade magazines and previous scholarly work (MacDonald and Clow, 2010). A general understanding of tree harvesting in the Southeast of the U.S. has been possible only through the generous support of Southern forest and mechanical engineers, woodlands managers, tree harvesting contractors and wood dealers whom we have interviewed, and the trade journalism of Hatton-Brown Publishers (including *Logging' Times*, *Pulpwood Production and Saw Mill Logging*, and *Southern Lumberman*). Most importantly, we received a wealth of assistance from Dr. Dale Greene, of the Warnell School of Forest Resources of the University of Georgia, and from Dr. Bill Stuart and Dr. Laura Grace of the College of Forest Resources of Mississippi State University[5].

Because of the paucity of earlier sociological studies, we had to begin 'making sense' of what we saw and heard essentially from first principles. We brought to bear our background as Marxist political economists and sociologists of work. Our attempt to theoretically understand the changes in tree harvesting began with some simple observations. Tree harvesting, we argued, is as an economic activity. Moreover, tree harvesting is not just resource 'gathering' but is a manufacturing activity by which trees standing in the woods are made into simple wood products of various kinds – for the most part short lengths of pulpwood, sawlogs of various lengths, tree lengths or wood chips – intended to be used as inputs to paper products and lumber-products mills. Tree-harvesting systems are particular production processes for accomplishing the manufacture of particular kinds of wood products from standing trees. Tree harvesting had been organized on a wage-labour (that is, a specifically capitalist[6]) basis long before 1945.

5• These scholars not only have spent many, many hours talking us through the history and organization of tree harvesting in the Southeast, but did all the work to arrange our interviews with retired and serving forest engineers, wood dealers and harvesting contractors in the Southeast.

6• We follow here the Marxist argument that capitalism is a specific way of organizing work, that is wage-labour.

Like any sociologist, we assumed that understanding how the work processes of tree harvesting were organized would allow us to understand woods work, and that changes in the work process (production systems) would be the consequence of the action of particular groups involved in the forest industry. Establishing the specifics of each production system allowed us to define and distinguish them from one another. We differentiated one tree harvesting system from another using the Marxist labour process approach (Brighton Labour Process Group, 1977) – that is, by studying the work process each system employed to fell and process the tree and to move the wood from stump to roadside. In the vast majority of cases tree harvesting is the production of 'roundwood' – short lengths of pulpwood, sawlogs or tree lengths, all for transport to the mill. Tree harvesting systems could then be differentiated by how various basic work activities (felling, delimbing, slashing the tree and yarding[7] the wood) were organized into various positions in a division of labour, where work activities were accomplished (at the stump, roadside or in-between), and whether workers employed tools (axes, handsaws, chainsaws) and draft animals or machines to accomplish their work activities (MacDonald and Clow, 1999). We noted a considerable number of distinct tree-harvesting systems that were being or had been used and when they had first become available (MacDonald and Clow, 1999).

How were these tree harvesting systems, and more particularly their order of appearance, to be explained? Forest engineers describe the transformation of woods work as the industrialization of tree harvesting and modern harvesting systems as industrial forest operations. They tend to think about industrialization as usually conceived of in the liberal economics tradition, as the *mechanization* of work, and "industrial development" as the progressive *mechanization* of production processes. We follow the Marxist tradition. In it *industrialization* is the process where an employer removes the control of the production process from his workers and substitutes a production process of his own design upon them. Pre-industrial craft production, though carried out by wage labourers, uses methods originating in the pre-capitalist era: typically workers utilized hand tools requiring relatively high degrees of skill in production processes devised by the workers themselves. The transition from craft work to industrial production begins when employers take control of the work process from workers, imposing production processes designed to increase worker productivity, lower unit costs, and expand the scale of production. Industrialization often began in industries before machines were introduced, but the expansion of production and

7• Yarding is the moving of trees or processed wood from the stump where the tree is felled to the road or landing.

increasing productivity soon depended on the use of more and more advanced machines in new production processes. Industrial "development" is the process by which a succession of more and more efficient production systems are developed and *deployed in the workplace*. An industrial revolution is a situation where the pace of industrial development is so rapid that it constitutes a dramatic and thoroughgoing transformation of the work process. The basic Marxist concepts of the difference between formal subordination (employment of workers by employers using their own pre-capitalist labour processes) versus real subordination (workers working with the labour processes determined by their employer (Marx, n.d.)) were readily applicable to pre-industrial woods work and to its transformation. We identified the emergence of a succession of more and more productive tree harvesting systems, which we argue constituted two distinct lines of industrial development (a 'cut-to-length' or shortwood path of development, and a longwood path of development (MacDonald and Clow, 1999)).

In previous articles we have published our research findings comparing the pace of industrial development in the forests of Eastern Canada and the Southeast of the United States[8]. The pace of change in Canada constituted a true industrial revolution in the woods between the end of WWII and the late 1990s (MacDonald and Clow, 1999). Canada was one of the three leading centres of innovation in tree harvesting machines and production systems (along with the US Great Lakes States and Sweden), beginning with engineering research studies sponsored by the Canadian Pulp and Paper Association's Woodlands Section in the 1940s (Pepler and McColl, 1949). In Eastern Canada the usage of systems over the whole course of the industrial development of tree harvesting systems followed the cutting edge of productivity as new systems were developed, whether they emerged in Eastern Canada, the Great Lakes States or Sweden. In the early 2000s the standard systems in Eastern Canada were the most advanced shortwood and longwood systems.

By contrast, the industrial revolution in tree harvesting in the Southeast was late, short, truncated, and derivative (MacDonald and Clow, 2010). Late because the South's favourable terrain enabled contractors to get by with an ad-hoc, labour-intensive, low-tech, low-capital-cost 'bobtail truck' system[9] as the *standard* system

8• For details, see MacDonald and Clow (2010).

9• Our discussion is based on two important field studies of the bobtail truck harvesting system. The first is Robert L. Schnell (1961). The harvesting operations studied included 12 in Tennessee, 5 in Alabama, 3 in North Carolina, 3 in Georgia, and 1 in Mississippi. The second is H.R. Hamilton *et al.* (1961). Both sources present systematic industrial engineering analyses of the bobtail truck system.

for more than 30 years (and to use it commonly for more than forty years)[10], during which time only incremental technological innovation was employed to maintain its viability, not to transform it (Schnell, 1961 and Hamilton *et al.*, 1961). The industrial transformation of the work process in the Southeast really begins with the diffusion of the simplest longwood harvesting systems into pulpwood production in the 1970s. The industrial revolution in the Southeast was short because once fundamental change commences it is over in only 15-20 years with the rapid ascendancy of a single advanced longwood system. The industrial revolution in the woods of the Southeast is truncated because only a very few important systems were used in the Southeast; many of those so important in Eastern Canadian development were missing[11]. And derivative because, with the exception of the Busch Combine (which we will discuss later), the industrial systems employed in the Southeast were ones whose principal machines and work processes had been pioneered elsewhere.

Conceptualizing Innovation in Tree Harvesting

How and why does technological innovation occur? What does technological innovation require? More to the point here, how does technological innovation in the capital goods sector, in production systems, occur? Indeed, how does a technological revolution occur, one which moves from a pre-industrial and pre-mechanized production system to a fully mechanized, sophisticated set of production systems? What did it take to create an industrial revolution in the woods?

In the liberal tradition, thinking about all economic activity occurs with the notion of market relations and transactions. An excellent exemplar of such thinking applied to mechanization and industrialization is Geoff Burrows and Ralph Schlomowitz (1992) study of why the mechanization of sugarcane harvesting in the American South lagged behind that of other crops in the US North. An accountant

10• These figures are provided by the following sources: G.H. Weaver *et al.* (1981), W.F. Watson *et al.*, (1989) and W. Dale Greene *et al.* (2001).

11• These classes of machines are: 1) forwarders; 2) shortwood (pulpwood) harvesters; 3) tree-length harvesters; 4) feller-forwarders; 5) swing-to-tree, tracked feller bunchers; 6) stroke delimbers; 7)cut-to-length Nordic harvesters. See MacDonald and Clow (2010) for details.

and an economic historian, Burrows and Schlomowitz phrased their analysis in the language of liberal economics, describing "'demand-side' and 'supply-side' explanations" (Burrows and Schlomowitz, 1992: 61) for the slower pace of mechanization in Southern agriculture. Demand-side explanations concern the desire of potential users of new production technologies to employ new machines (Burrows and Schlomowitz, 1992: 61). By contrast, supply-side explanations argue that the slow pace of technological innovation results from the inherent difficulty of mechanizing production processes: "inventive activity is responsive to the ease or difficulty of finding solutions to technical problems" (Burrows and Schlomowitz, 1992: 61).

We began with an emphasis on the groups of actors created by the organization of the forest industry before mechanization and the actions which brought about the industrial revolution in the woods. To provide a framework for our thinking we have found very useful the ideas of Swedish forest engineer Lars Laestadius and his notion of the "wood supply system" (Laestadius, 1990). Laestadius's notion was intended to be comprehensive, covering all aspects of the process by which mills obtain their supply of wood from the forest:

> The concept of a wood-supply system is proposed, defined as a mechanism generating a consistent flow of wood to a set of wood-consuming mills, beginning its work with the severing of trees and ending it by feeding a pulping digester [at a paper mill] or head saw [at a lumber mill]... (Laestadius , 1990:v).

Though the forested land from which wood is produced and the kind of harvesting systems by which the trees are turned into wood are the 'obvious' elements of the wood supply system, a wood-supply system includes many specifically *socioeconomic* arrangements and features: forest-land ownership, the ownership of harvesting operations, wood procurement arrangements (by which trees are obtained for harvesting), transportation arrangements for wood from the forest, and the mills' relationship to the other groups of people in the system (Laestadius , 1990: 3-4). These in turn led us to a triple focus: 1) on the various groups within the wood supply systems – the mill owners, tree harvesting contractors or woodlands' managers, woods workers, landowners and any middlemen in the wood procurement system; 2) on the socio-economic relations between them; and 3) on the changes in these arrangements created by their actions. While Burrows and Schlomowitz's inclination would be to identify these groups as the 'demand-side' of their market equation (with engineers and equipment manufacturers on the supply-side), as we will see shoehorning actors into market relations assumes simple market relations between them, when relations may be more complex.

Though there were important differences in the organization of traditional, pre-industrial, tree harvesting operations in Eastern Canada and the American Southeast, there were fundamental similarities. By 1945 the forest industry was dominated by pulp and paper product production. Pulp and paper mill owners were the largest companies and they dominated the industry. Almost everywhere, mills wanted no part in running forest operations, seeing the mills as their profit centers and forest operations as a cost-centre (Vail, 1989: 351), one that would divert capital from more profitable employment in the mill. Forest operations were also regarded as a headache, involving the management of many men scattered over large areas. Mills greatly preferred wood to be bought as bulk commodities like water and chemicals, obtained from other parties. Mills greatly preferred, in other words, to outsource their wood, rather than to produce it themselves.

To that end pulp and paper mill owners in the pre-industrial era had organized systems of contracting and subcontracting that made tree harvesting someone else's problem. Actual harvesting was conducted by seasonal workers, many of them farmer-loggers, using hand tools (axes, saws and the like) and draft animals for locomotive power. These seasonal workers were employed by small contractors, who were often sub-contractors for middleman[12] who had contracted with the mills to provision them with wood. There thus existed an odd juxtaposition of industrial with a pre-industrial capitalism, a combination of modern, high-tech machinofacture in the mill with outsourced production by simple co-operation in the woods[13]. Such a system made the industrialization of woods work very difficult to achieve.

Before industrialization could occur some social actor(s) had to take on the task of developing machinery and production systems, and some actor(s) had to have the financial and technical wherewithal to buy and operate mechanized, industrial harvesting systems. Traditional arrangements like those in the forest industry in 1945

12• In Eastern Canada these middlemen were usually called 'grand jobbers'. See particularly Silversides (n.d.) and Drushka and Kottinen (1997: 167). In the Southeast they were called "wood dealers". In both places they usually sub-contracted the actual tree harvesting operations to small contractors who managed the labour of the direct producers of the mills' wood.

13• In his analysis of the development of the factory system of production, Marx considered machinofacture - the mechanization of previously manual activities - to be the highest stage; indeed, this for him constituted industrialization. The earliest developmental stage - simple co-operation - is defined by employers' assembly of numbers of workers possessing crafts skills (i.e. producing a complete product by themselves) together into a single location. The striking factor here is the juxtaposition of both stages within a single productive entity.

precluded this possibility. Woods workers were poorly paid and lacked both the incentive and the financial ability to develop genuine woods machines, or even to buy or operate them. Even the unionized workers in 1950s' Eastern Canada (Radforth, 1982) found purchasing, operating and maintaining the new one-man chainsaws was a large investment, and all that could be expected — and many small-equipment manufacturers, not woods workers, had financed the decades-long gestation period of this powered tool[14]. Woods contractors were in no better position to initiate and sustain an industrial revolution in the woods. In general they were very poorly capitalized, and had no great technical knowledge of the production system for which they recruited the workers (and in Canada operated the deep woods camps in which the workers lived). They simply didn't have the means — even if they possessed the incentive — to change a harvesting system built on large numbers of manual workers using hand tools in conjunction with horses. They had neither the capital nor experience nor infrastructure with which to operate and maintain mechanized production systems, much less pay for their development.

In addition, innovation in the woods faced powerful, inherent technical difficulties. Terrain made moving over the forest floor of much of North America difficult and challenged post-WWII automotive know-how. The technologies of the 1940s were not up to the task of developing machines able to fell, delimb and slash trees. It would take a pushing forward of the technological frontier to create real woods machines[15].

As a result of the 'demand-side" limitations we discussed above, potential forest equipment manufacturers — the manufacturers of other heavy equipment — were very unlikely to make the expensive and risky effort to develop forest machinery. Heavy equipment manufacturers did not see a market for hypothetical woods machines, as workers and contractors couldn't afford to buy, operate and maintain such systems, and mill owners were uninterested in doing so. In any event manufacturers of heavy equipment faced other difficult to surmount problems – they had neither the knowledge and experience of woods work needed to design, test and build

14• Chainsaws are tools, not machines because the operation is entirely dependent on the skills of the man using it. Machines do functions largely automatically, with the workers operating as machine minders and servers (though they may need new kinds of skills to do so, the procedure of the machine dictates the production process). And as Radforth notes, chainsaws did not alter the division of labour or piecework reenumeration of woods workers in Eastern Canada (see Radforth, 1982: 88).

15• For this the best source is *Tracks in the Forest* ... (Drushka and Konttinen, 1997).

such machines. Backyard innovators with connections to the woods faced the same problem of markets, and lacked the financial wherewithal to develop or manufacture large numbers of new woods machines.

Thorough-going industrialization was not a possibility without fundamental change in the complex of social relations embodied in 'traditional' woods work, an argument we think supported by the contrasting histories of change in Eastern Canada and the Southeast. The only players in the traditional system with the capital to undertake a thorough-going effort to industrialize, the access to the woods on which to learn, test and develop the technology, and the money to buy, operate and maintain systems were the pulp and paper mill owners. Only when the mill owning corporations had the incentive to change woods work practices was large scale, rapid and thoroughgoing change likely.

Organizing the Industrial Revolution: The Case of Eastern Canada

Woods work in Eastern Canada underwent a long and sustained process of industrialization that kept it at the cutting edge of the use of new tree harvesting systems until the industrial revolution ended in the 1990s. Our forest engineering informants made there no doubt that Canadian pulp and paper mills "paid the freight" for bringing the new systems into the woods.

Mill owners invested in the *use* of new more and more mechanized tree harvesting systems in two ways: 1) by establishing mill owned, mechanized harvesting operations to replace the traditional contracting system; and 2) by creating a new genre of contractors able to operate these systems to replace company owned harvesting operations after new harvesting systems were proven in the field.

Once the Canadian pulp and paper industry decided that tree harvesting had to be industrialized, mill owners broke decisively with tradition and "took ownership" of tree harvesting. Beginning with "getting the horses out of the woods" in the late 1950s and early 1960s, Canadian mill owners set up there own "in house" forest operations to replace the traditional contractors and methods and brought in new mechanized systems. And they continued to bring newer, more mechanized systems into the woods as they became available. Our interviewees argued that company owned

operations progressively pioneered the way forward by bringing newer, progressively more productive and more capital-intensive systems into the forest in search of lower wood costs and greater productivity. Mill owners took on the burden of buying, operating and maintaining the machines in their chosen systems, as well as hiring and supervising the workers to run them in order to industrialize woods operation in search of cheaper wood, in greater volume, produced by fewer woods workers.

But our interviewees also argued that mill owners saw this direct involvement in woods operations as temporary. As quickly as job security provisions of union contracts on company operations would allow, mill owners made the efforts necessary to once again move to outsource their wood once a tree-harvesting system was proven and its costs known to the mill. To do this mill owners went about creating a new system of contractors, ones able to operate the company-favoured systems. These new contractors required a new financial and technical environment for mechanized contracting operations. Mills arranged and guaranteed loans for favoured potential contractors, aided in the establishment of the contractors' infra-structure for mechanized operations, and – most importantly – set wood prices and contracted annual volumes of wood in long-tern contracts that, given the companies' knowledge of a system's economics, mill owners knew would assure a modest profit for the contractors. So well did mill owners know the costs, one mill manager in New Brunswick told us, that the contractor's profit was calculated into the mill's own book as a 'management fee'. As new systems were proven in company-owned harvesting operations and their economics ascertained, mills would repeat the process of moving its use to contractors. By such means Eastern Canadian pulp and paper mills were progressively able to outsource their wood to contractors able to operate the more and more complex and capital-intensive systems, in the process ridding themselves of the need to invest all the needed capital and employ their own managers in company owned operations. In such a way Canadian mills sponsored, funded and facilitated the industrialization of tree harvesting, and then withdrew once again to re-outsource the conduct of woods operations into the hands of quasi-independent contracting enterprises.

But more interesting still is that mill owners in Canada not only took upon themselves the process of bringing more and more sophisticated industrial tree harvesting systems into use in the woods, they were intimately involved in the 'supply-side' of the industrialization process: that is, in the creative engineering studies that laid the intellectual foundation for industrial development, and in the actual invention and proving of individual machines and systems. Investigation of the possibilities for new production techniques began in the 1920s with the establishment of the Woodland Section of the Canadian Pulp and Paper Association (CPPA); active involve-

ment in the development of new machines and systems began through the Woodlands Section in the immediate wake of the end of WWII.

Pulp and paper mills in Eastern Canada had long been aware that productivity in woods operations was very low. This had led to the establishment of a Woodlands Section by the CPPA in 1918. Its purpose was to investigate best logging methods, and disseminate this information to its member companies. But though it conducted a number of industrial engineering types of analyses of the prevalent harvesting techniques between the wars, it had little impact on changing these, a result its first professional forester, A.M. Koroleff, attributed to the fact that "[h]uman physical energy is a cheap commodity..." (Silversides, 1997: 136). Traditional hand tools and horses, and traditional production systems were viable as long as woods labour and horses were abundant and cheap.

Eastern Canadian paper mills' general unwillingness to invest in industrial development began to change in the midst of WWII, the signal being the establishment of a Logging Mechanization Committee of the Woodlands Section in 1944 and in earnest from the 1947 reorganization that placed W.A.E. Pepler at the head of the Woodlands Section and Bruce McColl at the head of the logging mechanization project (Silversides, n.d.). A Mechanization Steering Committee[16] was created in 1948, to provide organizational sponsorship of technological innovation. The MSC was designed to function as a central reporting agency on matters mechanical and as a "spark plug" igniting mechanization (McColl, 1969: 5). Pepler and McColl made a presentation to CPPA member companies at the 1949 Annual Meetings of the Woodlands Section, CPPA (Pepler and McColl, 1949). Canadian forest engineers who have documented the process of industrialization date the Canadian effort from this initiative.

McColl was particularly ambitious: he campaigned for a national research and development organization funded by the Canadian Pulp and Paper Association and devoted to the effort of industrializing tree harvesting. McColl's grand systematic, centralized programme of engineering research did not happen. But Canadian mill owning corporations, sometimes singly, sometimes in small groups, and sometimes collectively through the CPPA's research arms did organize a considerable proportion of the North American effort to develop new tree harvesting production systems.

We have developed a three-fold typology of the organized forms of cooperation between different mill owners, and between mill owners and equipment manu-

16• This name could not have been improved upon had we invented ourselves.

facturers: 1) *liaisons*, co-operative arrangements and developmental agreements between individual pulp and paper companies and equipment manufacturers; 2) *inter-company associations*, formal collaborations among a specific number of competing pulp and paper companies to develop new machines and the informal intercourse among them whereby they shared their experiences with operating new equipment, including the costs of operating particular machines; and 3) *confederate organizations*, consortia of almost all the large pulp and paper companies (sometimes with aid of the Canadian state) to form and finance research institutes.

The first form of capital-to-capital linkage involved the creation and sustaining of co-operative relations between the two types of capitals — pulp and paper companies and equipment manufacturers — where together they participated in the development of technology. The forging of these institutional linkages between the pulp and paper companies and the equipment manufactures assumed a variety of different forms. The relatively straightforward iterations of these included the informal co-operative arrangements between the two whereby current production units were revised and improved, and the testing of prototype and pre- production units from the manufacturer conducted on the woodlands operations the user companies. The more complex instances included formalized user-manufacturer participatory contracts and, perhaps the most interesting of all, the specification of the actual design criteria by the pulp and paper company according to which the equipment manufacturer constructed the prototype.

The second form we label *inter-company associations*, formal collaborations among a specific number of competing pulp and paper companies to develop new machines and the share their experiences with operating new equipment. They required a specific exemption from the conventional directly competitive relations of these firms. As such, these non-market relations modified and attenuated conventional competitive market relations.

The third form we call *confederate organizations*, consortia of almost all the large pulp and paper companies to form and finance research institutes – a larger, umbrella organization capable of contributing to all member companies the knowledge and expertise so developed. The first historical example of such a research organization was the Woodlands Section of the CPPA. According to Silversides, someone in a position to have known, the Woodlands Section was a driving force in the evolution of logging machinery (McColl, 1969 and Silversides, 1997). Indeed with the hiring of A.M. Koroleff in 1927, the science of forest engineering began to be established by the Woodlands Section (Koroleff, 1943), an effort also contributed to by a sister organization sponsored by the CPPA, the Pulp and Paper Research Institute of Canada

(PPRIC). It was the Woodlands Section that played a key role in initiating the development of the first, key forest machine, the forwarder, whose locomotive system made real mobility on the forest floor possible (Silversides, n.d.). The successor to the Woodlands Section and PPRIC from the mid-1970s has been the Forest Engineering Research Institute of Canada, one of the foremost forest engineering research institutes in the world, and one that has also developed key roles in the actual development of machines[17].

Though we will discuss the importance of the machines developed and engineering knowledge produced by these forms of capital-to-capital cooperation shortly, it is appropriate at this point to mark what we will argue are the major or most significant machines developed by these forms of innovatory cooperation. We summarize them in tabular form:

Table I: Institutional Context of Significant Machines

Machine	Type	Institutional Context
Bonnard	shortwood forwarder	Confederate
Dowty	shortwood forwarder	Liaisons
Koehring-Waterous SWH	shortwood harvester	Liaisons
Beloit Harvester	tree length harvester	Liaisons
Arbomatik	full tree system	Inter-Company

NOT Organizing an Industrial Revolution: The Case of American Southeast

By contrast with Eastern Canada, our Southern interviewees reported that, with rare exception, the pulp and paper mills in the Southeast left technological innova-

17• It was, for example, responsible for the development of the circular sawhead in the 1980s, now used almost universally on all feller-bunchers.

tion largely to the discretion of "pulpwood producers" – that is to the abilities of the small, poorly capitalized contractors whose workers actually harvested the wood. The usual practice of the pulp mill owners was not to invest in the engineering development work and testing required to develop new systems, not to establish mechanized company owned harvesting operations in order to pioneer mechanized systems, and not to sponsor and facilitate the adoption of mechanized systems by pulpwood contractors. Most pulp and paper mill owners instead created a wood supply system that allowed them to outsource the provision of wood, not just harvesting, to a network of "wood dealers" and so to avoid a lot of costly headaches for themselves.

The characteristic feature of Southern forestland in the wake of WWIII was that it came in separate little parcels – small woodlots allowed to grow up on abandoned farmland owned by unorganized, non-industrial landowners scattered throughout the countryside – and not as large contiguous areas of wood under common ownership[18]. Small landowners – typically farmers or 'Aunt Josephines'' town-dwelling heirs – were in no way compelled, except by their own particular purposes and circumstances, to provide the mills wood. When this fact was combined with the fact mill owners and their managers were outsiders from elsewhere in the United States and so were not connected with local Southern social networks, mill owners had a very strong local incentive to completely outsource the provision of their wood. This led to the mills' wood supply systems usually being built around networks of "wood dealers" with strong local connections. These local merchant middlemen – a form of indirect control that was a well-established part of the rural Southern economy (Yafa, 2005 and Angelo, 1995) – took over the wood procurement process on the mill's behalf[19].

The result was what Southern forest engineers call the "wood dealer system". Wood dealers, the local intermediaries of the mills, handled the task of connecting many small, poorly capitalized local contractors and their workers with landowners willing to have their woodlots harvested. Wood dealers, their local wood yards and their local connections acted to concentrate the trickles of wood produced from many woodlots and many contractors into the stream required by the mill or mills with which he was associated. 'Pulpwood producers' – the contractors, also called 'pulpwooders' – were at a distant second remove from the mills for which they produced.

18• Even acquisitions of land by companies in the decades after 1945 still tended to be a scatter of these small plots spread across a large area.

19• For an account of the wood dealer system, see Warren A. Flick (Flick, 1985), and John C. Bliss and Warren A. Flick (1994).

Wood dealers kept this system going by advancing financial assistance to small pulpwood producers and 'problem solving' in the traditional, patron-client relationships of the South. Through debt-relations and by local knowledge not possessed by the mill owners themselves, wood dealers held together a pre-modern system of small-scale production based on cheap labour, traditional hand tools and production techniques, and fragile local enterprises.

While the mills found these arrangements much to their liking – as long as the wood dealers could keep enough contractors in business, enough workers showing up to work for them, and enough landowners selling stumpage to meet changing mill requirements – its effects on the wood producers (the contractors), their workers and the pace of industrialization in tree-harvesting were less benign. The wood dealer system put the onus for innovation and industrialization on the small, poorly capitalized local pulpwood contractors. The very nature of such a wood-supply system bred insecurity and poor returns the closer anyone got to actually working in the woods. Whether the mill needed enough wood to provide all the dealer's contractors with next *week's* contract was never certain, and many contractors went in and out of production, and in and out of business, on a repetitive and erratic basis. It was no wonder, as one forest engineer informed us, the old saying among bank managers in the South was 'never to lend money to preachers or pulpwooders'. The low margins of return and instability of the business environment put very strong pressures on pulpwood contractors to run low-cost operations. The incremental improvements made in the loading arrangements of the bobtail truck harvesting system over the 1960s and 1970s generally "satisficed" the needs of the mills for pulpwood at low cost by serving to reduce the hard manual labour associated with hand loading of the truck sufficiently to keep workers from deserting the woods (MacDonald and Clow, 2010: 149-150) – without compelling the use of the mills' capital to modernize production in the way mills in Canada had done. Southern pulpwood harvesters stuck with the 'bobtail truck' system through the 1970s, and in places into the 1980s, not out of conservatism, but because more mechanized and productive systems were beyond their financial reach. The vast majority of harvesting contractors simply could not afford more mechanized harvesting systems.

The Plausibility of Mills Importance to the Industrial Revolution in the Woods

We argue the involvement of pulp and paper mill owners was the key determinant of rapid industrialization of the woods based on three sets of evidence. First, on the significance of Canadian mills actions. Secondly, on the fact that only in the isolated cases where Southern mills acted strongly was industrialization there rapid. And three, on the professional judgment of forest engineers.

i) the consequences of Canadian mills' actions

The actions of Eastern Canadian mills were instrumental in the development of new machines and harvesting systems. The mills also provided the means by which new machines and systems went into the woods.

The Bonnard Prehauler / Dowty Forwarder arc of development created the forwarder, the first successful attempt to mechanize a portion of the shortwood category of harvesting system. The Bonnard Prehauler was the result of Project "E" overseen by the Mechanization Steering Committee of the Woodlands Section (a *confederate organization)*; the first commercial forwarder was the Dowty, produced in the framework of a user-manufacturer participatory contract (*liason*). Moreover, the Dowty served as both the conceptual and mechanical foundation of the Koehring-Waterous Shortwood Harvester (Silversides, 1997: 34) – by far, the most successful pulpwood harvester –which emerged from a *liaison* between International Paper and Koehring. Forwarders remain a part of the most advanced shortwood system, the single-grip harvesting system.

The Beloit Harvester was the first (and most successful) tree length harvester, thus inventing the genre of this type of machine. It was developed by Minnesota's Bob Larson in response to a request from Marthon, one of Ontario's most progressive mill corporations (a *liason*). Its development meant that, for the first time, the tree length class of harvesting system became fully mechanized. The success of the Beloit Harvester spawned that company's development of the grapple skidder, so necessary for the full-tree feller-buncher system.

The Arbomatik System emerged from formal co-operation among several Eastern Canadian pulp and paper companies via the framework of Logging Research Associates (an *inter-company* connection). It was the first example of a full tree harvesting system and demonstrated that possibility of practical full tree harvesting.

Perhaps the greatest long-term impact of all types of corporate inter-cooperation was the *confederate*, in form of the contributions to forest engineering theory, practice and evaluation by the CPPA's Woodlands Section and Pulp and Paper Research Institute of Canada (PPRIC). From the time of Koroleff the Woodlands Section theorized the proper course of the industrialization of tree harvesting. PPRIC began the development of the proper methods and criteria for comparative evaluation of forest machines and their maintenance and operation, and then proceeded to become a principle evaluator of the development of machines using those criteria. The development of standardized industrial engineering measurement protocols and their application to tree harvesting not only created the profession of forest engineering, but assisted in the provision of the empirical knowledge required by user companies to engage the risk of utilizing these machines. Their evaluation of prototypes[20] furthered the adoption and dissemination of machinery by companies. And their studies of component failure and of recommended maintenance schedules ameliorated the frustration no doubt felt by many as they struggled with these new machines. FERIC has continued this work.

The significance of the Eastern Canadian mills funding and organizing of the employment of new machines and systems in the woods is best understood against the fact that no other actor in the forest industry was capable of doing so. The weakness of a traditional pre-industrial system built on cheap labour and contracting out to poorly capitalized contractors is that large scale industrial investment can only be made by the powerful actors benefiting from the existing arrangements – in this case, the pulp and paper mill corporations.

ii) the consequences of mill inaction in the Southeast

The truth of this proposition is reinforced by the Southern experience, where change in the use of systems was slow, incremental and episodic for decades and the local development of new systems was, as our Southern key informants made clear,

20• Some of which were quite critical. See for example C.-J. Breberg (Breberg, 1970).

heavily dependent on the innovative efforts of 'backyard inventors" and the initiative of equipment manufacturers. The American Southeast provides evidence of what happened in the relative absence of the strong hand of paper making corporations.

A measure of the distance that mills took from involving themselves in industrial development, even when the contractors on whom they depended had serious problems, is contained in the story of Walter Jarck[21]. He had been hired as an engineer by Bowater at its then (1959) new mill in Catawba, South Carolina. The new mill was confronted by problems of wood supply arising from the difficulties of bobtail truck pulpwood harvesting in wet weather. In response to potentially repeated wood shortages Bowater sent Jarck off to "do something" to make all-weather harvesting more feasible.

His efforts, even though paid for by a prosperous multinational corporation, had all the flavour of backyard innovation. On a shoestring budget Jarck developed a forwarder, sans the characteristic knuckleboom loader. Jarck himself spoke of his innovation efforts as a "bootstrap" type of operation using "seat of the pants engineering". Having funded the creation of the machine Jarck called the Go Getter for a few thousand dollars, Bowater efforts to diffuse the use of the machine was equally penny pinching. Bowater distributed the plans to anyone who wanted them for 50 cents (Clow and MacDonald, 2009). Production of Go Getters relied on local welding and machining capacity using materials readily available in the local area. As in most Southern innovation, cost was the primary obstacle to the diffusion of the Go Getter – because that cost fell on the poorly-capitalized pulpwood contractors. Jarck thought his machine an extraordinary success with three hundred and forty plans provided by Bowater, and "... close to a hundred machines actually built in local shops all around"[22].

There were two contrasting "styles" of innovation in the two regions of North America. In the Southeast, one had pragmatic, small-scale innovation in response to "everyday" problems making do with what was at hand in the cheapest way possible. In Eastern Canada, innovation was the much more formalized and organized process we have described. For development, mass production, and widespread diffusion into the woods, the Canadian mode of operation was more efficient at sparking and sustaining technological innovation and progressive industrialization.

21• Our information is based on our interview with Walter Jarck.

22• Jarck Interview. For those who wished a finished machine, Jarck made arrangements with T.C. Brown in Mississippi, manufacturer of the Big Stick Loader, to produce the Go Getter, now equipped with a knuckleboom loader.

The proof of the rule may be judged by the outlying cases in the South, those rare instances where mills did take greater ownership of forest operations. The case of International Paper and their development of the groundbreaking Busch Combine is an example of how Canadian methods could have been employed in the Southeast, had pulp and paper companies been willing to follow IP's lead. The Busch Combine was the first successful pulpwood harvesting machine, one developed in the South to meet Southern conditions. The engineering credit goes to Tom Busch, a brilliant and accomplished mechanical engineer in the direct employ of the International Paper at Mobile, Alabama. The contrast with Jarck's work circumstances is striking. Starting in 1953, while the Bonnard Pre-hauler was still in development, Busch set out to create a pulpwood harvesting machine. Amazingly given the state of hydraulics, Busch produced a commercial quality machine capable of efficiently and rapidly felling, delimbing and slashing trees into 5'3" bolts of pulpwood (the standard length in the South) by 1959[23]. Without getting into engineering details, Busch's machine was uniquely tailored to the terrain and tree conditions of the American South[24] and a remarkable accomplishment for the time. And it was no merely experimental machine. International Paper and several other companies employed it very successfully in the South. But it was a footnote in the history of Southern tree harvesting, because so few companies would establish their own company-owned harvesting operations or create a force of contractors able to use the machines.

iii) the witness of professional forest engineers

Our sources in the forest engineering community are unanimous in their suggestion that the active involvement of the mills was the key ingredient in the pace and intensity of industrialization.

23• It would take another decade for a machine, inspired by the Busch Combine but able to handle Canadian terrain and trees – the Koehring Shortwood Harvester – to be ready for commercial use.

24• As we noted, the post WWII Southern forest was growing on relatively flat, obstacle free land that had until recently been cotton fields. In addition, Southern pine trees have few limbs, and those which remained were much more easily broken off that those farther North. Because it was easy to drive right up to the tree, the Busch combine employed the shear on an arm extending out horizontally from the vehicle, cutting the tree down from the side, then moving it upwards onto the vehicle where a set of knives delimbed it and the same shear as felled the tree was employed to slash it into uniform length bolts.

Canadian forest engineers told us the role of mills in the industrialization of tree harvesting was fundamental in Eastern Canada, both to the development of new systems and their use in the woods. The late Professor Tom Bjerkelund of the University of New Brunswick told us the cooperation between diverse capitals in various combinations put the financial package, the expertise of construction machinery manufacturers, and practical woodlands operational experience together to design, test and perfect new equipment. A central research and development agency to engineer new systems and put new machines together with potential manufacturers – as advocated by McColl (1969) and endorsed by Silversides (1997) – may have been even more efficient, but even the more piecemeal role of pulp and paper mill owners started and sustained the pace of industrial development in the Eastern Canadian woods. Canadian forest engineers believe it was the mills that supplied the *agency* required for rapid and sustained change.

Southern forest engineers, for their part, argued that Southern mills ability to stand off from tree harvesting held back innovation in the woods for decades. This came out strongly not only in their explicit statements. Our key Southern forest engineering informants were insistent that we interview two forest engineers, Tom Kelly of Scott Paper and L.O. Wright of Union Camp. These, we eventually realized, were two of the very few forest engineers who had the opportunity to do what all the others of the post-War era in the South had wanted to do – move forward aggressively with "mechanization". This had happened through the active support of the mill owners, who – unlike most of the others – took over their own provision of wood with company-owned woods operations.

Explaining the Divergent Role of Pulp Mill Owners in Eastern Canada and the American Southeast

It would be wrong to ascribe an unusual aversion to "taking-ownership" of woods operations to Southern mill owners. The real question is what led the pulp and paper industry in Canada to abandon its long refusal to take control of woods operations and industrialize the woods, and make the very substantial investment of money, time and effort it took to create sustained innovation in tree harvesting? And conversely, what allowed the Southeastern mill owners, the chief competitors of those

Canadian mills, to stand back and watch the bobtail truck system soldier on into the fourth decade after the end of WWII?

i) explaining the Eastern Canadian break with the past

What was special about the end of WWII in Canada that gave impetus to the transformation of tree harvesting in Eastern Canada? We argue the answer is the disappearance of the socio-economic conditions that had allowed the old pre-industrial system to persist.

Since colonial times tree harvesting in the small tree forests of all of eastern North America had been dependent on off-seasonal labour drawn from subsistence farming, the use of hand tools associated with work on farm woodlots, and the use of farm animals for logging operations (Drushka and Konttinen, 1997). Such low productivity methods of harvesting could only survive as long as cheap labour, and horses, were available in sufficient quantity to supply the wood required by the mills. Economic and political developments, even before WWII ended, were understood to threaten this in Eastern Canada.

Beginning in 1943 the Canadian federal and provincial Governments were making plans for a rapid continuation of wartime industrialization, the urbanization of the Windsor-Montreal corridor and the commercialization of agriculture. We believe it was no accident that in February 1944 the Woodlands Section established a "Logging Mechanization Committee" and set about attempting to develop a programme of action to break the logjam of innovation in pulpwood production (Silversides, 1984). Eastern Canadian mill owners understood the implications of the new national policy: the supply of cheap labour supplied by farmer-loggers was going to dry up as seasonal woods workers took better paying post-war urban jobs or moved from subsistence into commercial agriculture. The latter would also mean the replacement of the farm horse with a tractor, and the steady loss of both the supply of horses and the teamster skills upon which pre-industrial methods of harvesting depended. Worried mill owners responded by designating the Woodlands Section of the CPPA as the "sparkplug" for development. Though it would take more than a decade for the rupture of the "agriculture-forestry nexus" to produce dramatic decline in the availability of woods workers, the writing was on the wall with the absence of a flood of workers into the woods as demobilized soldiers returned to civilian life (Silversides, 1984).

The breaking of the forestry-agriculture nexus in Eastern Canada as the long-boom proceeded left Eastern Canadian mills without the option of relying on the old pre-industrial wood supply system (Drushka and Konttinen, 1997 and Silversides, 1997). As Radforth notes in regard to Northern Ontario, the heartland of Eastern Canadian forestry, continuing labour shortages continued to push mills toward greater productivity and more mechanized production systems throughout the process of industrialization (Radforth, 1982: 99). Mill owners knew that "mechanization" of a thorough-going sort would be required to displace the evaporating labour supply. Specialized vehicles would be need to traverse the rock strewn and boggy floor of the boreal forest, and complex machinery to fell and process the 'limby' trees. It was understood that mechanized production systems would be costly to develop and to utilize (Pepler and McColl, 1950). And that they, the mill owners, would have to take the initiative to provide themselves with a secure and growing supply of wood needed to meet the anticipated post-War growth in paper products.

But innovation under Canadian conditions also had real potential rewards for the mills. Mechanization promised to create all-season, year-round logging. Evening-out the flow of wood to the mills over the year would reduce the capital that had always been tied up in the wood yard when the whole year's supply arrived in a short period during the Spring. A reduction in the number of workers needed was also particularly attractive to Canadian mills, since serious mechanization promised to reduce the armies of manual workers who had to be fed and housed in Winter deep-woods camps. Industrialization of woods work would also allow mill owners to shed the very large component of 'sometime' woods workers in favor of the smaller percentage of the best, most committed, workers as both productivity and wages rose.

The mechanization of woods work was the only way to simultaneously shed the amount of labour required, improve working conditions, wages and productivity — all measures essential to developing a committed workforce of tree harvesters in the face of emerging job alternatives and the need to expand wood production to meet anticipated increases in demand for wood products. The cost of recruiting, transporting, housing and feeding many thousands of traditional workers in deep-woods camps hundreds and hundreds of kilometers from anywhere favoured the development and use of high volume production, and highly productive systems. The patterns of Canadian woodlands ownership and location — large blocks of company-owned and Crown land in the back-of-the-beyond — also facilitated large scales of operation. Necessity and opportunity for a through going-industrialization of woods work thus forcefully coincided in the post WWII era. The Canadian pattern of system development and use was the consequent.

ii) explaining the lack of a rapid industrialization in the American Southeast

Though the coming of the tractor to farming did occur quickly after the War in the South and meant the disappearance of the mule in pulpwood production, the bobtail truck provided a sufficient replacement to keep a pre-industrial tree harvesting system going. The secret to understanding the Southern case is the recognition Southern socio-economic conditions in 1945, and long thereafter, were very different that those in Eastern Canada. Most important was the fact the supply of rural cheap Black labour and Whites without better prospects than pulpwood contracting – the underlying prerequisites for the wood dealer system – did not dry up quickly in the South after WWII.

Put simply, the long boom of post-WWII prosperity did not come as quickly to the American South as it did in Ontario and Quebec, the heartland of Eastern Canadian pulp and paper production. Most importantly, this meant that a large number of rural, mostly Black, farmer-labourers, living amongst the trees that were growing on former cotton fields and available for local tree harvesting work, remained in place across the rural Southeast. Similarly, a large pool of mostly White contractors and potential contractors with few better business or job prospects than buying a bobtail truck and hiring a few workers to harvest pulpwood also remained available in the rural Southeast. Given this continuing availability of cheap labour and small employers to manage them, the old ways, and the old tools and work techniques could remain in place in the bobtail truck system for decades and decades after 1945.

The mystery lies in what sparked and catalyzed the move towards more capital-intensive tree-length systems in the Southeast in the 1970s. The appeal of symmetry suggests that the ready supply of cheap, rural, largely Black, labour must have been drying up. This may well be the case. The 1970s and 1980s were the days of the successful Sunbelt industry initiative to bring manufacturing to the cheap wage areas of the South (Cobb, 1982 and 1984), providing alternative steady employment in a far easier working environment. And sharecropping, which had bound farmers to the land through debt (Angelo, 1995 and Aiken, 1998) and made them available for off-season work had faded into insignificance by the 1970s. Migration by rural Southern Blacks and Whites into the towns and cities in the South (Aiken, 1998), as well as outward to the North, was a process that helped empty the rural areas of potential woods workers (Gregory, 2005 and Holley, 2000). One forest engineer suggested that easier access to welfare in the 1970s also made woods work less attractive.

Other explanatory suggestions have also been made. Some forest engineering informants argued the new "chip-n-saw" technology coming into use in lumber mills in the 1970s was a key factor. The "chip-n-saw" allowed smaller logs to be used to make lumber, and they produced wood chips (not dust) as it sawed logs into lumber. This made small logs more valuable than they had been[25], on one hand, and enabled lumber mill wastes to be used as a major source of wood for pulp mills, on the other. Pulp mill owners now had a reason to want tree lengths, not 63" bolts, to be delivered to them. By cutting the "chip-n-saw" logs from tree lengths in the pulp mill yard and marketing those logs to saw mills, pulp mill owners could realize for themselves much of the added value of the tree. They could use the rest of the tree length for pulpwood *and* later get the sawmill waste chips for their own operations. Articles in the trade press[26] make it clear mills' demands for wood producers to move to tree length systems was a notable feature of the process of change from bobtail trucks to tree-length systems.

The fact is that we don't know the full reasons why the industrial revolution in woods work in the South began in the 1970s. Similarly we don't know how "prime contractors' were able to upgrade their systems in the 1970s and 1980s – insufficient attention has been paid by historians and social scientists to the supply of Southern woods labour and to Southern woods contracting, as has been the case for so many other dimensions of tree harvesting.

Conclusion

"Innovation" covers a wide variety of types of action. Even what is usually considered "technological innovation" can only be understood within its social context, that is, within its place in larger human endeavours and societal organization. In the case of the transformation of tree harvesting after WWIII, that context is the political economy of the wood supply system. In particular a change in an industry's production systems and social organization from pre-industrial forms of production and

25• A log used for lumber delivers a better price than if simply used for paper.

26• We are referring here to the trade journalism of Hatton-Brown Publishers, including *Logging' Times*, *Pulpwood Production and Saw Mill Logging*, and *Southern Lumberman*.

work organization, typical of the earliest stage of capitalist relations, to modern methods and industrial organization. We have used a Marxist political economy framework to understand these changes. What we have seen are two very different routes to industrialization.

In both cases the 'start' points are broadly similar. Large industrial firms – pulp and paper mill-owning corporations – had established mercantilist systems of outsourcing their input of wood, ones which relied on small, relatively poorly capitalized "middlemen" – "grand jobbers" in the case of Eastern Canada and local "wood dealers" in the Southeast. These middlemen, in their turn, farmed out actual tree harvesting to smaller, even less well capitalized firms – called contractors in eastern Canada and 'pulpwood producers' in the Southeast – who employed seasonal workers to do the direct production using the pre-capitalist tools, methods and work organization these workers brought to their employment. The routes of change diverge depending on the actions of the powerful industrial corporations – that is, the pulp and paper mill owners – with the action of these mill-owners in turn depended on the large societal conditions in which the wood supply systems operated.

To move swiftly and steadily from the labour processes, technology and organization typical of the stage of "simple co-operation" to modern "machinofacture"[27] in tree harvesting required the kinds of multiple and intense efforts by pulp and paper mills we saw in Canada. While the actual efforts of Canadian mill owners fell far short of the national research and development organization funded by the national trade association urged by McColl, their efforts were nonetheless considerable. Abandoning their tradition of leaving the conduct of woods work to contractors and the farmer-loggers who brought their skills and horses into the woods, by the 1950s mill owners in Eastern Canada had begun to directly invest in difficult, expensive and risky efforts to mechanize woods work and progressively transform its production systems. Mill owners not only took direct control of harvesting operations, they formed new inter-corporate linkages with their competitors, and between themselves and potential equipment manufacturers, to foster the invention of radically new woods machines and production systems.

Just as forest engineers in Canada attributed the accomplishments of the industrialization of the woods to the leading role of pulp and paper mill owners, so forest engineers in the Southeast attribute the long delayed industrialization of tree harvesting in the Southeast to mill owners ability to continue to distance themselves from

27• See footnote 13.

woods operations. The exceptions in the Southeast prove the rule. Early industrialization in the Southeast occurred only where mills took over harvesting and employed machinery developed elsewhere, as in the case of Union Camp and Scott Paper.

As to the explanation of these divergent behaviours by the giants of the forest industry, the answer is persistence or evaporation of the underlying social conditions that made low-productivity methods of production viable. While in both cases the disappearance of horses as means of locomotion was an impetus to change, the key variable seems to have the continued availability or unavailability of the requisite volumes of the cheap labour that underpinned traditional, low-productivity systems in tree harvesting. Conditions of terrain and the difficulty of processing the trees into wood going to the mills did indeed differ between the regions. And it certainly made the innovation of machines necessary for higher-productivity systems more difficult than that for less demanding conditions. But it was Eastern Canada – where the terrain made movement much more difficult, and trees more problematic to process[28] – that saw the great and consistent strides in industrialization. The much easier conditions of the Southeast did not of themselves spur innovation. Dramatic, early and indigenous examples of the innovation of new machines and systems made possible precisely by the more favourable terrain conditions and trees of the Southeast only occurred in the case of the Busch Combine, where International Paper used its own engineering staff to push forward to fully mechanized shortwood harvesting. But without a willingness, or more accurately the necessity, for pulp and paper mills to take on the task of harvesting even breathtaking new machines remained but a footnote to incrementalism and delay in the transformation of woodswork.

We feel a critical political economy approach to understanding changes in the local wood supply systems is the best way to seek an understanding of the transformation of woods work since WWII in other regions of the world, notably the other major centres of innovation in tree harvesting – the US Great Lakes States and Sweden. Only such an approach can grapple with the scope of social and economic change the industrialization of woods work involves. The emergence of machines to replace hand tools and horses may be the most visible of changes during the last half of the 20th century, but technological change was contingent on much larger and deeper processes of change in rural life.

28• The most problematic of the elementary activities of tree harvesting was delimbing,

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