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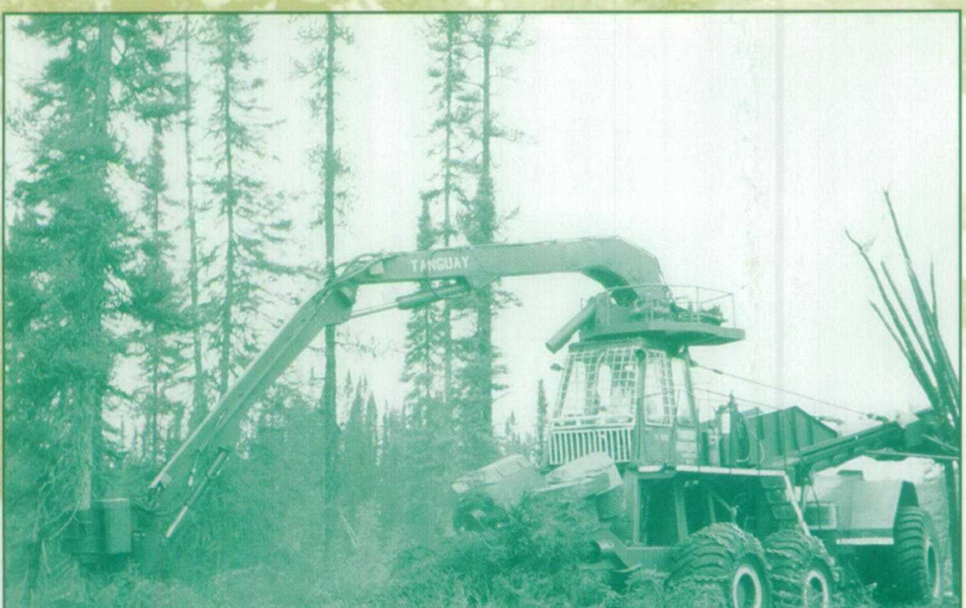
BROADAXE TO FLYING SHEAR

THE MECHANIZATION OF FOREST HARVESTING EAST OF THE ROCKIES



C. Ross Silversides
accompanying essay by Richard A. Rajala

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INFORMATION SOUGHT ABOUT THE LAKE COWICHAN COMBINED FIRE ORGANIZATION

This cooperative fire organization, the first of its kind in British Columbia, was founded in 1958 after a very serious forest fire season. Now into its 42nd year, the current members wish to honour the founding members and those who have supported it through the years.

The plan is to prepare a permanent display at the B.C. Forest Museum in Duncan. This will include a roster of those who served as Chair and Secretary, a list of members by company affiliation and a collection of old fire-fighting equipment, weather instruments, photographs and so on.

Our biggest challenge is to find old company records, minutes of the earliest meetings, attendance lists, etc. Files for several of the companies (Western Forest Industries, B.C. Forest Products and Crown Zellerbach) have been lost or destroyed. We have some data from 1974 to the present, but nothing for 1958 to 1973.

We are particularly interested in finding out why the organization was founded, who the founding companies and members were and the date and place of the first meeting.

Information can be forwarded to:

Art Walker, RPF		Telephone:	250-748-5266
6101 Wisteria Way		Fax:	250-748-0651
Duncan BC V9L 5E8		E-mail:	wfs@islandnet.com

RICHARD RAJALA WINS AWARD

Richard A. Rajala was chosen to receive the Charles A. Weyerhaeuser Award for best book on forest and conservation history for the two-year period 1997 – 1998. The winner is a previous recipient of the 1994 Blegen Award and the 1990 Hidy Award. Rajala's book, *Clearcutting the Pacific rain forest: production, science, and regulation,* (UBC Press, 1998) is original, insightful, and particularly impressive in the way it integrates logging technology, labor theory, and the intricacies of a century of regulation. His use of primary sources for British Columbia, Washington, and Oregon is thorough and illuminating, while his use of theory is intelligent without being pedantic. By comparing the experience of Canada and the United States as a single forest ecosystem, Rajala shows how powerful the forces of developing technologies were in altering Douglas-fir forests and economies. The book is unique in how it argues the reverse of common perception – Rajala argues that logging technologies shaped forest science and forestry education, not the reverse.

From *Forest History Today*, Fall 1999 issue, page 50.
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Transformation Series

Collection Transformation

6

Broadaxe to Flying Shear

The Mechanization of Forest Harvesting East of the Rockies

C. Ross Silversides, D.For., D.Sc., R.P.F., F.E.
accompanying essay by Richard A. Rajala, Ph.D.

National Museum of Science and Technology
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Abstract

In Canada, the harvest of our vast endowment of forests has long been viewed as a defining element of the country and remains an enterprise of extraordinary economic, social and environmental importance. Technologically, the finding, cutting and transportation of raw timber has given rise to its own specialized traditions, both here and abroad. Yet, while the tools of logging have generally evolved in step with refinements in metallurgy, the actual systems employed remained remarkably constant until the middle of this century. This is particularly true for the process of felling, bucking to length and skidding to a landing for transport. Since the 1940s, however, the practices, tools and techniques of logging have been dramatically altered by rapid, unprecedented mechanization and it is against this background that the contents of this volume are presented.

The volume consists of two separate components. The principal component was written by Dr. Ross Silversides and concerns the history of mechanization in forest operations in eastern Canada from the first decades of this century to the early 1980s. Based on published material, private files and interviews, the result is very much a personal view with the focus firmly set, in keeping with the author's special expertise, on a detailed account of technical innovation, change and development.

Complementing and contextualizing this detailed technical history is an extended essay by the forestry historian Dr. Richard Rajala. This overview provides a brief economic, social and political outline of the eastern Canadian forest industry from the early nineteenth century also to the early 1980s. Its primary intent is to document changes in markets and patterns of resource utilization, the organization of work, employment conditions and forest policy.

Résumé

Au Canada, la « récolte » des vastes ressources forestières a longtemps été considérée comme un élément distinctif du pays et elle demeure une entreprise dont l'importance économique, sociale et environnementale est considérable. Sur le plan technique, la découverte, la coupe et le transport des grumes ont donné lieu à une série de traditions spéciales tant ici qu'à l'étranger. Même si les outils utilisés en exploitation forestière ont généralement évolué en fonction des raffinements de la métallurgie, les systèmes eux-mêmes sont restés remarquablement stables jusqu'au milieu du xx^e^ siècle. Ceci est particulièrement vrai en ce qui concerne l'abattage, le tronçonnage et le débardage à des jetées en prévision du transport subséquent. Depuis les années 1940, toutefois, les pratiques, outils et techniques d'exploitation forestière ont subi un profond changement par suite d'une mécanisation rapide et sans précédent, et c'est dans ce contexte que cet ouvrage est présenté.

L'ouvrage comporte deux textes distincts. Le plus important, rédigé par Ross Silversides, se rapporte à la mécanisation des opérations forestières dans l'Est du Canada depuis les premières décennies de notre siècle jusqu'au début des années 1980. À l'aide de publications, de documents privés et d'entrevues, l'auteur a donné un aperçu très personnel, axé sur ses connaissances particulières, des innovations techniques, des changements et des progrès réalisés.

Cet exposé détaillé a pour complément un document de mise en contexte de Richard Rajala, historien de la foresterie. Il s'agit d'un bref aperçu économique, social et politique de l'industrie forestière dans l'Est du Canada depuis le début du xx^e^ siècle jusqu'au début des années 1980. Il vise d'abord à rendre compte de l'évolution des marchés et des caractéristiques de l'utilisation des ressources, de l'organisation du travail, des conditions d'emploi et de la politique forestière.

Foreword

The three decades immediately following World War II witnessed the most important and unprecedented changes ever to take place in the mechanization of logging in eastern Canada. Hundreds of engineers, foresters, equipment developers and industry managers struggled, often failed, and sometimes succeeded in overcoming challenges in the transition from manual to mechanized logging. One of a few, Ross Silversides played a broad and influential role in the mechanization of forest operations in general. His professional training did not prevent him from pursuing lifelong interests in systems modelling, the management of research and development in logging equipment, and the history of technology.

Beyond narrow professional concerns, Silversides' interests were wide, his reading extensive, and he enjoyed and drew upon the cooperation of a global network of friends, colleagues and competitors. More than a decade ago, he completed a draft of "Broadaxe to Flying Shear," the work of a gifted amateur historian during a period before the recent growth of interest in this field among historians and the general public.

Those of us who worked in eastern Canadian logging during this period will recall the failures and the survivors. We'll also be reminded of the powerful personality reflected in the pages that follow, still shining through the revisions and clarifications of latter-day editors. Silversides' — and almost all his contemporaries' — two major concerns were "labour shortages" and "wood costs that are too high." For both these problems, rational mechanization offered the most likely solution and it became the cornerstone of related research and development that produced much of the technology proposed by Ross Silversides.

For both older and younger generations, Richard Rajala puts Silversides' account into a usefully larger context. Few current woodlands managers will confess to more than a grudging admission that "we can live with our current contractors and wood costs." Those concerns remain central, but with the addition of critical new factors: the sustainability of forest resources and the acceptability of the environmental impact of logging can no longer be taken for granted.

The history of this history (as detailed in the Preface) is an instructive story in itself. The product of Ross Silversides' curiosity and labour will illuminate many aspects of "how we got here." At the same time, we must recognize that as the work of a key participant, this history is both graced and limited by its character as a memoir. Among the major omissions are the institutional relationships and conflicts that

Avant-propos

Les trois décennies qui ont immédiatement suivi la Seconde Guerre mondiale ont été marquées par les changements les plus importants de l'histoire de la mécanisation de l'exploitation forestière dans l'Est du Canada. Des centaines d'ingénieurs, de forestiers, de concepteurs d'équipement et de gestionnaires de l'industrie se sont acharnés, souvent en vain, parfois avec succès, à vaincre les obstacles de la transition des opérations de récolte de manuelles à mécanisées. Ross Silversides, entres autres, a joué un rôle étendu et influent dans la mécanisation des activités forestières globales. Sa formation professionnelle ne l'a pas empêché de nourrir toute sa vie un intérêt pour la modélisation des systèmes, la gestion de la recherche et du développement en équipement forestier et l'histoire de la technologie.

Dépassant le cadre de ses préoccupations professionnelles, Ross Silversides a su élargir ses intérêts, diversifier ses lectures et collaborer avec tout un réseau d'amis, de collègues et de concurrents. Il y a déjà plus d'une décennie, il a achevé l'ébauche de « From Broadaxe to Flying Shear », l'œuvre d'un historien amateur doué, produite avant le développement récent d'un intérêt pour ce domaine par les historiens et le grand public.

Ceux d'entre nous qui ont travaillé dans les forêts de l'Est du Canada au cours de cette période se souviendront des échecs et des survivants. Ils se souviendront également de la forte personnalité manifeste dans les pages qui suivent, malgré les révisions et les éclaircissements apportés par d'autres auteurs. Les deux principales préoccupations de Ross Silversides – et de la plupart de ses contemporains – étaient « la pénurie de main-d'œuvre » et « les coûts trop élevés du bois ». Pour l'une et l'autre de ces difficultés, une mécanisation rationnelle offrait la solution la plus réaliste et a constitué la pierre d'assise de la recherche et du développement associés, qui ont produit la plus grande partie de la technologie préconisée par Ross Silversides.

Tant pour les générations plus âgées que pour les plus jeunes, Richard Rajala situe l'exposé de Ross Silversides dans son contexte. Peu de gestionnaires de nos régions boisées d'aujourd'hui admettront sans hésitation que « nous pouvons nous accommoder des entrepreneurs actuels et du coût du bois ». Ces préoccupations demeurent cruciales, mais d'autres facteurs importants s'y ajoutent : le développement durable des ressources forestières et l'acceptabilité des répercussions sur l'environnement de l'exploitation des forêts, que l'on ne peut plus prendre pour acquis.

Le déroulement de cette histoire, tel que présenté en détails dans la préface, est intéressant en lui-même.

lay outside the scope of what a colleague generous as well as competitive would undertake. When sufficient time has passed and necessary records become available, a worthy opportunity will present itself to a disinterested historian of technology and the management of technological change.

For now, we are grateful to the author and to his collaborators and supporters for bringing his work into print, not merely as an appropriate honour to his memory but as a major contribution in its own right and as a solid foundation for future studies.

Herbert I. Winer, ing.f.
Former Director, Logging Research Division
Pulp and Paper Research Institute of Canada

Former Senior Researcher
Forest Engineering Research Institute of Canada

Le produit de la curiosité de Ross Silversides et de ses travaux éclairera de nombreux aspects de la situation actuelle. Nous devons cependant reconnaître que ce récit représente les mémoires d'un participant clé et en possède donc à la fois les attraits et les limites. Parmi les principales omissions, mentionnons les rapports entre établissements et les conflits, qui dépassaient le cadre de ce qu'un collègue généreux mais néanmoins concurrent pouvait aborder. Lorsque le temps nous aura donné du recul et permis d'avoir accès à des dossiers essentiels, un ou une spécialiste en histoire de la technologie et de la gestion de l'évolution technique pourra aborder ce thème d'un regard désintéressé.

Pour le moment, nous sommes reconnaissants à l'auteur et à ses collaborateurs d'avoir publié cet ouvrage qui, en plus d'être un hommage à la mémoire de Ross Silversides, représente un précieux compte rendu et une base solide sur laquelle fonder d'autres études.

Herbert I. Winer, ing. f.,
ancien directeur *de la Division des recherches forestières*,
Institut canadien de recherches sur les pâtes et papiers

et

ancien chargé de recherches principal,
Institut canadien de recherches en génie forestier

Preface

Wood has been used by humans since the earliest times in a multitude of ways. It is an essential fuel and a primary material in the construction of shelters, conveyances, tools and an infinite variety of other items. Logging, as an independent enterprise, began as the demand for wood exceeded local supplies, necessitating the organized harvest of distant sources. In Canada, the harvest of our vast endowment of forests has long been viewed as a defining element of the country and its people; the source of great wealth and rich local legends. Timber was used extensively by First Nations people and was readily identified by early European explorers as one of the richest resources of the land. Indeed, the harvest of timber became one of the most significant industries in the early history of Canada, and remains an enterprise of extraordinary economic, social and environmental importance.

Technologically, the finding, cutting and transporting of raw timber, has given rise to its own specialized traditions, both here and abroad. Yet, while the tools of logging have generally evolved in step with refinements in metallurgy, the actual systems employed remained remarkably constant until the middle of this century. This was particularly true for the process of felling, bucking to length and skidding to a landing for transportation — usually by water. Since the late 1940s, however, the practices, tools and techniques of logging have been dramatically altered by rapid, unprecedented mechanization, and it is against this background that the contents of this volume are presented.

Ross Silversides (1916–1993) was a leading figure in the mechanization of forestry both in Canada and around the world. Graduating from the Faculty of Forestry at the University of Toronto in 1939, Ross served during World War II in the Canadian Forestry Corps. After the War, Ross went to work for the Pulp and Paper Research Institute in Montreal and later the Abitibi Paper Company Ltd., where he served as both the woodlands development engineer and director of woodlands development. In 1968, Ross joined the Canadian Forestry Service in Ottawa, where he led a new program in logging development within the Forest Management Institute. Logging development projects subsequently became part of the Forest Engineering Research Institute of Canada (FERIC), established in 1975. In 1978, Ross transferred to the National Research Council where he remained until his retirement in 1981. An outstanding

Préface

Les êtres humains utilisent le bois d'innombrables façons depuis les temps les plus reculés. Le bois est un combustible essentiel et un matériau de base pour la construction d'abris, de véhicules, d'outils et une diversité d'autres articles. La coupe du bois est devenue une activité indépendante lorsque la demande a dépassé les approvisionnements régionaux, exigeant la « récolte » de sources éloignées. Au Canada, l'exploitation des vastes ressources forestières a longtemps été considérée comme un élément distinctif du pays et de sa population, une source de grande richesse et de légendes du cru. Les premières nations utilisaient le bois à plusieurs fins et les premiers explorateurs européens l'ont rapidement reconnu comme l'une des principales ressources du pays. L'utilisation du bois est d'ailleurs devenue l'une des industries marquantes des débuts de l'histoire du Canada et demeure une entreprise d'une importance économique, sociale et environnementale considérable.

Sur le plan technique, la découverte, la coupe et le transport des grumes ont donné lieu à une série de traditions spéciales tant ici qu'à l'étranger. Même si les outils utilisés en exploitation forestière ont généralement évolué en fonction des raffinements de la métallurgie, les systèmes eux-mêmes sont restés remarquablement stables jusqu'au milieu du xx^{e} siècle. Ceci est particulièrement vrai en ce qui concerne l'abattage, le tronçonnage et le débardage à des jetées en prévision du transport subséquent, normalement près d'un cours d'eau. Depuis la fin des années 1940, toutefois, les pratiques, outils et techniques d'exploitation forestière ont subi un profond changement par suite d'une mécanisation rapide et sans précédent, et c'est dans ce contexte que cet ouvrage est présenté.

Ross Silversides (1916-1993) a été un chef de file de la mécanisation des activités forestières tant au Canada qu'à l'étranger. Diplômé de la Faculté des sciences forestières de l'Université de Toronto en 1939, il a fait partie du Corps forestier canadien durant la Seconde Guerre mondiale. Après la guerre, il s'est joint à l'Institut de recherches sur les pâtes et papiers de Montréal et, plus tard, à la Compagnie de papier Abitibi limitée, où il a été ingénieur puis directeur de l'aménagement des régions boisées. En 1968, il s'est joint au Service canadien des forêts à Ottawa, où il a dirigé un nouveau programme de développement des opérations forestières au sein de l'Institut d'aménagement forestier. Ces activités ont professional, a leader in his field and the recipient of many awards and honours during his lifetime, Ross was both a witness to and a participant in the rapid and multi-faceted technological development that so greatly transformed forest harvesting during the last half of this century.

It was from this unique and informed individual perspective that Ross set out to chronicle the technical history of mechanization in Canada's eastern forests. Following discussions with Mac Hamilton, President and CEO of FERIC, and his executive assistant, Jean Bérard, an agreement was reached whereby Ross Silversides would pursue his retirement project under contract to FERIC. The terms of the contract called for a history of the development of mechanized forest operations in eastern Canada, from the 1930s to the early 1980s, based on published material, personal files and interviews. The result was and is very much a personal view, with the focus firmly set, in keeping with the author's special expertise and experience, on a detailed account of technical innovation, change and development, including various false starts and failed attempts. His intended audience was forestry practitioners and students, especially those who shared his interest in forest harvesting.

After his death in 1993, a deepening appreciation of Ross's lifetime achievement and contribution led to an intensified effort by various interested forestry professionals to develop the manuscript into a publication that could serve both as a record of technological development and of Ross's own personal experience during this era of unprecedented change. In the fall of 1995, a copy of the manuscript was sent to the National Museum of Science and Technology in Ottawa by Prof. Herbert Winer of Yale University. After a formal meeting in the winter of 1996 between curatorial staff at the Museum and Prof. Peter Murphy of the University of Alberta, a decision was made to publish the manuscript as one of the Museum's *Transformation Series* of occasional papers. Additional funding for the project was provided by a group of interested institutions within the forestry sector, represented on the publication working group by Prof. Murphy.

Recognizing that the focus of Ross's manuscript was both personal and technical rather than broadly historical, and seeking, in keeping with the intentions of the *Transformation Series*, to provide the reader with an appropriate context within which to view Ross's account, the Museum contracted Dr. Richard Rajala, a scholar of forest history teaching at the University of Victoria, to write an overview of the economic, political and social changes associated with mechanization in the forest industry in Canada, east of

par la suite relevé de l'Institut canadien de recherches en génie forestier (connu sous l'acronyme FERIC), institué en 1975. En 1978, Ross Silversides a été muté au Conseil national de recherches où il a travaillé jusqu'à sa retraite, en 1981. Professionnel hors pair, chef de file dans son domaine et récipiendaire de nombreux prix et distinctions, Ross Silversides a été à la fois un témoin et un participant de l'évolution technique rapide et complexe qui a si profondément transformé l'exploitation forestière au cours de la deuxième moitié de notre siècle.

C'est dans une perspective individuelle inusitée, nourrie par l'expérience, que Ross Silversides a décidé, à la fin de sa carrière, de raconter l'histoire de la mécanisation des activités forestières dans l'Est du Canada. À la suite de discussions avec Mac Hamilton, président-directeur général de FERIC, et Jean Bérard, directeur adjoint, une entente a été conclue selon laquelle Ross Silversides poursuivrait la réalisation de son projet de retraite dans le cadre d'un contrat avec FERIC. Ce contrat stipulait que Silversides devait faire l'historique de l'évolution des opérations forestières mécanisées dans l'Est du Canada, des années 1930 au début des années 1980, à l'aide de publications, de documents personnels et d'entrevues. Il en est résulté un récit très personnel, axé sur les connaissances et les expériences particulières de l'auteur, qui donnait un aperçu détaillé des innovations techniques, des changements et des progrès, sans oublier un certain nombre d'erreurs d'aiguillage et d'échecs. Son exposé s'adressait aux forestiers praticiens et aux étudiants, en particulier ceux qui partageaient son intérêt pour la « récolte forestière ».

Après le décès de Ross Silversides en 1993, une profonde considération pour les réalisations de cet homme remarquable a incité plusieurs forestiers professionnels à entreprendre des démarches pour faire publier le manuscrit et ainsi rendre compte aussi bien de l'évolution technique que des expériences personnelles de l'auteur au cours de cette période de changements sans précédent. À l'automne de 1995, le professeur Herbert Winer, de l'Université Yale, a remis une copie du manuscrit au Musée national des sciences et de la technologie, à Ottawa. À l'hiver de 1996, une rencontre officielle a eu lieu entre des conservateurs du Musée et le professeur Peter Murphy, de l'Université de l'Alberta, et il a été décidé de poursuivre le projet dans le cadre de la collection *Transformation*, une publication en série du Musée. Des fonds supplémentaires ont été versés par des établissements du secteur forestier représentés au sein du groupe de travail de la publication par le professeur Murphy.

the Rockies. This essay is presented as a companion piece; an account of the larger historical forces, factors and events relevant to the technological change described and discussed by Ross. The resulting combination is intended to serve as wide a readership as possible, including forestry professionals, engineers, historians of technology and anyone with a general interest in the subject of forestry and forest harvesting.

Although funded and published as part of the *Transformation Series* of the National Museum of Science and Technology, the volume in its present form would not have been possible without the efforts and generosity of a number of individuals and institutions. In particular, we would like to acknowledge the financial support provided for the original Silversides manuscript by FERIC. Their foresight in contracting Ross to write this history based on his personal recollections and network of colleagues deserves the gratitude of all concerned. We also extend thanks to FERIC for relinquishing copyright and making the manuscript available for publication. The opinions expressed by Dr. Silversides are his own and do not necessarily reflect those of FERIC.

Dr. Paul Aird, a professor in the Faculty of Forestry at the University of Toronto, and a colleague of Ross, also received support from FERIC to edit, rearrange and condense the original manuscript. The resulting version was approved by Ross and formed the basis of this publication. We extend our gratitude to Dr. Aird. Dr. H.K. Steen, President of The Forest History Society, Inc. also arranged to support an editorial review of Dr. Aird's revision that confirmed its merit and provided valuable suggestions. Further organizational and editorial changes were made to prepare the manuscript for publication in its present form.

Ross Silversides also enjoyed the support and encouragement of a number of other colleagues, prominent among whom are Edmund Mooney, Dr. Herbert Winer, Tony Rotherham and Tim White. It was this group that encouraged publication of the original manuscript and whose dedication brought it to the attention of the National Museum of Science and Technology. During the final reviews for publication, Prof. Jeremy Rickards at the University of New Brunswick arranged for Prof. Tom Bjerkelund, a contemporary of Ross Silversides, to check references and dates in the revised manuscript. Dr. Herbert Winer also kindly agreed to write the foreword. We greatly appreciate these contributions, so generously made within severe time constraints.

In addition to the resources contributed by the Museum, funding was generously provided by the

Reconnaissant que ce manuscrit revêtait un caractère plus personnel et technique que largement historique et cherchant, compte tenu des objectifs de la collection *Transformation*, à présenter aux lecteurs le contexte dans lequel l'exposé avait été rédigé, le Musée a chargé Richard Rajala, spécialiste de l'histoire forestière et professeur à l'Université de Victoria, de rédiger un compte rendu détaillé du contexte social, politique et économique de cette période et cette région, mettant l'accent sur le secteur forestier. Ce compte rendu est présenté ici sous forme de document complémentaire, offrant un tour d'horizon des forces, facteurs et événements historiques associés aux changements techniques décrits et commentés par Ross Silversides. Le produit final s'adresse à un auditoire élargi englobant des forestiers professionnels, des ingénieurs, des historiens de la technologie et tous ceux qui s'intéressent aux forêts et à leur mise en valeur.

Bien qu'il soit financé et publié dans le cadre de la collection *Transformation* du Musée national des sciences et de la technologie, cet ouvrage n'aurait pu voir le jour sans le dévouement et la générosité de plusieurs autres établissements et personnes. Nous tenons à reconnaître en particulier le soutien financier accordé à la rédaction du texte original par FERIC, dont l'idée de charger l'auteur de tracer cet historique en fonction de ses expériences personnelles et de son cercle de collègues est vivement appréciée. Nous tenons également à remercier FERIC d'en avoir cédé les droits d'auteur et remis le manuscrit au Musée national des sciences et de la technologie pour publication. Les vues exprimées par Ross Silversides sont les siennes et ne représentent pas nécessairement les opinions de FERIC.

Le professeur Paul Aird, de la Faculté des sciences forestières de l'Université de Toronto, un collègue de Ross Silversides, a également reçu le soutien de FERIC afin de remanier et de condenser le manuscrit original. La version remaniée a été approuvée par Ross Silversides et c'est elle qui a servi de base à cet ouvrage. Nous remercions le professeur Aird. Le président de The Forest History Society, Inc., H.K. Steen, a aussi fait le nécessaire pour que la révision du professeur Aird soit soumise à un comité de lecture qui en a confirmé le mérite et apporté de précieuses suggestions. Le texte a subi d'autres réorganisations et corrections avant d'être publié sous sa forme actuelle.

Ross Silversides a en outre reçu l'appui et l'encouragement de plusieurs collègues, dont Edmund Mooney, Herbert Winer, Tony Rotherham et Tim White. Ce sont eux qui ont soutenu la publication du manuscrit original et ont signalé l'existence du document au Musée national des sciences et de la

following: Sustaining Members Group of the Woodlands Section of the Canadian Pulp and Paper Association representing the manufacturers and dealers of woodlands equipment; the Canadian forest products companies; the Forest Engineering Research Institute of Canada; and the Canadian Forest Service of Natural Resources Canada.

Dr. Peter J. Murphy
Professor Emeritus
Department of Renewable Resources
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Garth Wilson
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technologie. Au cours des dernières étapes de l'édition, le professeur Jeremy Rickards, de l'Université du Nouveau-Brunswick, a demandé que le professeur Tom Bjerklund, un contemporain de Ross Silversides, vérifie les références et les dates du manuscrit révisé. Le professeur Herbert Winer a accepté de rédiger l'avant-propos. Nous tenons à exprimer à ces personnes notre profonde reconnaissance de leur généreux dévouement malgré de sérieuses contraintes de temps.

En plus des ressources du Musée, des fonds ont été généreusement accordés par les organismes suivants : le Groupe des membres auxiliaires de la Section des bois et forêts de l'Association canadienne des pâtes et papiers, représentant les fabricants et distributeurs canadiens d'équipement forestier, l'Institut canadien de recherches en génie forestier et le Service canadien des forêts de Ressources naturelles Canada.

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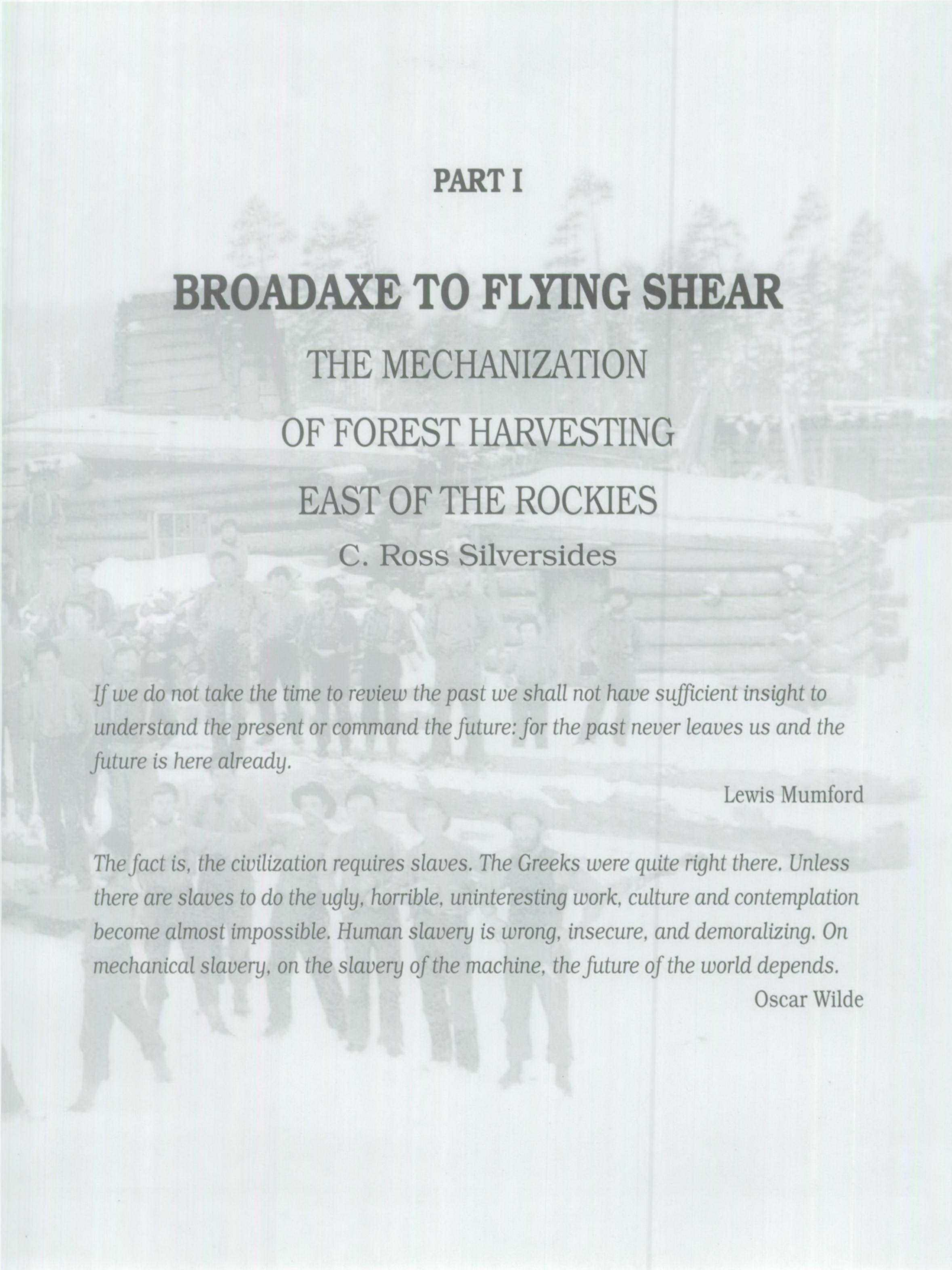


PART I

BROADAXE TO FLYING SHEAR

THE MECHANIZATION OF FOREST HARVESTING EAST OF THE ROCKIES

C. Ross Silversides

If we do not take the time to review the past we shall not have sufficient insight to understand the present or command the future: for the past never leaves us and the future is here already.

Lewis Mumford

The fact is, the civilization requires slaves. The Greeks were quite right there. Unless there are slaves to do the ugly, horrible, uninteresting work, culture and contemplation become almost impossible. Human slavery is wrong, insecure, and demoralizing. On mechanical slavery, on the slavery of the machine, the future of the world depends.

Oscar Wilde

Introduction

Build a snow machine to transport people, equipment and timber? Design a power saw light enough for a single operator to fell and buck trees? Make a tractor, with a swivel-joint in the middle, to pull or carry trees over rough terrain? Develop a machine to remove the bark from tree lengths? Create a logging system that will shear off a tree, remove the limbs and bark, buck it to any desired length, transport, and load the wood at roadside? Can we do such things?

Yes, and we have done them all. Many hundreds of inventors and innovators have combined to lighten the task of logging, which has changed it into a much safer and year-round occupation.

The inventors with the ideas and concepts, coupled with the innovators who manufactured the hardware and those who took the risks to introduce and improve on the machines, have made many worthwhile contributions. Some of their innovations have contributed significantly, not just to the logging industry, but to the agricultural and construction industries as well.

The mechanization of logging in eastern Canada* and the inventors, innovators and investors, are the substance of this book. It spans a century of development of new logging equipment and systems, ranging from manual methods to fully mechanized and partially automated operations. It is a book about ideas that evolved into new logging machines and systems, the people and the companies involved, and their successes and failures.

The history of logging mechanization in eastern Canada is the history of the development of pulpwood logging. The mechanization of sawlogging lagged far behind. The lumber industry in eastern Canada, with few exceptions, consisted of many small mills that often had little financial backing; they therefore tended to be conservative. Without a substantial margin of security there was little interest in innovation, with its attendant risk of failure.

The status of logging mechanization at the turn of this century was described in the *Canada Lumberman and Woodworker*:

> *There has been from the earliest days practically no change in regard to the logging industry in general in the eastern provinces of Canada. Practically no improvements or radical changes have been introduced until the present decade. The lumberman of today is handling his logs in the woods practically in the same manner as did his grandfather. This is a statement which in itself, to any practical business man, should attract great attention and make him realize that there is something radically wrong. It is practically the only industry of any size in regard to which such a statement would have any truth. There have, of course been slight changes in the construction of sluices or improvements in the building of roads, dams, etc., and there have been changes in that horses are used instead of oxen, and the methods in a general way have increased in efficiency, but there has been no radical change such as all other industries have shown. Yet lumbering is one of the largest industries in the country. It handles a very bulky product, a product of great weight, and which in comparison to its usefulness, weight and bulk, is exceedingly low in price. It would, therefore, seem that it is the one industry which should demand the most efficient power devices for its conduct, yet as stated above, until the past ten to fifteen years there have been absolutely no improvements, and at the present day such improvements as are in use are very local in their application (Anon. 1910a).*

During the animal power era, operations were primarily conducted in daylight, and were highly seasonal in nature. Cutting and skidding (hauling wood by dragging it from felling site to trail transfer) were carried out in the late summer and early winter, transportation from the stump area to river or lake landing occurred in late winter and early spring, and the log floating took place in summer (Figure 1.1). As a result, on certain operations in Newfoundland, the manpower requirements fluctuated from a minimum

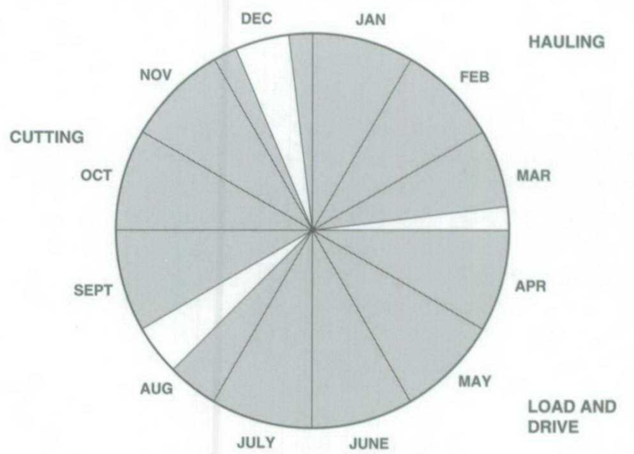


Figure 1.1 *Calendar year and pre-mechanization seasonality of operations.*

*While many of the developments discussed in this volume have roots in the Maritimes, Quebec and Ontario, the same issues applied to forest harvesting everywhere in Canada east of the Rocky Mountains.

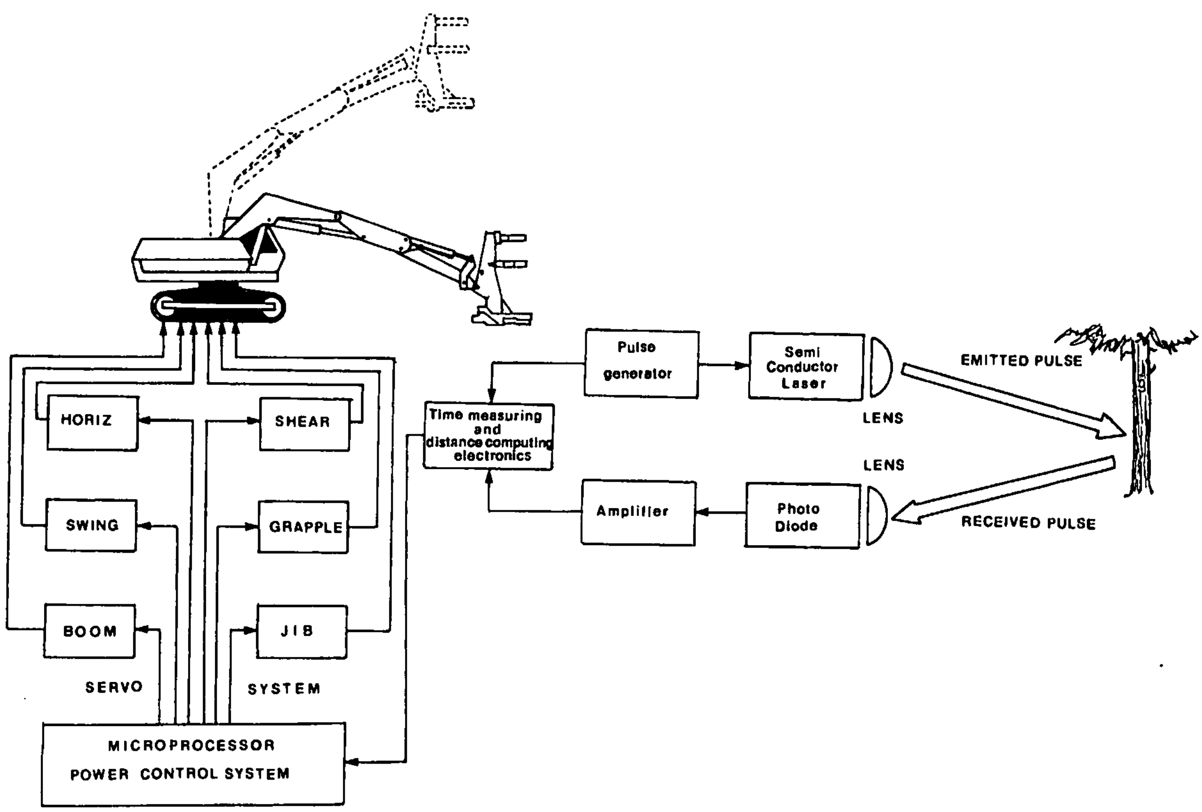


Figure 1.2 *A concept for a microprocessor-controlled tree felling and bunching machine.*

of 420 to a maximum of 2 286 in one calendar year (Curran 1971).

In this period, kerosene or naphtha gas lanterns provided what light they could, but camps tended to be dark. This changed with the advent of gasoline-powered electric generators. Beginning with relatively small plants, with a capacity of perhaps 10 kw, their use and size mushroomed until larger plants, between 50 and 75 kw, became commonplace. Initially, they were used solely to provide light, and were commonly referred to as light plants. But, as loggers learned to live with electricity, mechanical tools in garages, repair shops and cookhouses rapidly increased the demand for power.

Mechanization had a marked effect on the seasonal nature of logging. Changing from the bucksaw, horse and river drive to the power saw, skidder and truck meant that a tree standing in the forest could be wood pulp and lumber within a day; under the earlier system, the cycle required eight months to two years, depending on what delays occurred during the river drive.

Logging Mechanization and Mechanical Logging

Logging mechanization and mechanical logging are not synonymous (Fogh 1947). The application of mechanical devices to any of the operations involved in logging as a means to an end is *logging mechanization. Mechanical logging* — the ultimate goal of logging mechanization — is the harvesting and transporting of wood from stump to landing entirely by mechanical means. According to Clough et al. (1965), logging mechanization progresses through six stages as it moves from an entirely manual and animal powered operation to a totally mechanized and partially automated operation: hand tools and manually operated machines; powered tools and machines; single-cycle automatic machines; repetitive-cycle automatic machines; feedback-controlled machines; and computer-controlled machines and processes.

Stage 1: Hand Tools and Manually Operated Machines

In this stage of logging mechanization, none of the machines used are self-operating; although they may provide a mechanical advantage, they do not replace human energy or manual dexterity. The tools in this category are based on one or more of the five simple machines known to the ancient Greeks: the lever; the wheel and axle; the pulley, the inclined plane or wedge; and the screw. At this stage of mechanization, tools such as axes, bucksaws and pike poles help the logger, but human labour is the major component of their operation.

Stage 2: Powered Tools and Machines

Powered tools and machines substitute for most of an operator's muscle power in this stage of the mechanization process, but manual dexterity or information-processing are still required from the logger. The chainsaw, for example, is used at this stage.

Stage 3: Single-Cycle Automatic Machines

The next stage of mechanization is reached when single-cycle automatic machines replace all human effort except the amount required to load and control the machine. Usually, once the operator initiates an action, a machine will feed and position the tools automatically. At this stage, machines such as the portable debarker are in use.

Stage 4: Repetitive-Cycle Automatic Machines

When repetitive-cycle automatic machines replace the need for muscle power and manual dexterity, except that needed to control the operations, the fourth stage of mechanization is reached. The machines at this stage operate by internally or externally programmed instructions, such as a tree harvester programmed to crosscut a tree to specific lengths.

Stage 5: Feedback-Controlled Machines

The next stage of mechanization is reached when machines become feedback-controlled, automatic and self-correcting. Automatic tree-planting machines, able to select a point to plant a tree, determine if the spot is suitable, and either plant or select another point, are used at this stage.

Stage 6: Computer-Controlled Machines and Processes

Finally, computer-controlled machines and processes replace the logical decision-making processes of highly skilled human operators. The tree-length merchandizer, for example, senses certain physical characteristics of a tree length and automatically adjusts the saws to provide the highest economic return (Nissi 1983). A microprocessor-controlled tree-felling and bunching machine (illustrated in Figure 1.2) also requires no human input (Golob 1981).

Basic Development of Logging Mechanization

Detailed studies have been made of the mechanized logging systems used to harvest pulpwood in eastern Canada. These studies suggest that there are three basic lines of development — *shortwood processing at the felling site*, *tree-length operations*, and *fell and forward full trees and load or process at roadside* — any one of which can be profitable (Figure 1.3).

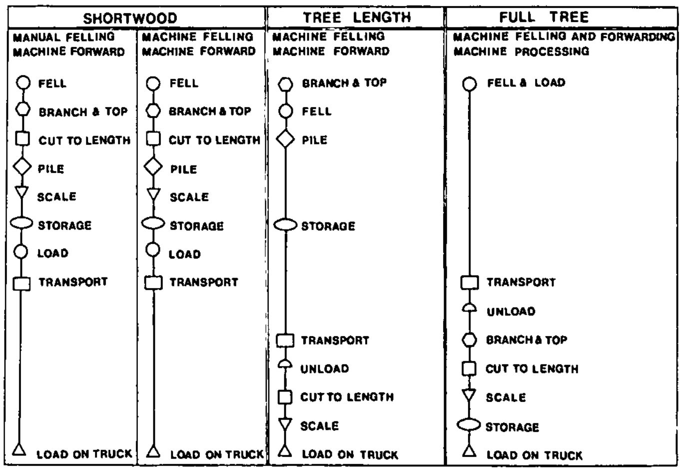


Figure 1.3 *Flow charts of various logging systems.*

In *shortwood processing at the stump*, the trees are felled, delimbed and cross-cut into short lengths manually or by machine at the stump. The pulpwood is either transported a short distance by the stump area harvester itself or piled on the ground and transported at a later date by another machine.

During *tree-length operations*, trees are felled, delimbed and piled in the forest either manually or by machine. The tree lengths are then skidded with rubber-tired skidding machines to the truck-loading terminals where they are loaded on truck trailers or stockpiled, and later cross-cut into shorter lengths.

In the *fell and forward full trees and load or process at roadside* system, trees are felled by a machine that either bunches them on the ground for future transport or forwards (carries) them intact to the delivery loading terminals. Here they are either: loaded onto truck trailers; delimbed and topped and then loaded onto truck trailers; or are fed into a machine that removes the limbs and possibly the bark, and piled in short lengths along the roadside.

Topographic Influence

Topography can have a profound effect on the development of logging systems. Bjerkelund (1971) has described three distinct systems developed in eastern Canada: the Saguenay System, the Gaspé System and the Jacques Cartier System.

The *Saguenay System* was developed in the Lake St. John region where soils are generally thin, the ground is scattered with boulders and exposed bedrock is common. This meant that geometric road patterns were seldom possible and usually expensive. Truck roads were constructed along the contour and at the base of the hill being harvested. On the longer slopes (usually those over 1 km), several such roads were required across the face of the slope as well.

Tree lengths were produced using chainsaws, and where ground roughness conditions permitted, slopes of up to 80% were worked. Fellers were often paid bonuses of up to 30% to work under such conditions. The tree lengths were skidded with a conventional articulated frame-steered skidder. The operator assembled his load and then drove his skidder straight down the slope. The tree butts and tops were often allowed to drag on the ground to help brake the unit, or, in deep snow, the skidder's dozer blade was lowered to provide an even greater braking effect.

The major problem in the Saguenay System was that the skidders had to climb steep slopes to reach the felling sites; they often required construction of trails that zigzagged up the slope, covering four times the loaded distance.

The *Gaspé System* was used on slopes of 60 to 80%, but only where soils allowed geometric road patterns. The key to this system was the road layout. The skid trails were bulldozed diagonally across the slope so that maximum grades did not exceed 30%. The distance between the skid trails was maintained at 50 m. When making up a load, the rear end of the skidder pointed down the slope, the mainline and chokers (the noose that tightens around the log) were pulled down and the load was winched up the slope to the machine. Skidding distances of 1 200 m were common.

The *Jacques Cartier System* was used when slopes were between 0 and 60%; bulldozed skid trails were not used. This resulted in minimum damage to the forest floor, which was appropriate for unstable hillsides subject to erosion. This system used a small flexible-track articulated frame-steered quadratrack machine that had a low ground pressure, a low centre-of-gravity and carried the wood in short lengths. It was common practice to drive up the slope with the power section forward; then, after loading, drive the machine down the trail with the power section on the upper portion of the slope. This eliminated the need to turn by reducing wheel base on the low side, and thus optimizing machine stability.

Terrain Conditions

The Woodlands Section of the Canadian Pulp and Paper Association (CPPA) conducted a survey of terrain conditions on the timber limits of its member companies. The area surveyed covered 209 460 km^2, of which 171 000 km^2 were productive forest. A general picture of operating conditions derived from this and others surveys is presented in Figure 1.4.

About 79% of the forest was composed of long, small, straight conifers, with a slow growth rate.

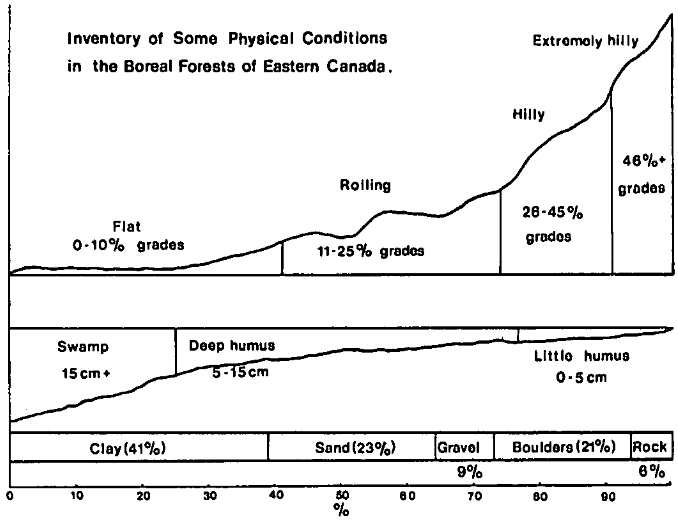


Figure 1.4 *Terrain conditions in eastern Canada.*

These were suitable for multiple stem and bulk handling. There were also mixed stands in many areas, which included poor-quality hardwoods. Much of the forest was difficult to harvest; it was on soil with low ground-bearing capacity and removed from a supply of experienced woods labour by its remote locations. However, these obstacles were at least in part compensated for by the large operating area that could easily accommodate large and efficient machines. Because many forests were located far from established communities, there was minimal interference from alternative land uses or environmental restrictions, and the land and stumpage values were low.

The distance of the forests from populated areas meant that there was no stable local labour supply. Companies had to establish housing facilities and support services, but government aid was often available for this. The isolation could be to the advantage of companies; they were able to maintain control over all operations and joint ventures (Boyd 1977).

Forests

As indicated earlier, the Acadian and Boreal Forest Regions have provided the best opportunities for tree-harvesting-systems development during the last four decades. Coastal (Pacific) Forest Region forests are unique because of their excellent tree-growing sites, however, terrain conditions make transportation operations extremely difficult. These Coastal forests are Canada's most productive, and tree-harvesting development has been carried out in parallel with systems employed in the Boreal forest. In general, the large size of trees grown in Coastal forests has resulted in development that has lagged behind the more pressing needs of the Boreal Region. As the title implies, it is not the intent of this book to deal with Coastal forests.

The principal species of the Boreal forest are: black and white spruce (*Picea mariana* (Mill.) BSP and *P. glauca* (Moench) Voss); balsam fir (*Abies balsamea* (L.) Mill.); white birch (*Betula papyrifera* Marsh.); poplars (mostly *Populus tremuloides* Michx.); jackpine (*Pinus banksiana* Lamb.); and larch (*Larix laricina* (Du Roi) K. Koch). There is a change in the composition of the forest between the eastern and western region of the Boreal forest. Balsam fir is the dominant species on the wetter and better soils of the Atlantic region, and reaches its peak in the Gaspé area, where it forms pure stands that can run as high as 350 m^3/ha. On the rockier soils with poorer drainage to the north and west, black spruce is the principal species. To the west, in Ontario, jackpine becomes more common. It often forms pure stands on sandy or gravelly flats. There is a great mix of both softwood and hardwood species throughout the Boreal forest. The principal species is about 90 m^3/ha.

The Acadian Forest Region, along with the Great Lakes-St. Lawrence Region, covers the area that lies south of the Boreal Region and east of the Coastal Region. Part of this forest is on the better soils south of the Canadian Shield. It is a much more complex forest than the Boreal. The characteristic species are: white and red pine (*Pinus strobus* (L.) and *P. resinosa* Ait.), eastern hemlock (*Tsuga canadensis* (L.) Carrière) along with spruce, balsam fir, white cedar (*Thuja occidentalis* (L.), and basswood (*Tilia americana* L.). The most important hardwoods are: yellow birch (*Betula alleghaniensis* Britt.); hard maple (*Acer saccharum* Marsh.); and basswood (*Tilia americana* L.).

The Acadian Forest Region, along with the Great Lakes-St. Lawrence Region has, in general terms, more productive forests than those of the Boreal Region. Soils are often deeper and more fertile (sometimes adequate for agriculture), growth period is longer because of the more southerly location, species are more diversified, and a qualified labour force is in closer proximity to tree-harvesting operations.

Climatic Influence

The eastern Canadian climate is largely determined by the movement of two air masses: the polar air mass brings cold dry air from the north and the tropical air mass brings warm moist air from the south. Climatic aspects can have a substantial impact on logging operations — particularly the quantities and distribution of rain and snow. The wetness of the Acadian Region at times presents difficulties for logging machines; wheeled skidders and forwarders are less efficient here than they are further west. The steep terrain and deep snow cover in the highlands of east Quebec combine to make it difficult to use machines effectively.

Early Attempts at Mechanization

Fixed and Mobile Cable Yarders

Cable yarding or skidding (transporting logs from felling site to unloading terminal using cables and yarders, or winches) has been used in the Coastal (Pacific) Forest Region since 1890. The first skidders used in the woods were powered by steam engines, and would skid logs short distances along the ground; a horse was used to return the cable to the falling and bucking crew.[1]

By 1915, skyline logging, which transported the logs through the air, was in widespread use in British Columbia. Spar trees were used and the pulley blocks hung from portable steel spars, which were also used to lift the cable off the ground. This method eliminated the need for skid roads. Cable yarding has played such a prominent role in coastal logging operations that it is often believed to have been developed there; in fact, it originated in Michigan.[2]

The Lidgerwood Cable System

The Lidgerwood Manufacturing Company of New York was selling cable equipment before 1905, primarily in the swamps of the southern United States. The equipment, mounted on pull-boats, was used to log swamp areas, where ground skidding was not possible.[3] Steel spars up to 60 feet high were used, but when machines were sold on the West Coast, spars between 80 and 100 feet were used. The Lidgerwood cable system was used in eastern Canada as early as 1905. Among the earliest users was the Cleveland-Sarnia Sawmills Company, which introduced the combination of cable logging and railroad operations to Ontario.[4] In 1910, Allis-Chalmers-Bullock Limited of Montreal acquired the manufacturing and sales rights for Lidgerwood logging machinery in Canada.[5]

The cable skidding operation of Cargill Limited of Cargill, Ontario was described in "Logging Operations in Bruce County, Ontario" in 1916 (Anon. 1916). Cargill used a Lidgerwood steam skidder with a 40-foot spar mounted on a railroad flatcar to log a mixed stand of hardwood and softwood in the Greenock Swamp. Cables were run from the spar into the bush for 20 rods (110 yards) on each side of the track. The skidded logs, from poles two inches in diameter to the largest logs, were piled 15 to 20 feet high along the track. Nothing was left in the clear-cut but brush and stumps. The logs were loaded onto railcars by a homemade steam log-loader.

The Iroquois Falls Division of Abitibi Power and Paper Company Limited experimented with cable skidding in 1926. In conjunction with its railroad operations, the Lidgerwood system was useful in the black spruce swamps of northeastern Ontario (Soderston 1928).

Cable Skidders

In 1937, several trials were conducted in Ontario using a one-drum winch on the back of an RD-6 Caterpillar tractor. The highlead effect was obtained by fastening a pulley block 16 feet above the ground on a tree; the skidding cable was returned by hand. It was estimated that, with an average skidding distance of 110 feet, 27 cords could be produced in a ten-hour shift (Koroleff 1938).

A Clyde Utility Logger, manufactured by the Clyde Iron Works Inc. of Duluth, Minnesota, was used in Quebec in 1937. This unit had a 65 hp Ford V8 engine, two drums and an A-Frame 25 feet high. It was mounted on steel runners and could pull itself short distances under its own power (Townsend 1938).

In general, however, there was little development in cable skidding during World War II. Then, in 1945, the Canadian International Paper Company introduced a cable skidder at their Clova, Quebec, operations. The unit, manufactured by the Lawrence Manufacturing Company of Vancouver, consisted of a crane with mast, boom, turntable, and a 360° swinging clearance (Putnam 1945). The top of the mast was 20 feet above the ground and the boom was 30 feet long. The winch-set had five drums and was powered by a Chrysler T120 engine. It was conservatively estimated that, with a properly trained crew of four and under good topographic and stand conditions, the machine could yard tree lengths a distance of up to 250 feet at a rate of 30 cords per day.

Cable Yarding of Bundles

A number of attempts were made after World War II to develop yarding systems that could function efficiently where the amount of damage to residual crop trees was important, ground-bearing capacity of the soil was low (i.e. where water tables were high, topography was flat, and vegetation was mosses), and forests were growing on steep slopes with very rough ground. In all cases, development attempts were based on improving existing systems rather than designing for a specific set of conditions. Attempts were made to develop systems that optimized load-size yarded per turn (e.g. bundles of pulpwood logs) but this additional function required significantly more manual input to complete the fell-to-pulpwood function. In most, if not all, cases cable yarding was discontinued in favour of forwarding and/or skidding vehicles as they became available.

Although not a part of this study, it is important to note that Coastal (Pacific) Forest Region tree-harvesting operations continue to depend on cable yarding systems of one type or another. The following conditions are essential for efficient cable yarding operations but are not usually available in Acadian or Boreal forests:

- highly productive stand types (usually greater than 5 000 cubic feet per acre at maturity) since road access, moving and set-up time, etc. are essentially constant in relation to each production unit required;
- steep, concave, uniform slopes to assume that adequate deflection can be achieved on every turn (approximately 0.8%);
- access by truck to each yarding set so that operating time per year is optimized;
- dependable rigging anchors on each set. Shallow rooted tree species (or most Acadian and Boreal forest trees) are not satisfactory and it is usual to use excavation, bulldozers, etc. instead of tree stumps, as is common in Coastal forests;
- investment must be planned to minimize equipment purchases and maximize equipment life; this has proven difficult to achieve in both Acadian and Boreal Regions (e.g. Fraser Inc. in New Brunswick, during 1986, required, per unit, a yarder (mobile), feller-buncher (track vehicle), cable anchor (choker wheel skidder plus bulldozer), stockpilier (grapple skidder), and service vehicle; all high-level investments).

Mobile Highlead Cable Systems

In the late 1970s and early '80s, a renewed interest developed in cable yarding in Newfoundland and New Brunswick. By this time, yarder technology had

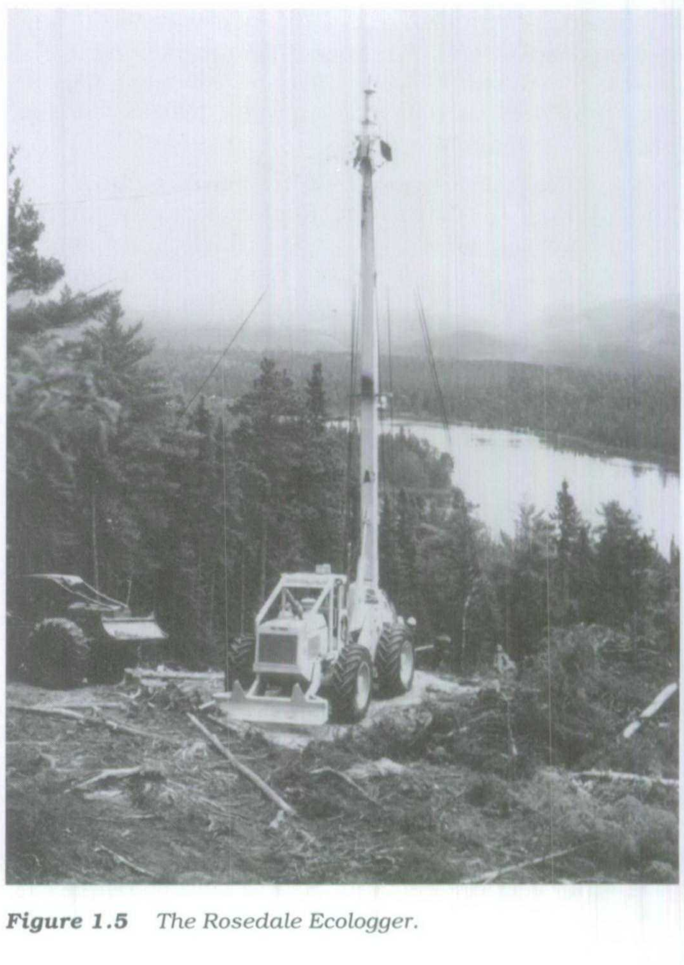


Figure 1.5 *The Rosedale Ecologger.*

Figure 1.6 *The Smith Timbermaster on Bowaters Newfoundland Company operations.*

changed considerably, and cable systems were economical in situations where no other form of tree extraction would be suitable. In this respect, cable yarding is more appropriately considered a special tool than a system with universal application.

The Department of Forestry and Agriculture, Newfoundland Forest Service, carried out extensive tests with cable systems in cooperation with Bowaters Newfoundland Limited, Price Newfoundland Limited and the former Labrador Linerboard Limited. These tests were prompted by the fact that 11% of the island's growing stock was located on slopes greater than 30%. The tests were conducted using a Norwegian radio-controlled cable crane from R. Nestertog Limited, Vinje, Norway that the Forest Management Institute of the Canadian Forestry Service had purchased (Case and Salter 1976). Results from the trials indicated that this system was nor acceptable, mainly due to parts supply and maintenance problems, but the potential productivity led to a continued search for cable equipment suitable to Newfoundland conditions.

The cable system later used in Newfoundland was basically a highlead self-contained unit mounted on the rear of a skidder. The most common unit was the Ecologger (Figure 1.5) developed by the Rosedale Machine Shop, Rosedale, B.C. (Leonard and Westoll 1976, Skory and Strong 1978). It was introduced into Newfoundland in 1975. The basic carrier was a Can Car Tree Farmer Model C7D with 130 hp GM engine. It was equipped with four independent hydraulically driven guy-line drums. The main winch set consisted of main and haulback drums, belt and gear driven through cone clutches with air-operated disc brakes. The mainline carried 1 200 feet of 5/8-inch cable. It was possible to average 17 cunits of wood per eight-hour shift with a crew of six people.

Fraser Inc. on the Restigouche River watershed in New Brunswick began to use the Ecologger in 1979. It operated with a crew of five on wood that was inaccessible with conventional methods (Allison 1980).

The United Kingdom Forestry Commission carried out extensive trials in the use of cable systems in the Scottish Highlands. They began with Norwegian equipment, and modified it to operate in their conditions. Scottish manufacturers cooperated and built the Smith Timbermaster. This unit combined simplicity with ruggedness in a machine operated by two people. In view of this, the Smith Timbermaster was introduced on Bowaters operations (Figure 1.6), where it enjoyed some success.

The Smith Timbermaster was a long range (1 300–1 400 feet), high speed skyline or highlead winch. It was mounted on a two-wheeled chassis and required an external power source, such as a farm tractor power-take off of 35–40 hp. The unit has four drums — a skyline, haul in, haulback and strawline. A crew of four was required, and productivity averaged about 18 cords per shift. The successful introduction was due to proper training of personnel prior to putting the units on a production schedule. Though the training period was relatively short, production benefited greatly as a result. Although the Timbermaster's productivity was lower than that of the Ecologger, the final cost was lower as the capital investment was only one-third that of the Ecologger. After several years of testing, it was concluded that the Smith Timbermaster was better suited to Newfoundland's small wood conditions than the Ecologger (Colbert 1979).

The intense interest in cable systems in eastern Canada during the 1950s and 60s waned during the 1970s and 80s. The cable systems were almost always reserved for specific applications, such as steep slopes, swamps, or dense stands to be clearcut. It ultimately became a rule of thumb not to use cable systems if wheels or tracks could be used.

The Forestry Industry During the Depression

Between World War I and the Depression, the pulp and paper industry in eastern Canada grew rapidly. As mechanization was introduced in the sawmills in the 1920s, the capacity to manufacture newsprint grew from 2.10 to 4.25 million tons annually (Ellis 1960). Forest operations had to expand to meet this demand.[6] Although in the early 1900s lumbermen, principally from Michigan, had introduced some machines in the woods,[7] Ontario operations were still primitive and labour-intensive (Figure 1.7).

For the most part, however, when a logging job became too great for the existing manpower, more workers were added. During the Depression, there were hundreds of thousands of unemployed men and women, and thus little incentive to mechanize logging operations.[8] The use of animal power remained dominant, a traditional solution greatly encouraged by the abundance of horse power — during the 1920s, the horse population in Canada peaked (Figure 1.8).

However, as sawmills demanded more wood, various kinds of tractors and specialized steam and later internal-combustion-powered log haulers began to replace horses and oxen for loading and pulling sleighs. Horses work at a speed of three to four miles per hour; beyond this, they cannot work for any length of time. When they were skidding or hauling, they worked about 50% of the time, and then only in daylight hours (Figure 1.9). Mechanical power, however, could be applied to combine functions and carry out a wide variety of operations for which animals were physically incapable. In contrast to animal

Figure 1.7 *Pit sawing lumber for construction of logging camp (Quebec).*

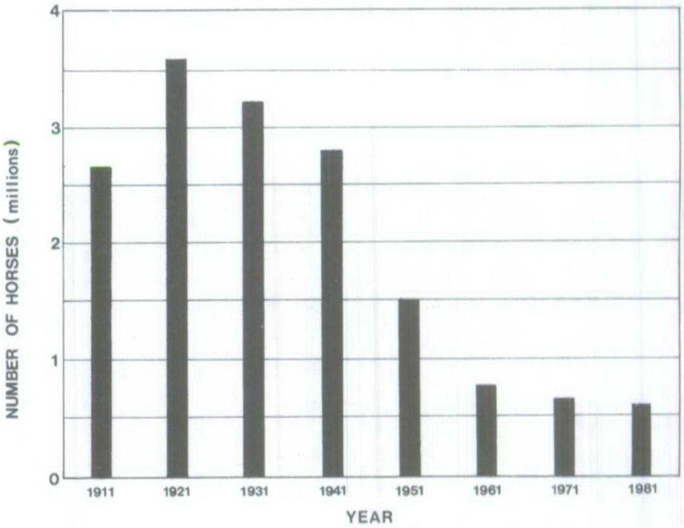


Figure 1.8 *Horse population in Canada, 1911–1981.*

Figure 1.9 *The average load a horse could skid, and continue working for any length of time, was about 14 cubic feet of logs or about 800 pounds. This was increased by a factor of 10 or more when hauling sleighloads in wintertime.*

power, the speed of machines could be varied widely through torque converters, as dictated by ground conditions. Working within designed capabilities, they had great endurance and could be double- or triple-shifted if required. Their load capacity could be varied by changing the engine power and design.

In the late 1920s, although the economy was on an upswing throughout eastern Canada, there was still a considerable amount of unemployment. Then the Depression struck and from the high point of 1929 to the low point in 1933, there was a continuous economic decline. With such an oversupply of labour, the employer clearly had the advantage.[9] Prices paid for pulpwood also declined.[10] Table 1.1 shows the price paid to farmers and settlers for wood delivered to an eastern Canadian newsprint mill between 1929 and 1935 (Guthrie 1941).

During the Depression, almost every major pulp and paper company was in receivership. The few that

Table 1.1 Purchase Price for Farmers' and Settlers' Wood Delivered to an Eastern Canadian Newsprint Mill

Year	$/cord f.o.b. Mill
1929	6.15
1930	6.05
1931	6.10
1932	5.25
1933	4.15
1934	4.25
1935	4.75

Letter 1.1

Sault Ste Marie, Ontario May 19th, 1933

G.T. Clarkson, Receiver and Manager
Mr. W.H. McClelland, Mile 138 A.C.R. Ontario.

Dear Sir:

We notice from the weekly Report on May 13th you had on Pickeral Drive 60 men working 12 hours per day. Is this correct as to the hours worked? When we last discussed this you were to work long days and certainly 12 hours per day cannot be considered a "long day" on the drive, whereas on the Spanish and Vermillion they are working as high as 15 hours per day. Is it possible that you are working only 12 hours while the water is fairly good and losing results, or is the report wrong? I trust the latter is the case, otherwise what excuse can we offer? I will be glad to receive your reply.

I also want from you a report on your trip to Mountain Lake as we have heard nothing to date regarding this. Please let me hear from you.

I want from you each a letter stating the progress you are making and if you are satisfied with that progress, that is, that the drive will be successful and all the wood delivered at a reasonable rate. To date we have not had a letter direct from you and we must have this as we have to give certain explanations and cannot do so without receiving from you reports to enable us to answer.

We sent the Alligator Engineer (Shey) out this morning to Mile 138.

I am quite anxious to see the final cost of meals on the drive as it seems to me from the supplies going in that this is going to be an unreasonable cost per meal. You will remember my speaking to you concerning this point. I also wish you would advise me if in the near future you will be able to release either Parks or Breckenridge for a few days to make a trip to Michipicoten for me to obtain information required.

Yours truly, ABITIBI POWER & PAPER COMPANY, LIMITED

c.c. W.R. McKIBBON/M.

Letter 1.2

Anjigemi, May 23rd, 1933

Mr. W.R. McKibbon:

Regarding your letter of May 19th, I am very sorry I did not report on Mountain Lake drive as soon as I got back. I found everything in good shape to take that wood to the lake in two floods with 20 men. That would mean two days work for 20 men each day and one day to rear the creek out. They could do that with less water, to bring down lakes and run through dams would not take more than eight men.

Regarding the hours we work per day we work from five o'clock in the morning to seven and eight at night every day and we have not wasted any water. When Mr. Foster made out the first report he asked me what hours per day he should report. I asked him if we should give exact hours per day and he told me that he put 12 hours on report last summer so I told him that would be good enough for this spring. I was thinking it would look better on paper than 15 hours per day which we really work.

I will put the exact hours on this week's report.

I have done my very best to get this wood out quick and cheap and all the foremen and their men have worked with me. The wood has been in the creek for two or three springs in high water which makes it hard to rear. Brakinridge is helping Pete today and tomorrow they are moving to the Bridge near Pickerl lake. Tomorrow I am putting Break to run through Mile and Half Mile lakes and to fill the booms for McAuley. We had a good run into Mile Lake yesterday. Yesterday Parkes gang was on the river at 4 in the morning and quit at eight last night. I was with them all day. I left Pickerl Dam when they closed it last night at 8 o'clock and went back to the rear gang. I had to stay at Pickerl Dam til they shut down to examine the flooring. The wood pounds it very hard.

In my opinion we are safe for water and have a clean rear so far.

Now, Mr. McKibbon if there is anything required of me that I am not able to do I am only too willing to resign in favor of some one that can fill the bill. We have the alligator in the water here tonite and are ready to chain boom tomorrow. We will have wood across Anjigami this week with a little good luck.

I never had very much to do with reports so do not know much about it.

As for the cost of the meals, the clerks should be able to tell me the cost at the end of every week and then I could come at the cooks, but as it is I have no way of telling if it is high.

I think if I have to keep tabs on everything that was to go on the report sheets I will be the busiest man in Canada. However I will try to get it as near right this week as possible. Mr. McKibbon, there was no jam of drift wood in Manituic River that Hans had to move. I heard his boy telling B. Avery that they had a gang removing drift wood at Whitefish dam. Now there was none there to move for I was there as soon as the ice was out.

Yours truly,

W.H. McClelland

were not were wholly owned subsidiaries of substantial American newspaper interests, such as the *New York Times* and the *Chicago Tribune*. Moreover, there were no new mills built in the 1930s except for the previously postponed newsprint mill at Baie Comeau. Because most of the companies were being run by receivers and were in desperate financial straits, pressure was on woodlands managers to keep costs down and on job foremen to produce. An exchange of correspondence in 1933 (Letters 1.1 and 1.2) illustrates this.[11]

The Mechanization of Log Hauling

The introduction of steam log haulers had a significant impact on the transporting of logs in the woods. The following passage explains the advantages of the steam log haulers.

> *Logging is primarily a problem in transportation — from the stump to the skidway, the skidway to the stream or railroad and thence to the mill — and though there are other expenses, the greatest saving that can be made in the cost of logging is in the various processes of transportation. The steam log hauler attempts to cheapen just one of these processes, viz: the transportation of the logs from the skidways to either the railroad or the river. It is not a panacea for all the troubles of the logging business, but simply a substitution of a machine and a few men for a larger number of men and a number of horses, on the sleigh haul... Where a logging railroad can be cheaply constructed and has a heavy enough stand available to justify the initial cost, we believe it makes cheaper logging than the steam log hauler, particularly as it can be used the year round. On the other hand, there are some conditions, such as a very short haul, a rough country or lakes when a sleigh haul with horses is cheaper than either. The conditions favouring the steam hauler, which is substantially a railroad proposition on ice instead of steel, are a moderately long hill and an uphill grade, as against horses, and too little timber and too great expense of grading, taking in and laying steel, as against a logging railroad. (Anon. 1911a)*

The first tractor log hauler developed in North America was invented by Alvin Lombard of Waterville, Maine. He patented his endless track in Canada in 1901, and successfully defended it against infringements until it expired (Howard 1962). Alexander Dunbar and Sons Company Limited of Woodstock, N.B., began to manufacture logging engines in competition with Lombard in 1906. Several of their units appeared on logging operations in the Maritimes and Quebec in the first decade of the century (Anon. 1910b).

The first crawler-tractor sleigh haul, the Holt tractor, appeared in eastern Canada in 1922. As the mechanical reliability of tractors improved, their use spread rapidly in the woods, and a number of manufacturers entered the field.[12]

The Linn Tractor followed the Lombard and Dunbar developments of 1906. It was similar in concept to the steam-powered hauler but was powered by a gasoline engine, and had a steering sled in front and crawler tracks at the rear. It proved highly successful in operation.[13] It was followed by the Best tractor, and later by a revised version of the Holt, both of which were full crawler tractors without steering sleds or wheels in front.[14]

By 1930, crawler tractors were widely accepted in the woods, initially for hauling sleighs and later as bulldozers on road construction. Bulldozers were often used in winter time to pack down snow roads preparatory to the sleigh haul. They reduced the cost of road construction and soon led to the widespread development of road networks and a reduction in branch-stream river driving. Bulldozers were originally powered with gasoline engines; diesel engines were introduced in 1931 (Anon. 1954b). This technology made land transportation possible in the open or non-frozen season, and in turn allowed mills to reduce wood inventories, levelling out the peaks and valleys in the demand for woods labour, and eliminating the loss due to sinkage that occurred during water transport.

An early attempt to use crawler tractors in ground skidding involved the use of skidding pans (Delahey 1937). These did not prove successful because the pan was not self-loading; manually loading the pan added labour costs and made this method uneconomic (Carson 1936).

Wheeled farm tractors were introduced into the woods on a short sleigh haul in 1939. It was a partial success, but the method did not spread (Townsend 1940). Although they were used to a small extent on private woodlots, a number of attempts to introduce them into limit-operations of pulpwood and sawlog failed. Tractors designed for relatively light open-field operations did not survive under the more severe environment of logging operations. In the late '40s, farm tractors appeared briefly in the woods in Quebec, because of an acute shortage of horses during the hauling season (Montgomery 1950). Besides the lack of structural strength in these farm tractors, studies in New Jersey (Rettig and Becker 1958) showed basic morphological shortcomings.[15] Moreover, farm tractors of this period also lacked the manoeuverability that was essential for successful mobility in the forest environment.

A large West Coast logging arch manufactured by Willamette Hyster Company of Portland, Oregon, mounted on crawler tracks, was tried by Singer Manufacturing Company (Seheult 1939). While it did not prove suitable for pulpwood-sized timber, it was useful on a hardwood sawlog operation (Townsend 1940). This technology was used for about two years but was unable to compete in an environment of low wages and an abundant supply of horses.

The first significant move away from the conventional cut-and-pile operations occurred in 1939. It arose from a request by the pulp and paper industry that the logging equipment manufacturers develop equipment more suited to their needs (Carson and McNeil 1940). The Willamette Hyster Company and the Caterpillar Tractor Company of Peoria, Illinois, and their distributors developed the logging sulky. The first unit appeared in 1938. The general design and principle of application were similar to those of the logging arch that Hyster had developed earlier, but with only limited success. The difference lay in the fact that the sulky was equipped with large pneumatic-tired wheels instead of crawler tracks. These logging sulkies were used for long-distance skidding, up to 2.5 km. Tree lengths were assembled first by horse in bunches of sulky load size, and then skidded to the river bank or lakeshore landing.

Other technologies complemented this development. One operator employed a Dolmar bow power-saw

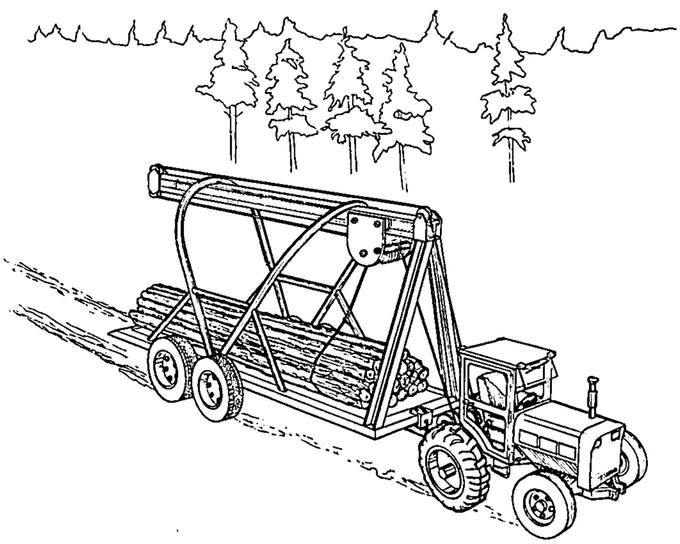


Figure 1.10 *The operating technique of Godwin's Goblin was to back the unit up to the load. Pulling on the secondary or unloading line moved the travelling block to the end of the monorail and held it there. The mainline was pulled out by hand and attached to the load-binding choker. A pull on the mainline by the tractor-winch caused the platform and its superstructure to tilt into the loading position. The travelling block then lifted the load onto the platform and, as the mainline was winched in, the load moved forward and the platform tilted to the horizontal position, where it was held by the weight of the load. To unload the unit, the mainline was unhooked and the unloading line attached. A pull on the unloading line caused the load to move backwards, about 6 feet, and the load slid off. When the tractor moved ahead the load slipped off the platform in the choked bundle as loaded.*

(weight 75 pounds), instead of a bucksaw, to buck tree lengths into bolts at the landing — with considerable success. This saw enabled skidding by the tractor and sulky to operate day and night. It was possible to buck the accumulated wood by noon and to take care of the day's skidding production in the afternoon. Night-hauling production was equal to that in the daytime, and the two shifts permitted better use of the skidding equipment. Still, it was often difficult to make a success of these mechanical operations. Wage rates remained low, horses were cheap and plentiful, and tire failures were common. The overall results were not encouraging.

One influential, albeit unsuccessful, logging sulky of note was developed in 1945 by Gordon Godwin, Quebec North Shore Paper Company, and came to be known as Godwin's Goblin (Figure 1.10) (Godwin 1945). The unit was designed to transport logs or tree lengths, but instead of dragging the load it was designed to pick it up and carry it. The unit consisted of an 18-foot tilting platform that carried two arches supporting a monorail. A double-sheave travelling block was free to travel the length of the monorail. The unit was mounted on a tandem bogie, with the pair of wheels on each side mounted on a walking beam.[16]

Tests under field conditions indicated that this unit could increase productivity by at least one third, but the development of this unit did not go past the fabrication and trial of the original prototype. Gordon Godwin, years later, admitted that the concept had merit but the prototype was too cumbersome. He claimed, tongue in cheek, that it was a great rig to load, transport and unload river-drive boats, but lost its potential market as river driving passed into history. It did, however, contain a number of novel components that appeared in later machines: the tandem bogie on a walking beam; the monorail and travelling block; and the tilting platform or deck to facilitate loading and unloading.

Finally, there was a brief postwar revival in the use of crawler tractors and rubber-tired arches on the 1946 operations of Marathon Paper Mills Limited, to skid tree lengths into cold decks preparatory to mechanical slashing (Skory 1975a). There was also an attempt to introduce an integral arch on crawler tractors for skidding tree lengths, but ultimately it failed (McCraw 1950). After this, the logging arch disappeared from the woods of eastern Canada until the introduction of rubber-tired skidders equipped with winch and integral arch. The apparent lack of success in forest-operations development was at least in part due to the lack of experience with support services for mechanization in the hostile environment encountered in the Boreal Forest Region.

The Nineteen Forties

The Need for Mechanization in the Logging Industry

During the first half of the 1940s when Canada was at war, there was great pressure to produce lumber and pulp and paper. At the same time, financial constraints were imposed on the logging industry by the Maritime Prices and Trades Board. The manpower shortage was so severe that it was only by using prisoners of war, both German and Italian, that sufficient wood was produced to keep the mills running.

This adequate supply of prisoner-of-war labour, along with imposed wage and price controls, reduced or eliminated most efforts to mechanize logging, until it became evident that existing harvesting methods were becoming less productive and more expensive. In fact, during the 1940s, productivity declined steadily, as can be seen in Table 1.2 (Loughlan 1980). In 1945, there was a new surge of interest in the mechanization of woods operations. Because the flood of labour anticipated when Canadian troops returned home did not materialize, companies found themselves searching for woods workers. It was then that the Woodlands Section of CPPA was reorganized, and a greater emphasis was placed on logging mechanization.

Table 1.2 Average cutting production in cords per man-day in Northern Ontario

Operating Year	Production in cords per man-day
1939–40	2.23
1940–41	2.11
1941–42	2.03
1942–43	1.75
1943–47	*
1947–48	1.65

* The 1943–47 production used prisoners of war, so figures are not available.

First Attempts at Mechanized Logging on a Large Scale

The first serious attempt to introduce mechanized logging on a large scale was made in 1945–48 by the Anglo-Canadian Paper Mills Limited of Forestville, Quebec. Felling was carried out manually using power saws. Rectangular cutting blocks were laid out and trees were felled in a herringbone pattern with their tops toward the road. Once they were delimbed and topped, cable-yarding equipment skidded or yarded the tree lengths into large piles or decks. Three yarding units were tried: one with double-drum winches mounted on tractors operated with spar trees; a second specially built experimental mobile unit with a self-contained boom; and a third which had logging winches mounted on heavy sleds carrying A-frames. Over time, the latter two units proved most favorable (O'Halloran 1949).

On an average strip, approximately seven cords of wood were collected. A large track-type tractor (e.g. Allis-Chalmers model HD-19), towing a large wheeled sulky with a capacity of seven cords, was used to transport the load of tree lengths, which had been pre-choked. The average distance skidded was one and one-half miles (2.5 km). Powerful skidding units were required because trees were skidded top first creating ground friction and because the pitches in the area were steep.

Once the trees were skidded to their destination, three types of mobile slashers were positioned on river banks to reduce the tree lengths to four-foot bolts. They had varying capacities, which permitted flexibility in job layout and scheduling. In a ten-hour shift, a slasher with two swing-saws had a production capacity of 90 cords; a three-swing-saw slasher had a capacity of 220 cords; and a large slasher with three slide saws had a capacity of 350 cords. The multiple swing-saws were synchronized to prevent them from binding and jamming the pulpwood produced. The slide saws, capable of cutting a full conveyor load of tree lengths at one time, were also synchronized to prevent binding. From the swing-saw slashers, the bolts were either conveyed to a surge-storage pile or loaded loose into trucks with box-type bodies. From the slide-saw slashers, the bolts were either conveyed to a dump or on the river bank or into the channel of a stream.

In retrospect, this effort was clearly an attempt to replace horses and manpower with machines without changing the basic system. It did not involve the innovation of dramatically new machines or systems. Many millions of dollars were spent before operations reverted to the conventional jobber cut-and-pile four-foot pulpwood with horse forwarding. This failure to mechanize acted as a damper to mechanical development for many years.

Obstacles to Mechanization

The grand jobber system, in which companies give contracts to individuals for the production of large volumes of wood, was a dominant factor in the desire to maintain the status quo. In this system, the wood was usually produced by many subcontractors, or jobbers, who provided the labour, housing and equipment to carry out the work.

The companies generally retained tight control of the operations, from the top down, and this hierarchical structure provided little possibility or incentive for change. Subcontractors, with little or no financial resources, had no margin for risk and therefore little or no interest in owning and operating new and relatively expensive logging machinery. Many of these jobbers showed great ingenuity in organizing and laying out their tasks, in a continual effort to beat the contract price, but for the most part, logging was conducted within the framework of the job as they had always done it.

One of the forces that brought about change was the move away from the grand jobber and contractor system toward company-operated camps. Another force occurred between the two world wars, when university-trained foresters and engineers on logging operations gradually began to replace old-time practical foremen.

There were always strong arguments and heated discussions on the subject of contractor versus company camps. On the one hand, the drive for profits by contractors who were independent entrepreneurs was expected to result in the most efficient operations at the lowest cost. On the other hand, there was no contractor to pay in company-operated camps, which reduced the cost of producing wood. Many companies used both systems, sometimes as the result of indecision, but often to compare the two approaches.

Incentives to Mechanize

As logging machinery became more expensive, contractors often became financially dependent on the company's credit or backing to finance the purchase of their equipment. In turn, companies with large financial commitments to a contractor became more involved in the management of the operation. The fact that these rapid increases in costs were not accompanied by a comparative increase in production highlighted the need for more efficient ways of logging.

The Woodlands Section of the CPPA, formed in 1917, and later, the Woodlands Research Division of the Pulp and Paper Research Institute of Canada and its successor, the Forest Engineering Research Institute of Canada, were the primary proponents of mechanizing logging in eastern Canada.[17] In 1922, a special committee of the Woodlands Section, formed to study logging improvements, reported that the situation "was not ripe for the establishment of either a central logging experiment station or a program of experiments to be conducted on individual company operations" (Anon. 1974a). In the same year, a recommendation was put forward by the Woodlands Section to the CPPA that a permanent secretary be engaged to visit members' operations, to write up interesting developments, to stimulate experimentation and to distribute the information to members of the association. It was not until 1927 that this recommendation was acted upon, and Alexander M. Koroleff was employed to undertake the work.

In 1929, Professor Ralph C. Bryant of Yale University spoke to the Canadian Pulp and Paper Association about development in woods operations (Bryant 1929).[18] Because the complex logging problems demanded more skill than traditional loggers possessed, control of logging was gradually being transferred from the old-style practitioner to the trained specialist. Bryant described the great advances in the standardization of logging and the trend towards mechanizing the industry, which he suggested was chiefly due to the cooperative effort and studies by organizations, such as the Woodlands Section, that provided the incentive for companies to engage independently in research and development. The spirit of cooperation engendered by the Woodlands Section was considered to be of great value to the logging industry, and the advances in logging techniques were ascribed to this attitude of cooperation.

Alex Koroleff carried out his mandate during the 1930s and 1940s in an exemplary manner. The quantity and quality of the papers and books issued from his office summarized current practices, and recommended preferred methods and possible improvements.

Koroleff wrote a paper entitled "Economic possibilities of mechanized logging" (1938) in which he compared logging costs between eastern Canada and the Pacific Coast. Table 1.3 shows, though some may claim it compares apples and oranges, the extent to which logging operations in the East were dependent upon muscle power. Koroleff could see that the rapid increase in the cost of woods labour was not followed by a compensatory increase of productivity, and argued that industry needed more mechanization. Low market prices for products and increasing competition made further economy in the industry a necessity.

Where logging operations were economic, the success was due to the introduction of machinery and equipment, not to any improvement in the use of men or horses.

There were, however, obstacles to the mechanization of logging operations. There was a lack of systematic,

Table 1.3 Approximate Logging Costs in Eastern Canada and the Pacific Coast

Item	Cost of Logging (%) Eastern Canada	Pacific Coast
Supervision	21	11
Manual labour	62	53
Horses	12	—
Machinery	5	36
Total	100	100

persistent and adequately financed effort by qualified men to mechanize logging. There was still a widespread tendency to adhere to established logging practices, often supported by the prevalent jobber system, and the fact that the woods departments frequently lacked the time and funds for the extra effort that changes in logging practices would require. General executives were often reluctant to introduce logging machinery without definite assurances that these would lead to immediate economy. Most of the operators preferred not to risk their reputations on innovations; hence the attitude: "Let someone else do the experimenting first."

The Process of Mechanization

The Woodlands Section Council established a logging mechanization committee in 1944, in an effort to do something to unify the pulp and paper industry's attempts to mechanize logging. As noted, during the war years, progress in mechanization had come to a standstill; it was practically impossible to obtain machines of any sort, let alone those requiring specialized design features. Unfortunately, the unit pieces of pulpwood were too large and heterogeneous to be handled by customary bulk-handling equipment, and too small to be moved like the large logs.

The committee's objective was to improve logging techniques in eastern pulpwood forests by increasing the level of mechanization, thus increasing labour efficiency (Godwin 1944a). They focused on three objectives: providing a mechanical means to handle the tree from stump to final transport; developing mechanical methods and machines that could be applied to the variety of terrain and timber types found in the forests of eastern Canada; and establishing manufacturing plants in eastern Canada that would specialize in producing logging machinery designed to operate in eastern forest conditions.

The Logging Mechanization Project

The CPPA established a cooperative project on woodlands mechanization in 1945 (Fowler 1945). One year later, A.A. St. Aubin was appointed to lead the Logging Mechanization Project, which became a full-fledged section, parallel to the Woodlands Section, shortly thereafter. At the annual meeting of the Woodlands Section in 1947, St. Aubin made the first pronouncement of his program: he described proposed improvements for pulpwood-hauling trucks, ship transport and loading, and the development of a new lightweight (12.5 kg; 28 lbs) power saw called the Hornet. That same year, St. Aubin retired and the Logging Mechanization Project was taken over by Bruce McColl, a brilliant young mechanical engineer.

McColl's mandate was two-fold: to be a central reporting agent for the woodlands side of the forest industry in matters relating to mechanization; and to act as a "spark" in the woodlands mechanization process. McColl had left the aeronautical industry to come to the Woodlands Section. He understood the need for a united systems approach to machine development, an approach that was foreign to the people with whom he was dealing.

To present the process of mechanizing logging, McColl used a step-by-step approach, describing concept, prototype, pre-production and production models in the context of both time and money. He explained that the production stages, the form in which the output was produced and the machines that processed it were all interdependent. This meant that the harvesting method selected affected subsequent materials-handling and storage. Because there was more than one way to perform the various tasks at different stages in each of the harvesting systems, McColl stressed the need to meet established criteria, such as minimum cost, maximum man-day output and maximum profit.

The magnitude of his proposals caused the potential users to back off. The logging industry continued to operate as it had, trying different methods and machines as they appeared on the market with no clear plan or program to minimize wood costs.

While the advances in mechanization were being spearheaded by McColl and W.A.E. Pepler, manager of the Woodlands Section, the Woodlands Research Division of the Pulp and Paper Research Institute of Canada, under Alex Koroleff, was directing its research efforts towards the infrastructure of woods operations: roads, river drives, dams and holding grounds, camp construction and the feeding of men. This work complemented that of the Woodlands Section, Canadian Pulp and Paper Association.

In its pre-mechanized period, the logging industry was very open. There appeared to be very little proprietary information that was kept from public disclosure until fully protected by patents. Both labourers and supervisors were highly mobile, and knowledge moved with them, so information on new developments or machines rapidly became common knowledge. This fact, plus the purposeful exchange of information, permitted developments to move ahead.

The Nineteen Fifties

Mechanization Begins

The forest industries in Canada were staple industries in which the raw material was extracted, prepared mainly for the export market and sold in a form short of its final manufactured potential. This applied to the lumber industry and to the fibre industry, but both were subject to fluctuations in demand, depending upon cycles in economic activity. These fluctuations affected the mechanization of logging. Developments introduced on the downside of one of these cycles sometimes failed, not because they lacked merit; they were merely victims of the North American business cycle.

During the 1950s, the power saw took hold and was quickly improved. It was accepted so rapidly that within approximately five years, the bowsaw was completely displaced. As well, a range of machines were designed to move piles of pulpwood as a package, from the stump area to roadside. The decade saw the rise and passing of slooping, of bundle-forwarding with wheeled sulkies, and of forwarding by tracked vehicles. Cable yarding of bundled wood was introduced but required forest conditions that were unusually favourable.

The Rate of Mechanization

In 1951, 95% of the pulpwood produced in eastern Canada was cut manually into short lengths and piled along strip roads before being hauled away. In 1971, 68% of the pulpwood produced was skidded in tree lengths to roadside or landing. In the same period, production increased from 200 cunits to 2 000 cunits (a unit of 100 cubic feet of solid wood, not including bark or air space) per man-year.

Even at the start of the decade, the rapid pace of change could be seen. An indication of the rate that logging operations were being mechanized was provided by Godwin:

> *In 1950 the industry owned 5 500 machines of all types and during the production period 1950–51 contracted for the use of an additional 2 800 machines. In 1945 the industry used 2 900 machines. Machine usage increased almost 300 percent in five years. Five years ago (1945) the estimated value of machines used in pulpwood logging was $7 000 000. Today it is $37 000 000.*
>
> *Five years ago [1947] the industry owned 477 crawler tractors. We now own 747, with more than one-third of them 80 h.p. plus, whereas in 1945 we had only 20 crawlers of more than 80 h.p. During the logging season 1950–51, we and our contractors used 1 000 crawler tractors [minimum] four times the number used five years previously and in addition used 340 wheeled skidders.*
>
> *There are 3 300 trucks, from pick-ups to the biggest jobs built, engaged in various phases of pulpwood logging, more than ten times the number used five years ago. Eighty percent of them are in the one and one-half to five-ton group, but each year sees a growing number of tractor-trailer units in the heavy duty class.*
>
> *The snowmobile as a prime mover has become important during the last three years. In 1945 there were only 20 snowmobiles reported in use, none of them for hauling wood. Last winter the industry and its contractors operated 340 snowmobiles, at least two-thirds of them being used to haul single sleighs with two to three cord loads an average distance of about two miles (Godwin 1952).*

Late in the 1950s, the Beloit harvester was conceived; Canadian International Paper designed its first full-tree processor which, in the 1960s became the basis of Logging Research Associates' Arbomatik system; and Quebec North Shore Paper Company and Ontario Paper Company experimented with different full-tree harvesting systems. So many systems and machines were being developed that Huntley Duff of Canadian International Paper Company remarked: "this is the beginning of the Industry's education in the perversity of inanimate objects."

Toward the end of the decade, attempts were made to develop a stump-area harvester to replace the manual cut-and-pile shortwood system. The loggers who supported this development believed that it was most efficient to fell and process the trees in the stump area, where the limbs and tops could be left. However most loggers considered the final objective of mechanized logging to be "a continuous economic method capable of utilizing all parts of all merchantable trees under all conditions of soil, terrain and weather, with the minimum destruction of unmerchantable trees and regeneration, and doing it with a greatly reduced and highly trained labor force" (McNally 1954).

The Impact of Mechanization on Loggers

In the 1950s, the average length of continuous employment in a logging camp in eastern Canada was 44 working days. The average productivity per man-day was 0.7 cords, for all men in camp. Loggers were paid by piece-rate, which served as an invisible foreman and made close supervision unnecessary. Each logger's output at the end of the day was a clear and measurable indication of productivity. Men who chose piecework liked it because they were free from supervision and earnings were often higher than day wages. However, with the piecework system, workers tended to burn out; few lasted on the job past 50 years of age.

Traditional cut-and-pile methods of production were incredibly energy intensive. Wood cut to four-foot or eight-foot lengths was neatly piled along a prepared strip road, usually at the end of the day. (Piling alone occupied 30% of the logger's day.) This was done merely to permit the scaler to measure the logger's output, an operation that could have been accomplished just as simply by conducting a stick count. Once the neatly prepared piles had a scaler's mark on them, they were broken and loaded onto sleighs. This wood could just as easily have been swung and piled in small bunches, which would have saved the cutter much effort.

To deal with this dismal situation, Alex Koroleff (1951) proposed that logging be deseasonalized, mechanization be increased, a permanent, efficient labour force be built, and the industry change from nomadic to settled logging. That he accurately assessed the situation is evident in the fact that all of his suggestions have come into being.

With increasing capital investment in mechanical equipment, there was a trend towards the payment of wages by time rather than piecework. The shift from individual loggers cutting and piling to crews of men skidding tree-lengths, and being paid as a team, led to many problems in eastern Canada. Loggers who cut and piled wood knew at the end of each day exactly how much money was earned, but, on tree-length skidding operations, the feller who cut, delimbed and topped the tree was distinct from the skidder operator and the bucker at roadside. Usually a rate per unit volume from stump to road was established, and this was divided among the two to four members of the crew. Each person performed only one stage of production and often didn't see how the other stages were carried out, even though his income was dependent upon his teammates. However, on most operations, the incentive principle was not completely abandoned, and some form of incentive bonus, over and above time payment, was given to be divided among the team members on the basis of an agreed formula.

As logging became mechanized, work became a steady, daily pattern; this concept was accepted by workers in an urbanized environment, but often repugnant to a forest worker, who worked at their own pace and were relatively free (Silversides 1966a). Table 1.4, derived from an unpublished report entitled "History of Logging at KVP" by Harold Burk, illustrates the impact logging mechanization had on loggers in the 1950s.

Table 1.4 Mechanical Horsepower Factors, Woods Department, the KVP Company Limited

	1949–50	1959–60
Cords produced	35 500	137 800
Man-days	35 200	78 300
Mechanized hp days	75 000	2 622 800
Man days per cord	0.99	0.57
Horse days per cord	0.48	—
Mechanized hp days per cord	2.14	19.10

The Introduction of Power Saws

It was the forest workers' dream to mechanize the cutting operation, including both felling and crosscutting. These were two of the most labour-intensive operations in the logging cycle.

The development of the chainsaw represents one of the longest lead-in times in the history of mechanical technology, though the need and desire for a practical power saw existed for well over a century. It was finally two wartime developments, neither of which had any direct bearing on saw design, that made the chainsaw possible: light-metal technology (aluminum, magnesium) and light air-cooled engine technology.

Chainsaw manufacturers were originally German and Scandinavian, but when the potential market in North America was recognized, new manufacturers in North America rapidly developed[19] (Table 1.5). There were many attempts to produce chainsaws light enough to use in the forest, but this breakthrough did not come until after World War II. Yet even in the early saws, the origins of current power saws can be seen.[20]

The first mechanical saws, called dragsaws, were introduced between 1913 and 1920 in Canada (Figures 1.11, 1.12). These were adaptations of the crosscut saw, and were mounted on poles or skids. They had cumbersome gasoline engines that operated a crank, which converted the rotary action of an engine-drive shaft into reciprocal motion. However, these saws were so heavy and awkward that they had to be operated by two or more people and were of little use in the forest; they could really only be used in crosscutting operations.[21] In British Columbia, however, they were used to cut firewood for the steam-powered cable skidders.[22]

It was among manufacturers that the chainsaw generated the greatest interest; they saw the potential market for such a product. During the late 1920s, there were many manufacturers producing different models of saws,[23] most of which disappeared because the market never developed. In 1930, Alex Koroleff

Table 1.5 Power Saws in Eastern Canada

DATE	ITEM
1858	First patent issued of chainsaw, U.S. Patent Office[1]
1917	First chainsaw manufactured in the U.S. in the State of Washington[1]
1929	German Dolmar saw tried by the Anglo-Canadian Paper Mills, Quebec.[2]
1931	Summer Meeting, Canadian Pulp and Paper Association, Woodlands Section on Montmorency Limits of Anglo-Canadian Paper Mills Limited, demonstration of Stihl, 1-cylinder, 2-cycle, 8-hp saw, 85 lbs., 2 men[3]
1932	The first chainsaw announcement appeared in *Pulp and Paper Magazine of Canada* for February in an article describing the "Wolf" timber sawing machine sold by Canadian Ingersoll Rand Limited.
1937	Bloedel Stewart and Welch in British Columbia tried out a 2 man saw[3]
1938	Only one company in North America producing chainsaws[4]
1942	Six companies in US producing chainsaws[4]
1944	Bloedel, Stewart and Welch in B.C. operating 112 power saws[5]
1945	Two power saws tested by Quebec North Shore Paper Co., Baie Comeau, Quebec.[5]
1949	Thirty companies in US producing chainsaws[6]
1951	Survey in 1950–51 operating season in eastern Canada showed 21 220 cords produced by power saw[7]
1952	Consolidated Paper Corporation cut 15 000 cords by power saw[7]
1952	20% of pulpwood in eastern Canada is produced by power saws[8]
1952	Consolidated Paper Corporation had 720 power saws on its operations[9]
1952	Quebec Forest Industries Assoc. estimates more than 2 000 saws on its member operations[9]
1953	Consolidated Paper Corporation had 1 700 power saws on its pulpwood operations[10]
1953	Survey of power saws — 26 manufacturers and 50 models (includes European manufacturers)[11]
1954	In season 1952–53, 20% of limit pulpwood in eastern Canada cut by power saw, and in season 1953–54, 28% of limit pulpwood in eastern Canada cut by power saw, according to Kerr. In season 1954, Consolidated Paper Corporation cut 450 000 cords with power saws, according to Kirkpatrick[12]
1955	In 1949–50, less than 1% of pulpwood was cut by power saw. In 1954–55, over 50% was cut by power saw[13]
1956	In Lake St. John region, 75% of all pulpwood cut by power saw (Hunt)[14]
1964	Abitibi Paper Company limit production using power saws[15]
	(1953–54 — 13% of total; 1954–55 — 34% of total; 1955–56 — 71% of total; 1956–57 — 82% of total)

NOTES
1. Powersaw training panel discussion, Woodlands Section Index 1321 (1953).
2. Development of portable mechanical saws, Woodlands Section Index 733 (1944).
3. Stephenson, J.N., and J.S. Turner, "Milestones" 1923–32. *Pulp and Paper Canada*, August, 1953.
4. History of Chainsaws, C. Miller, *Southern Lumberman* 15, April 19, 1949.
5. Development of portable mechanical saws, (G. Godwin), Woodlands Section Index 733 (1944).
6. History of chainsaws, C. Miller, *Southern Lumberman* 15, April 9, 1949.
7. Reports on power saw tests, T.M. Pond, Woodlands Section Index 1139 (1951).
8. Power saw training-panel discussions, (Carter) Woodlands Section Index 1321 (1953).
9. Woodlands Review, March, 1952.
10. Power saw training-panel discussions, (Carter) Woodlands Section Index 1321 (1953).
11. Survey of power saws, (Anon.), Woodlands Section Index 1355 February, 1954.
12. The proper use of the power saw as a cutting tool (Logen) Woodlands Section Index 1369 (1954).
13. Practical mechanization of Woodlands Operations. F.J. Farrell, Woodlands Section Index 1560 (1955).
14. Development and trends in logging equipment Woodlands Section Index 1556 (1956).
15. Letter dated 22 September, 1965, Silversides to J. Bérard.

offered this explanation for the failure of chainsaws to catch on with loggers:

> *Possibly a certain mental inertia on the part of pulpwood operators shares responsibility for their failure to give a thorough and patient trial to the most practical of the present day saws. Some of the operators are so busy with the routine work in logging that they have no time left for improving the techniques of their logging methods. Each of those who are keenly interested in the possibilities of the motor-saws are willing to wait for the appearance of a perfect model instead of trying to adapt the best of the available machinery.*

Prevailing attitudes also reflect the skeptical nature with which the prewar units were viewed: "I doubt very much that its use would result in savings over hand bucking," "It is a dangerous instrument to work with," "The motorsaw is impractical for use on strip roads due to the amount of lost time and also due to the fact that we do not believe the saw is sturdy

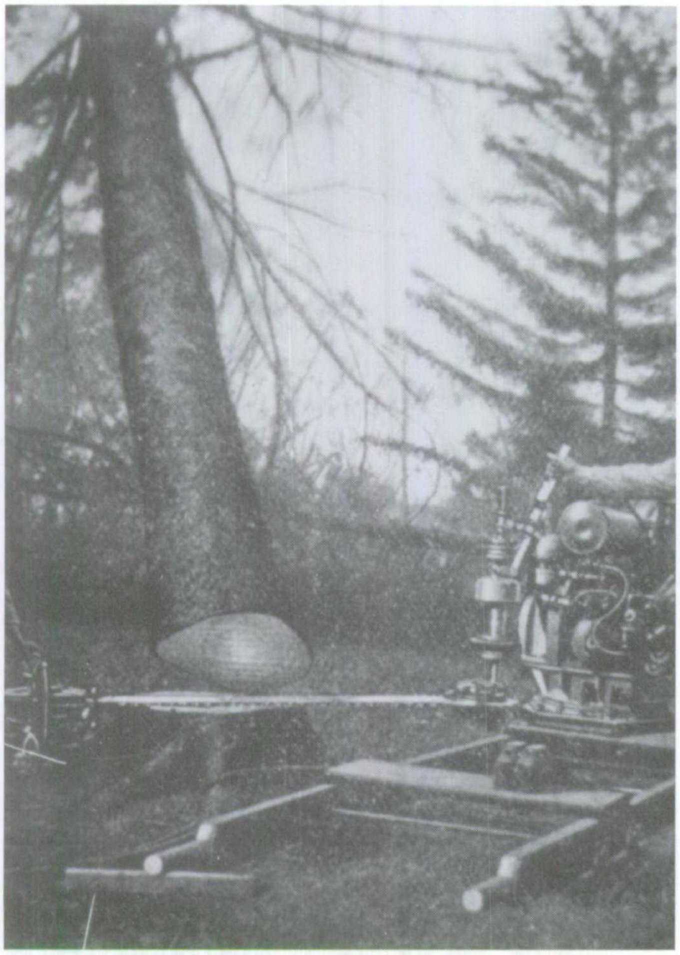


Figure 1.11 *A chainsaw developed in New York, 1911.*

Figure 1.12 *A World War I-era (1918) power saw "Sector" designed and manufactured by A.V. Westfelt (Glaser 1955).*

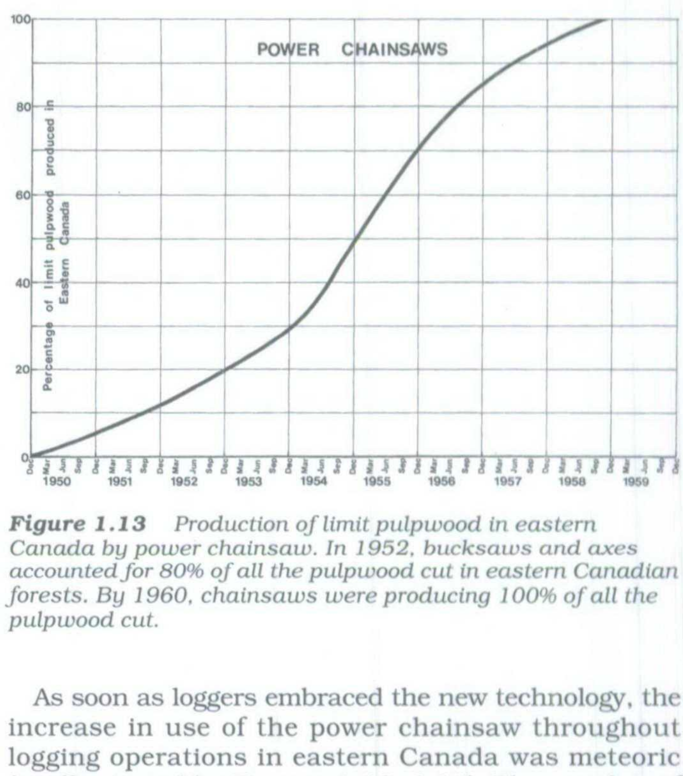


Figure 1.13 *Production of limit pulpwood in eastern Canada by power chainsaw. In 1952, bucksaws and axes accounted for 80% of all the pulpwood cut in eastern Canadian forests. By 1960, chainsaws were producing 100% of all the pulpwood cut.*

enough to stand this work," and "It is greatly dangerous to operate this saw, especially in snow" (Koroleff 1930).

It wasn't until the decade and a half after World War II that manufacturers recognized power saws as essential tools. The logging industry, however, refused to supply them to their workers. The logic behind this thinking was that the chainsaw increased a worker's output, which was to the worker's benefit, not the company's — the worker expended less energy and earned more per day, since payment was almost universally on a piecework basis. Some companies also felt that saws would not be cared for or properly maintained if they were provided to the workers. Limited experience provided some support for this argument.

Loggers eventually began to use power saws when they recognized their benefits. Their acceptance by bushworkers was encouraged by the fact that the saws were relatively inexpensive in relation to the increase in earnings they provided,[24] they gave the worker control over his productivity,[25] and they were useful outside the forest, therefore worth owning[26] (Curran 1971).

As soon as loggers embraced the new technology, the increase in use of the power chainsaw throughout logging operations in eastern Canada was meteoric (as illustrated by Figures 1.13, 1.14). The number of makes and models of saws manufactured led to a lack of standardization of saws within logging camps. This gave the loggers the opportunity to weed out saws that performed poorly, or were difficult to service. By 1963, only four manufacturers produced 68% of the chainsaws sold in the free world.[27] The chainsaw is now universally accepted in the forest industry. Bucksaws have completely disappeared and axes have almost disappeared as logging tools.

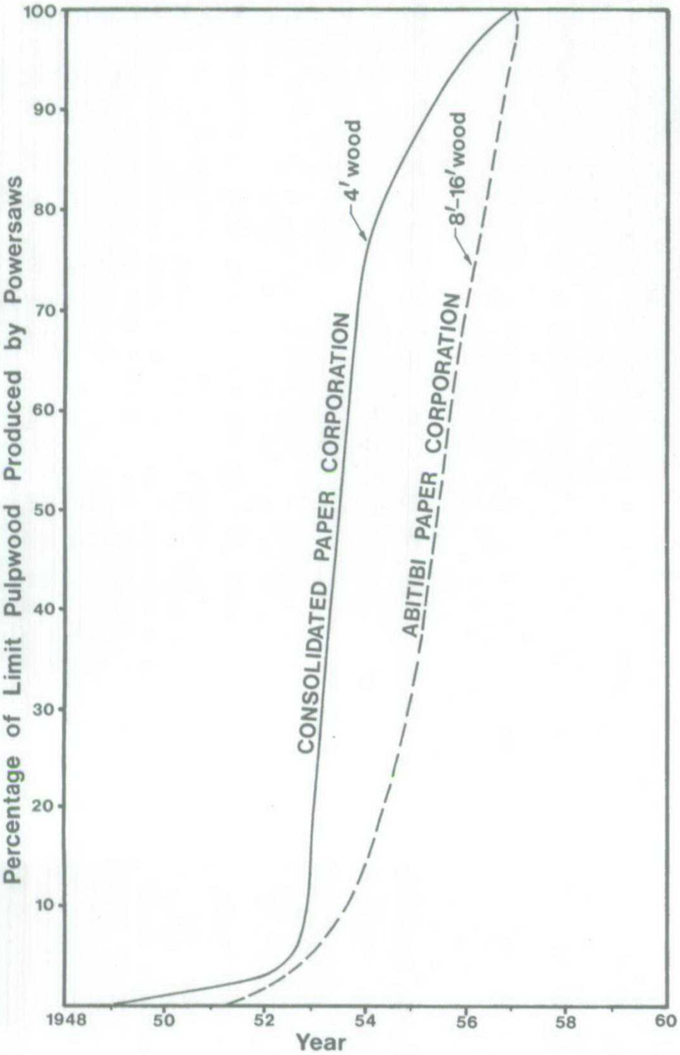


Figure 1.14 *Intrafirm rate of diffusion of power chainsaws.*

The Introduction of Hydraulic Shears

The complexity of the chainsaw led to the search for simpler mechanisms, and the concept of shearing wood was developed. Shearing wood with knives was common in veneer production, where specially prepared bolts were cut, parallel to the grain, into thin ribbons of wood. Shearing wood with knives at right angles to the grain, for felling trees or bucking them into logs, was a departure from traditional wood-processing methods (Johnston 1964).

The Mammoth Tree Shears Company of San Antonio, Texas, manufactured a large tractor-mounted tree shear for use in land-clearing operations in 1945. These shears were not powered, but were mounted on the front of a tractor with a linkage that used the forward movement of the tractor to close the scissor-like blades and fell trees up to 30 inches in diameter (Anon. 1946).

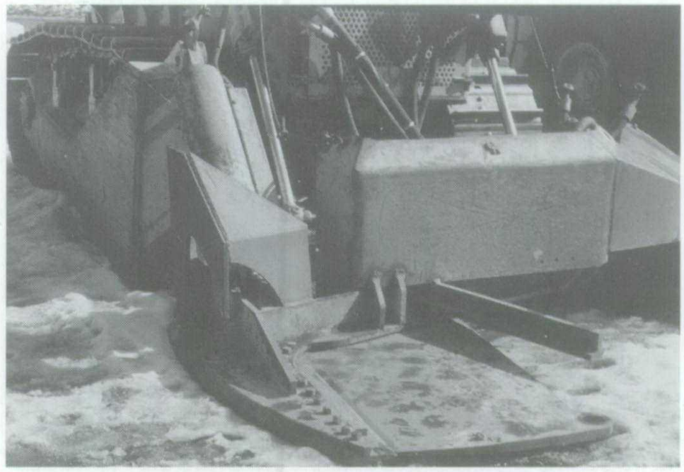


Figure 1.15 *Roanoke shear mounted on tractor.*

The first reference to tree felling with a hydraulically powered shear was in 1954, at Olla, Louisiana, on the operations of International Paper Company. The shear was mounted on a farm tractor as part of a project that started as an experiment but eventually led to the development of the Busch Combine (Cline 1967).

The Harrington Manufacturing Company Inc. of Lewiston, North Carolina produced a front-end-mounted hydraulically operated tree shear. This development was in such demand that the first dozen units were built and sold before they were completely designed on paper. In Canada, the first of these units, known as the Roanoke tree shear, was put on trial at the Lakehead Woodlands Division of Abitibi Pulp and Paper Company Limited in the fall of 1966 (Figure 1.15). This tree shear consisted of a wedge-shaped blade, and anvil head, a hydraulic cylinder to activate the blade and a supporting frame and hydraulic system. It was mounted on the front of a tractor for felling. In a typical situation, the tractor operator sheared a tree at ground level, and the tree fell 90° from the tractor's direction of travel, because of the wedging action of the shear blade.

Unfortunately, this unit did not prove economical in the pulpwood stands of northwestern Ontario. A great deal of time was spent manoeuvering to approach each tree, and its productivity was hampered by the low stand density and small tree size typical of the area. Productivity averaged between 350 and 400 trees felled per eight-hour shift. However, when introduced into the interior of British Columbia, the hydraulic shear was widely accepted. With denser stands and larger tree sizes, machine felling was readily accepted. A productivity of 800 trees per eight-hour shift was common (Cottell et al. 1976). This acceptance spurred other manufacturers into this field, and variations of the original shear began to appear.

A major problem encountered in the shear-felling of trees was butt shatter. When a shear blade $1^1/_2$ to

2 inches thick at the back is forced into a tree, a volume of wood equal to the volume of the blade is displaced. The stresses imposed on the wood included intense and localized crushing next to the blade, and longitudinal splitting. This was not of great concern if the tree was to be used for pulpwood, but if the butt log was to be used for lumber, splits up to a metre in length were undesirable (Kempe 1964, Johnston et al. 1973, Johnston 1968, Wiklund 1967, Schmidt and Melton 1968, McIntosh and Kerbes 1968).

Different approaches were tried to reduce the splitting, none of which was entirely satisfactory (Johnston and St-Laurent 1975). One solution was to use two blades in a scissor action; this meant that the blade thickness could be considerably reduced. Blades were designed in a "V" or gauge shape, or were "dished" so the stresses were directed into the stump and the butt of the tree was left relatively undamaged. Difficulties in blade manufacture and maintenance made this approach unattractive (Johnston and St-Laurent 1969). Another approach was to groove the blade's surface, which localized the crushing. This development was made in the Western Forest Products Laboratory by Dr. Tom McLauchlan and was licensed to the QM Machinery Limited, Prince George, B.C. The grooved blade reduced butt shatter by almost 50% (McLauchlan and Kusec 1975).

The Introduction of Feller-Bunchers

The first feller-buncher was developed by Rudy Vit of the Quebec North Shore Paper Company in 1957. This machine incorporated a hydraulically driven chainsaw in its felling head. The first feller buncher to use hydraulically operated shears in Canada was the Beloit Harvester, fielded in 1960. The Beloit Harvester grappled the tree and sheared it with two opposing blades, closing in either a scissor-like fashion or with the two opposing blades parallel to each other. In either case, each blade was required to penetrate only half the tree, so the blades were relatively thin.

Then in 1961, the modified Busch Combine was introduced by Abitibi Paper Company Limited and Canadian International Paper Company Limited. The Busch Combine used a single thick blade acting against an anvil, so the blade was required to pass through the entire tree. This machine had been used successfully in the southern United States since 1953, but encountered the major problem of shearing wood in the northern climate: frozen wood shattered to an unacceptable degree.

The problem of splitting and crushing was not critical if trees were small or were to be used as pulpwood. However, if the trees were to provide butt logs for sawmilling or for studmills, these problems were unacceptable. To overcome the problem of splitting and crushing, Aubrey Muirhead of Prince George, B.C., invented a hydraulically driven spiral-auger tree cutter in 1971. Initially, the auger was designed as a front-end attachment for a crawler tractor. The felling unit consisted of the rotating auger, a toothed anvil and a hydraulically powered pusher, which relieved the pressure on the auger during the cutting cycle and guided the falling tree (McIntosh 1971b).

The Muirhead auger was originally developed to be used on the large timber in the interior of British Columbia. However, its potential for smaller timber in the East was recognized by the Manitoba Forest Resources Limited, in The Pas, Manitoba. When they modified the auger and mounted it on a Drott Feller Buncher, the Drott Corporation purchased the patent from Aubrey Muirhead. The unit worked particularly well on frozen wood, and its productivity compared favourably with shear-blade feller bunchers.

The search to overcome wood damage when shearing is still underway. In 1982, the Forest Engineering Research Institute of Canada, in cooperation with equipment manufacturers, developed a new design for a circular-saw felling head. The new design was based on the circular-saw felling head, developed by Prince Albert Pulpwood Limited for their A-line Swather, which could sever trees without crushing and splitting damage. A number of these circular-saw felling heads were on harvesting operations by 1983. Some of these units have a single circular saw while others have two overlapping saws.

The Introduction of Snowmobiles and Other Tracked Vehicles

The early snowmobiles, most manufactured locally, had automobile bodies and were capable of carrying up to ten passengers. They were equipped with endless treads at the rear and sleigh runners at the front, to permit steering. The Landry, equipped with a Ford V-8 engine, was a popular make (Grainger 1939).

In the winter of 1948, several snowmobiles, homemade by the now renowned Joseph Armand Bombardier, were used on the sleigh haul of the Ste-Anne Power Company Limited (Stephenson 1963, Silversides 1948). The engines were taken from three-ton GMC trucks, the transmissions from a 1938 Pontiac and a 1939 Buick, and the differentials from 1937 Chrysler trucks. The wheels, lags and tracks were similar to the standard "Bombardier" snowmobile, except the units had smaller sprockets.

Even though these vehicles had been a familiar sight in the woods for several decades, little thought had been given to using snowmobiles as motive power on the sleigh haul. In the winter of 1950–51, though, Price Brothers and Company Limited pioneered the use of snowmobiles for this purpose (Figures 1.16 to 1.19). It was estimated that some 500 000 cords were

Figure 1.16 Bombardier snowmobile forwarding a single sleigh-load of four-foot wood, transferring load to truck pallet on landing.

Figure 1.17 Bombardier J-5 snowmobile forwarding four-foot wood with trailer.

Figure 1.18 F-4 Dion snowmobile in forwarder configuration.

Figure 1.19 F-4 Dion snowmobile with skidding arch.

moved in this manner (McColl 1951a). The same year, another homemade snowmobile was used on the South Kenogami Division of Price Brothers and Company. This unit had been built by one of the Company's jobbers, M. Lemieux. It had a Cletrac rear end and differential steering, similar to the light tractors that were in use at that time (Figures 1.20, 1.21).

In 1957, Bombardier produced a model HDW machine designed specifically for forwarding four-foot pulpwood in bundles. It was tested on the operations of Quebec North Shore Paper Company at Franquelin, Quebec. The unit was 15 feet long, 7 feet wide, with a ten-foot platform and a hydraulic dumping system. Fully loaded with a cord of wood, it had a ground pressure of only 2 psi. This unit could produce 27 cords per nine-hour shift, for an average forwarding distance of 1 000 feet (Sewell 1958). It found considerable acceptance, especially in Quebec, but maintenance costs were high.

Converted wheeled farm tractors were tried in the woods to haul sleigh loads of wood (McColl 1949). The units were fitted with conversion kits manufactured by l'Autoneige Bombardier Ltée of Valcourt, Quebec (Figure 1.22). These conversion kits gave wheeled tractors the necessary flotation to operate in snow or on soft terrain. The kits consisted of a continuous track, similar to the standard Bombardier track, which was wrapped around the large driving wheels of the tractor and around a standard snowmobile wheel, the centre of which was three feet forward of the centre of the tractor rear axle. The idler wheel was mounted on a pivoted arm and was kept in contact with the ground by means of a coil spring acting downwards. This maintained tension in the tracks,

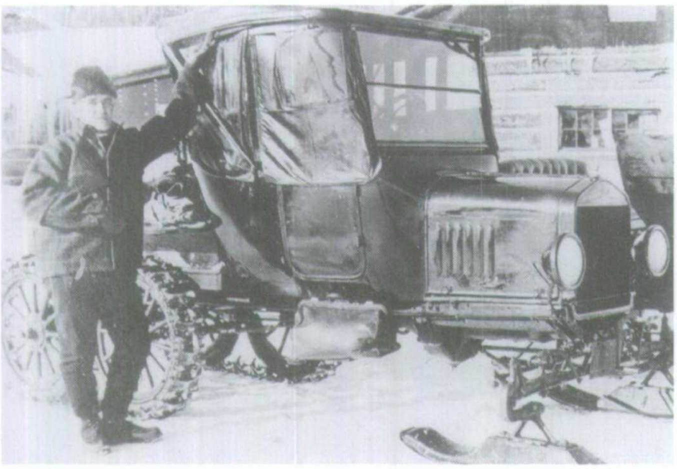


Figure 1.20 *The Ford Motor Company made a Model T snowmobile ca 1922. This machine was used by the Company doctor to visit logging camps north of Blind River, Ontario.*

Figure 1.21 *A homemade snowmobile on operations of Price Brothers and Company Ltd.*

which prevented slippage between the drive wheels and the track.

The Ford-Ferguson farm tractor, with track conversion, was tried out on the operations of Brown Corporation of La Tuque, Quebec, and by Consolidated Paper Corporation on Anticosti Island (McColl 1950). The tractors were used with a wooden sloop with a one-cord capacity. The front end of the sloop was attached to the tractor; this transferred part of its weight onto the rear axle of the tractor, increasing its traction.

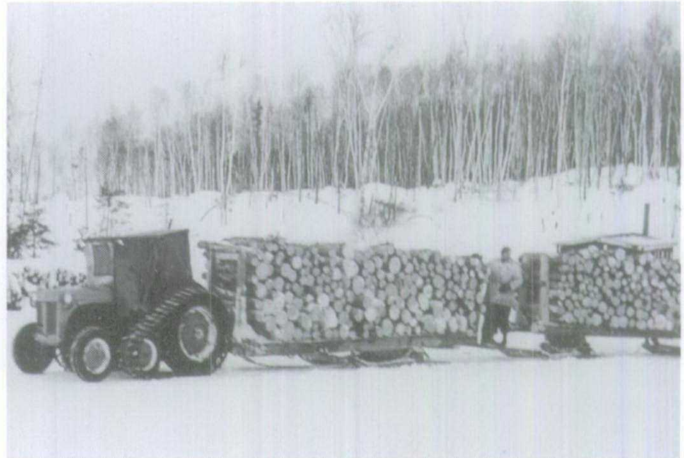


Figure 1.22 *Farm tractor used on a sleigh haul.*

In one application, a semi-trailer was made from a discarded truck frame and an army surplus trailer axle and wheels. The trailer's axle was located behind the load's centre of gravity, so about one third of the load was carried on the driving axle of the tractor. This unit transported loads of two and one-half cords of four-foot pulpwood.

In 1959, the St. Lawrence Corporation (now Domtar Limited) made a dramatic change on its logging operations north of Lake St. John, on the watersheds of Rivières aux Rats and Mistassibi (Caplan 1960a). The company decided that, to hold production costs in line, it would have to increase man-day productivity by mechanizing its cutting, forwarding, loading and transport operations. This could only be done by switching from the conventional four-foot jobber system to the mechanized eight-foot wood system. As George Lavoie, the river superintendent claimed: "The 8-foot logging acted as a catalyst breaking up the established pattern of woods operations and permitted a whole series of changes. The mechanized forwarding and loading was introduced with the intention of extending it to replace the horse entirely." With this change, the operating season was extended from five to ten months.

Anglo-Canadian Paper Mills Ltd. experimented with an Oliver OC3 crawler tractor in 1954. The tractor had poor stability on steep slopes and accidents were severe and numerous.

With the availability of hydraulically operated grapple loaders and mobile wheeled and tracked chassis, a number of forwarders appeared in the woods.[28] Most, however, disappeared soon after they appeared, because of the increasing cost to manually cut and pile the wood to be forwarded. Reliable and economic stump-area shortwood harvesters had not yet been developed.

The Use of Tracked Vehicles to Move Packaged Wood

The Evolution of Slooping

Horse slooping was the early method of moving packaged wood; it was used on the 16-foot operations of Spruce Falls Power and Paper Company Limited at Kapuskasing in 1934. One end of a pile of 16-foot logs was raised about 45 cm above the ground. The sloop was manoeuvered under the raised end of the logs and the pile was skidded as a unit to the haul road. This eliminated the need to handle the wood piece by piece.

When logging operations converted to eight-foot pulpwood, the sloops, or drays, were redesigned to accommodate the shorter wood. When the stamina of the horses began to limit production on this type of prehaul, small D-2 and D-4 class tractors were substituted for the animals. This increased productivity by approximately 33% (Flatt 1941).

In the winter of 1947–48, Ted Summers, Logging Superintendent on the operations of Ontario Paper Company Limited at Heron Bay, Ontario, designed and built a self-loading sloop for handling $^3/_4$- to $1^1/_4$-cord bundles of four-foot pulpwood (Figure 1.23). Production reached 25 cords per eight-hour day on a 1 000-foot haul, and proved more economical than conventional horse and sleigh forwarding (Horncastle 1950). These self-loading sloops were later manufactured by Timberland Machines Limited of Woodstock, Ontario.[29]

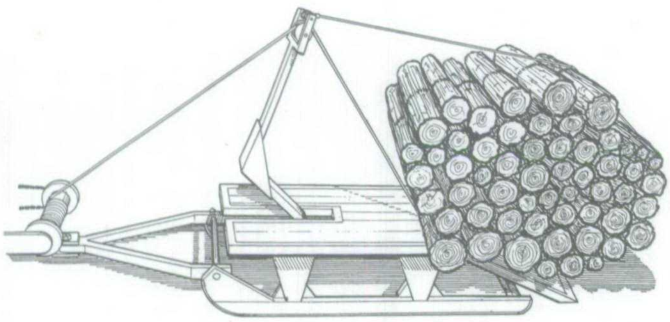


Figure 1.23 *The operation of the Summers sloop was simple. The tractor, usually of D-4 class, backed its sloop up to a pile of four-foot wood about which a choker cable had been placed. The free end of the choker was threaded through sheaves on the loading arm and hooked onto the tractor-winch cable. The L-shaped loading arm was then swung over, its tip falling at the base of the pile. As the winch pulled the cable, the pile was bound until there was sufficient tension in the choker to lift the arm and bring the pile of wood up and onto the sloop. A binder chain was placed around the load of wood to secure it to the sloop, and then the winching cable was slackened for travelling.*

The Use of Crawler Tractors

For a short period of time, particularly in northwestern Ontario, crawler tractors were used to skid or forward bundles of eight-foot pulpwood from the stump area to roadside. A cable was winched tight around a pile of wood that had been prepared by the cutters. This operation worked best with eight-foot wood. Sixteen-foot wood was too long to move crosswise, and four-foot wood often pushed out of the bundle as it was being formed. As soon as the wheeled skidder was introduced, however, crawler tractors were no longer used for skidding.

The Introduction of Wheeled Skidders

The time was ripe for wheeled-skidder development. Experiments had been conducted prior to WW II using crawler tractors, arches and sulkies to move wood in tree lengths. These indicated the potential benefit of tree-length skidding over the traditional shortwood cut-and-pile method (McNally 1940). The experimental work was dropped during the war, but revived shortly thereafter.

It was in the early 1950s that wheeled skidders were introduced, originally as stripped-down, four wheel-drive trucks, and later as four-wheel-drive machines with articulated-frame steering, specially designed for forest operations. The wheeled skidder caught on rapidly because it performed no new functions. It was designed to replace a horse, and this it did very well. Little selling had to be done, particularly with horses and experienced teamsters in short supply; the anticipated postwar period of unemployment had never materialized.

Skidders were first used merely to replace animals, but the consequences were far-reaching. The change from the cut-and-pile method of logging that accompanied the wheeled skidder resulted in a restructuring of the labour process. What had formerly been an individual operation became a group or team enterprise. Because the skidders could operate the year round, felling, skidding and bucking operations all had to be coordinated.

The Nelson Skidder

The Nelson skidder (forwarder) was developed and patented by E.Y. Nelson in 1955, a pulpwood contractor at Port Arthur (now Thunder Bay) Ontario (Figures 1.24 to 1.26). This unit found application mainly in northwestern Ontario. Though it had a relatively short life-span, it moved several hundred thousand cords of wood annually. In 1958, 30 units were operating (Keys 1958b), but it was phased out in the mid-1960s.

The Nelson frame was mounted on a D-6 size tractor. This was a relatively inefficient means of forwarding wood (a 25 000-lb. machine that could carry

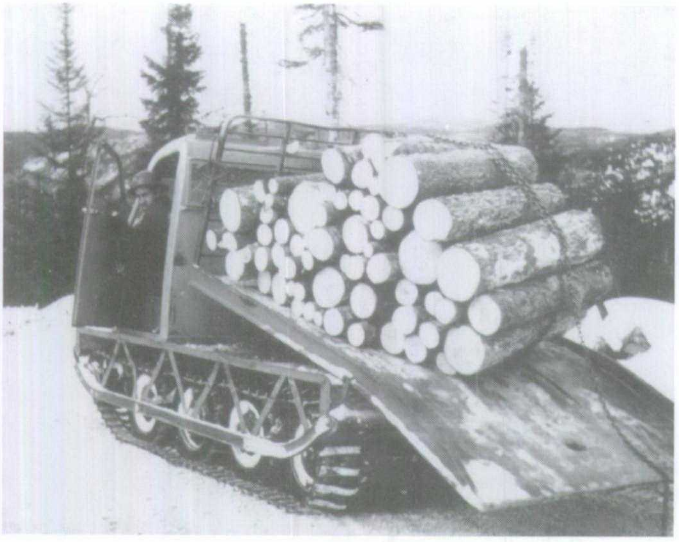


Figure 1.24 *A Bombardier HDW with tilt deck carrying a load of four-foot wood.*

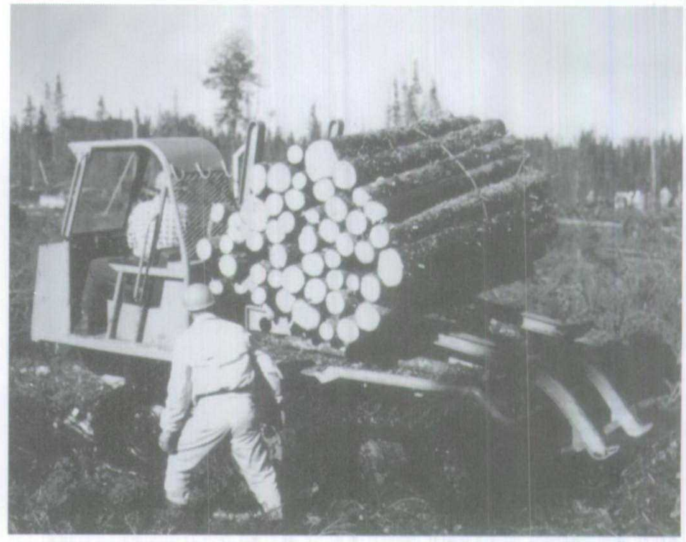


Figure 1.26 *A Nodwell forwarder carrying a one-cord bundle of 8-foot wood (Smooth Rock Falls, Ontario).*

Figure 1.25 *A Nelson skidder dragging a cord bundle of 8-foot wood (Thunder Bay, Ontario).*

a 5 000-lb. bundle of wood gave a dead load/live load ratio of 5:1; most equipment designers strive for a 1:1 ratio). The additional weight of a bundle of wood, along with the winch at the rear of the unit, required counter balancing with a bulldozer blade at the front. Excessive wear and tear on the drive sprockets and rear rollers occurred, and higher repair costs were experienced with track assemblies. This operation was said to reduce the life of the machine by one third to one half.

The Nelson, and other machines operating on this principle, could only bring out one pile at a time. For this reason, cutting had to be closely supervised so that piles were of optimum size. Wood could be piled, however, anywhere in the cutting area and in any orientation.

The Johnson Skidder

The Johnson skidder of 1956 was also an attachment for a D-6 size crawler tractor, but it was a considerable advance over the Nelson. Though costly to purchase, it required only one operator; no ground labour was needed to make up loads or unhook them. Like the Nelson, it was capable of working two or three shifts, and maintaining a steady level of production. The grapple of the unit had a capacity of 1 cunit. When piles were consistently of this size, production was 35% higher than when cutters made the pile size to suit themselves (Figures 1.27, 1.28).

Anderson Woodhawk Skidder

The Anderson Woodhawk (Figures 1.29, 1.30) was developed in the Lake States in 1958. It was a separate unit towed by a D-4 size tractor. It resembled a logging sulky, except that it carried its load. It was mounted on a single axle, with two large pneumatic-tired wheels or crawler tracks, and consisted of a hydraulically operated grapple that could be extended backwards to pick up a cord of wood, raise it and pull it forward onto itself. Once loaded, the unit was towed out by a crawler tractor. Cord bundles of

Figure 1.27 *A Johnson skidder (in winter) backing into a roadside pile.*

Figure 1.29 *An Anderson Woodhawk (in winter) backing into a pile of eight-foot wood on a strip road.*

Figure 1.28 *A Johnson skidder (in summer) forwarding a pile of eight-foot wood to the truck road.*

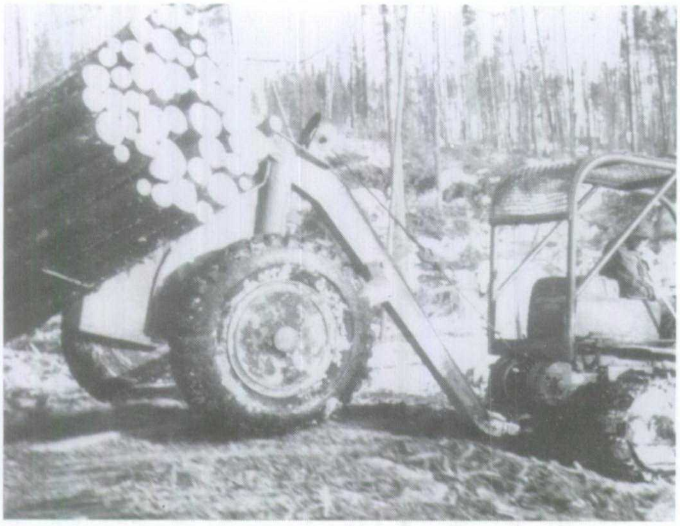
Figure 1.30 *An Anderson Woodhawk (in summer) picking up a cord pile of 8-foot wood. Note that the piles have crib frames at each end of the pile instead of one frame at the centre of the pile.*

eight-foot wood were moved by tractor and this rubber-tired sulky on the operations of the Ontario and Minnesota Paper Company in northwestern Ontario (Figures 1.31 to 1.35).

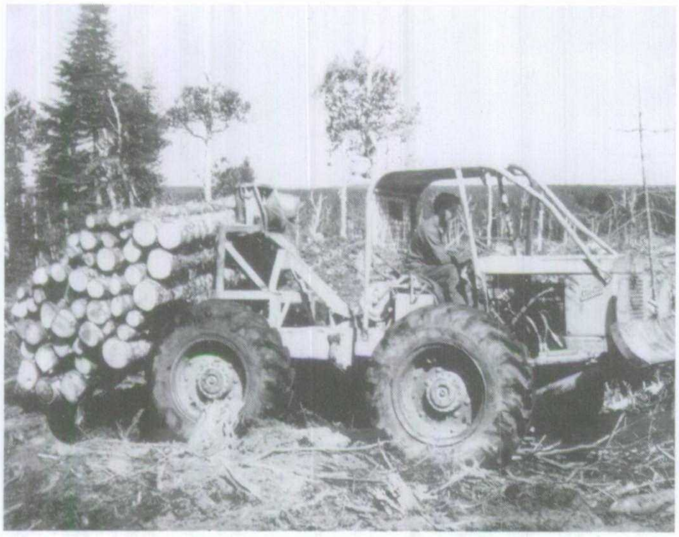
The sulkies were towed by TD-9- or D-4-sized crawler tractors. The operator backed the sulky up to a pile. An open hydraulic grapple was lowered over a pile from above, closed around the pile to be forwarded, then lifted onto the sulky. Vehicle types varied according to terrain conditions: rough ground required wheels; snow required ski-like runners; and steep slopes required Athey tracks. No strip roads were cut. Forwarding distance averaged 400 to 500 feet and production was about 40 cords per shift (Binger 1953).

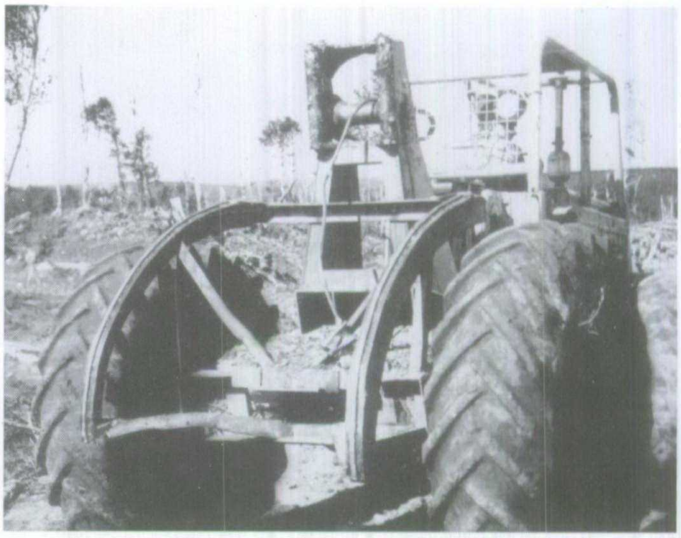
Tractor-Arch Transport

The first application of tractor-arch transport was by Bowaters Newfoundland Pulp and Paper Company Limited, in 1947. In the initial trial, the company used a standard Hyster D-7 Logging Arch to load and



Figures 1.31 and 1.32 *Fowarding eight-foot wood in cord bundles by rubber-tired sulky.*





Figures 1.33 and 1.34 *Forwarding or "packsacking" cord bundles of eight-foot wood by wheeled skidder.*

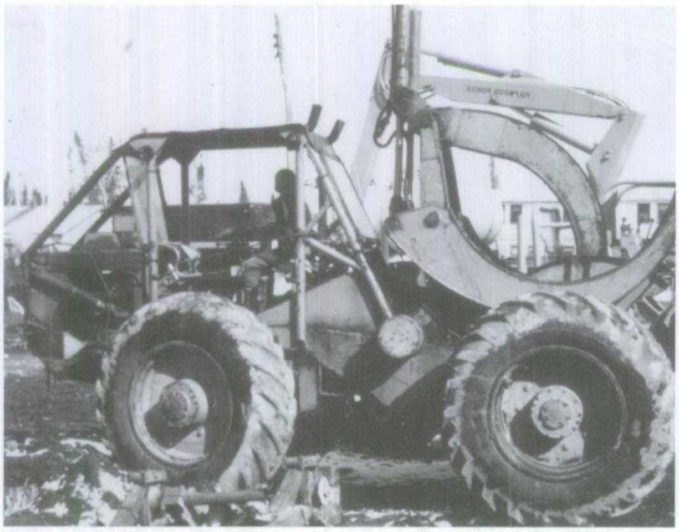


Figure 1.35 *A Timberskidder modified for forwarding eight-foot wood in cord bundles.*

Figure 1.36 *A Hyster D-7 logging arch designed to carry two bundles of four-foot pulpwood. One bundle is loaded and the second bundle is being chokered for loading.*

carry bundles of four-foot pulpwood (Figure 1.36). A framework of pipe was welded across the rear portion of the arch to prevent the bundles from interfering with the tracks. The early trials showed promise, and in the late summer of 1948 several more arches were put into service. The success of these early trials was due, in part, to the development and use of self-locking cable slings that permitted bundles to be formed and held tightly, so no wood was lost in transit.

In 1950, the Tractor Equipment Division of Hyster Company, Portland, Oregon, presented scale models and detailed data on this machine to the Woodlands Section of the CPPA. Hyster was hoping to determine whether there was enough support to justify a substantial development program for the tractor-arch transport, but no conclusion was ever forthcoming. Bowaters Newfoundland used the method for several years, and then phased it out in 1951 (Anon. 1952).

The Use of Tracked Vehicles to Move Prepackaged Shortwood/Pulpwood

In the early 1950s, Consolidated-Bathurst Inc., on Anticosti Island, was developing methods to move prepackaged shortwood. They modified the conventional cut-and-pile four-foot pulpwood operation so that bolts were simply gathered in bunches but not piled. By eliminating the piling, man-day productivity increased 16%. At the same time, power saws replaced bucksaws, which increased production by 40%. The bolts were later forwarded on wooden sloops hauled by either horse or farm tractor.

In another modification, four-foot pulpwood bolts were produced and bunched along a trail cut down the centre of the cutters' strip. A separate crew followed the cutters and piled the bolts in 1-cunit piles to permit the passing of a cable sling under them. Piling crew production averaged 11 cunits/man-day.

The piles of pulpwood were prechoked, using self-locking slings. In operation, the tractor would back up to a pile, the tractor cable would be attached to the sling, the self-locking sling would be pulled tight around the bundle and pulled up under the arch, free of the ground, and carried out. TD-18-sized tractors that had two curved boxed sections of 8-inch channel iron welded to the winch shaft were used. Two nine-inch sheaves were hung at the top of an A-frame to take 9/16-inch cable. The tractors were equipped with lights to permit day and night shift work. One such tractor using this system could replace 20 horses with sloops.

The packaged pulpwood at roadside was loaded onto 5-ton trucks. Four bundles were placed on the truck platform and four more on a single-axle semi-trailer. A rubber-mounted Michigan crane loaded the bundles. The crane would lift each bundle about six feet from the ground, then drop it four to five feet, to further tighten the sling around the bundle. It then raised the bundle and loaded it onto the truck platform.

The importance of these developments was the recognition that pulpwood had to be handled in packages. By not breaking down the piles to individual bolts and being able to move them as a whole, man-day productivity in loading and forwarding made a quantum leap forward.

The Bonnard Prehauler

At a field meeting of the Mechanical Hauling Committee of the Woodlands Section, CPPA, held at Heron Bay, Ontario in 1950, an *ad hoc* committee was struck to coordinate the work of all the Woodlands Section committees that dealt with mechanization, i.e., the hauling, cable-yarding and cutting-tools committees. One of the recommended projects was the plan called Project E.

The mandate of Project E was to design and develop a machine that would pick up a conventional pile of pulpwood at the stump, move it a distance of 1 000 feet, with a crew of two, at the rate of 40 cords per eight-hour day. At the Heron Bay meeting, the Summers Self-Loading Sloop (Figure 1.23) had been demonstrated. What the committee envisioned was a self-contained "sloop on wheels," using the same loading system as the Summers Sloop, but capable of operating in more difficult areas than the existing sloops could.

Figure 1.37 *A Bonnard Prehauler MK 11 demonstrated at Grenville, Quebec, 1951.*

The Mark II Forwarder was demonstrated in 1951 (Figure 1.37). It was financed and constructed by Dan Bonnard of Bonnard Equipment Limited of Lachine, Quebec, who had constructed the Mark I Forwarder. It was a front-wheel drive, four-wheel vehicle with hydraulic steering cylinders and a steering trunnion assembly.

The Mark II was a major innovation. It was the first articulated-frame-steered unit to appear in the woods, or anywhere else in eastern Canada. The application of this frame-steer principle was basic to the successful introduction of wheeled skidders and forwarders onto Canadian logging operations.

Rigid-Frame Wheeled Skidders

The use of wheeled skidders in eastern Canada began because of the joint efforts of Don Gray of KVP Company Limited, Espanola, Ontario, and Archie Kerr of Kerr Equipment Limited, Toronto. Kerr was the Canadian representative of the FWD Company Limited of Clintonville, Wisconsin and Kitchener, Ontario.

In 1952, a stripped-down FWD truck was tried on KVP's operations.[30] The unit was christened the "Blue Ox" after the companion of Paul Bunyan, the mythical giant logger. The Blue Ox had the standard four-wheel-drive power train, a rigid truck frame with leaf-spring suspension and conventional Ackerman steering. It was equipped with a winch and A-frame at the rear (Figure 1.38).

The Blue Ox was tested for several years under a variety of conditions. Production increased from 9 300 cords in 1955, which was the first year of skidding on an operational scale, to 82 000 cords in 1959. By 1960, the KVP Company was operating 36 units. In the meantime, other companies introduced the Blue Ox onto their operations, both experimentally and operationally: Abitibi Power and Paper Company Limited; St. Raymond Paper Company; Great Lakes Paper Company Limited; Howard Smith Paper Mills Limited; and others.

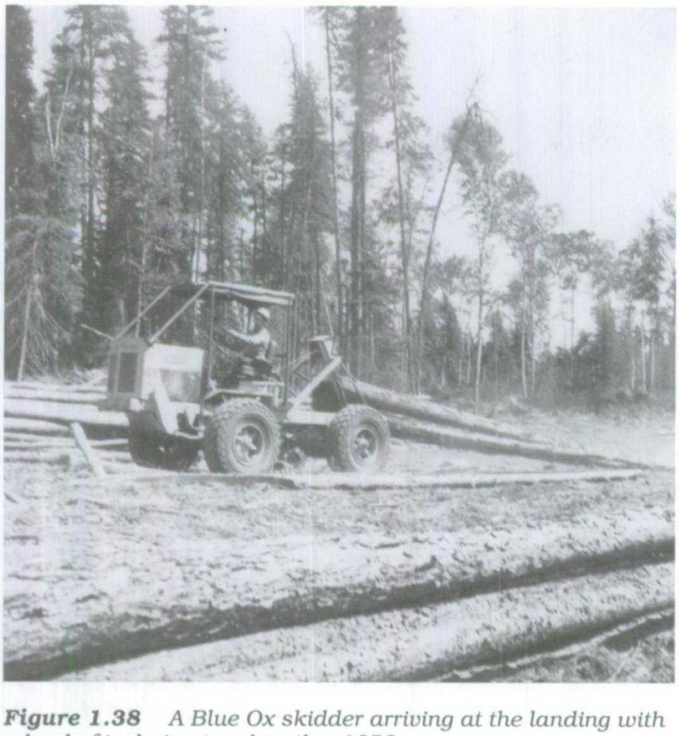


Figure 1.38 *A Blue Ox skidder arriving at the landing with a load of jackpine tree lengths, 1953.*

The Blue Ox was accepted by the industry for about a decade, but it was rendered technically obsolete when the articulated-frame-steered skidder was developed. The rigidity of the solid frame and the conventional Ackerman steering greatly constrained its manoeuverability in the woods. The unit was sprung, and broken spring hangers plagued the units. There were no suitable low-pressure tires on the market at this time. The introduction of this wheeled machine, with all of its shortcomings, did, however, establish the potential for wheels in the forest, and developments in this field moved forward rapidly. The last of the Blue Ox units to be used operationally was retired in 1966.

At the 1956 Woodlands Section Summer Field Meeting in Ramsay, Ontario, a new skidder was introduced. It was the Timberskidder, designed and developed by Bob Symons and manufactured by Timberland Machines Limited of Woodstock, Ontario. This development capitalized on the success of the Blue Ox, and its design, to a large degree, was based on the successful features of that unit. It was a rigid frame, four-wheel drive, rubber-tired tractor equipped with torque converter and planetary geared hubs. Timberskidders operated by the Great Lakes Paper Co. were each equipped with a pair of winches that increased payload, which allowed the economical transfer of full trees to approximately 6 000 feet.

Articulated Wheeled Skidders

Spending money to develop a machine capable of working in summer, and of duck walking its way on the soft forest floor, had to overcome the prejudices of many people in the industry. At a logging field meeting, one highly respected logging engineer said: "*God has given us snow on which to sleigh-haul wood and we should use it.*" He also said "*No machine designed to work on the forest floor should be wider than the rear end of a horse.*" Nevertheless, four prototypes of the Timberskidder were competing with the Blue Ox in 1958.

In 1959, however, Wes Magill and Bob Symons of Timberland Machines Limited made a momentous decision. Faced with the options of continuing to develop the Timberskidder, with its rigid frame and Ackerman steering, or to drop that line and concentrate on an experimental articulated frame-steered unit, they selected the latter.

In an articulated vehicle, the pivot point is not located over the axle of either unit. Steering is accomplished by rotating the vehicle around the pivotal point and, consequently, is often referred to as frame steering. This concept was not new; it was used in a one-row cultivator machine by John Deere and Company as early as 1919. In this original machine, the steering was mechanical, using rack and pinion gears. The development of hydraulic systems made the reemerging articulated-frame machine more flexible.

It has not been possible to establish quantitatively just why articulated steering succeeds where conventional steering fails, but comparative tests show that vehicles with frame steering are more capable of extricating themselves from ruts, mud holes and other obstructions. No particular increase in drawbar pull is apparent for machines with articulated steering over conventional Ackerman steering on a straight pull. The merit in the frame-steered vehicle appears to be its ability to "step" or "wiggle," and each time the vehicle is steered, light forward movement is obtained. The fact that these mechanical units could rotate in the middle gave them a manoeuverability in the forest almost the equivalent of a horse. The concept of articulated-frame steering was an idea whose time had come.

Ken Nielsen, Woodlands Manager of Dryden Paper Company Limited, Dryden, Ontario, had seen the Garrett tree-farmer working in Washington and had been very impressed with its performance. It was designed by Dwight Garrett of Enumclaw, Washington, as a thinning machine to remove small timber from second-growth West Coast stands. In 1959, Nielsen purchased and tested a unit. Then he persuaded Can Car Fort William Limited, a subsidiary of Hawker-Siddeley Limited, to acquire manufacturing rights to this machine in Canada, which they did, and it became known internationally as the Can Car Tree Farmer.

The Dowty Forwarder Concept

The machines developed under the Woodlands Section, CPPA, Project E were capable of handling only one package of pulpwood at a time, and the productivity of the machines therefore depended on pile size. A major lesson learned from the Bonnard Prehauler development was that shortwood-handling machines should operate independent of pile size, to permit capacity payloads to be transported on every trip.

During the 1958–59 season, two of the Mark IV Bonnard Loggers, at the Maniwaki Division of Canadian International Paper Company, were converted to load and forward eight-foot wood. The units were equipped with a 120-cubic-foot capacity load cradle and a Hiabob knuckleboom grapple loader (Figure 1.39, 1.40). Performance studies were carried out under summer and winter conditions, and in different forest stands. These tests indicated that the forwarder concept of handling wood could provide considerable savings over any other method currently employed.

The use of a boom-mounted grapple loader permitted the fellers to produce wood in small bunches, which could be located anywhere. Strip roads were no longer a necessity, since the large-tired articulated machines could pass anywhere within the cutover. The switch from cut-and-pile to cut-and-bunch increased a feller's output by at least 30%. Besides being able to collect optimum payloads in the woods and carry them to the roadside, the forwarder was able to transfer its load directly onto trailers or pile it down in stockpiles along the haul road. This was entirely a one-man operation.

In 1958, Bruce McColl, who had moved from the Woodlands Section to the Pulp and Paper Research Institute of Canada, had submitted a paper to the *Pulp and Paper Magazine of Canada* entitled

Figures 1.39 and 1.40 *A Mark IV Bonnard Prehauler.*

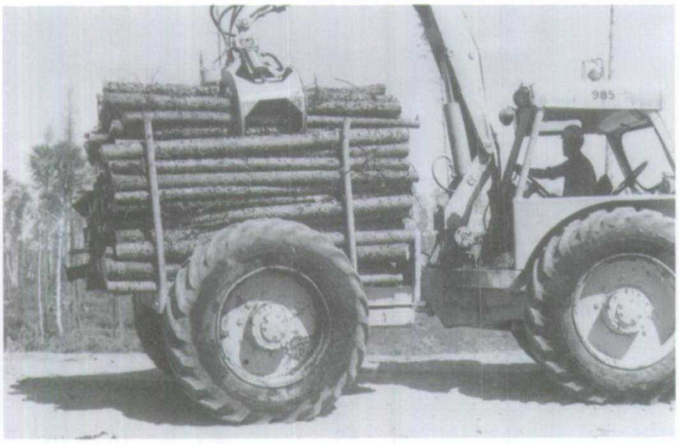


Figure 1.41 *A Bonnard Prehauler converted to a self-loading forwarder, C.I.P., Maniwaki Division, 1958.*

Figure 1.42 *A Bonnard Forwarder off-loading eight-foot wood onto a parked semi-trailer.*

Figure 1.43 *Dowty Forwarder at Maniwaki, Quebec, 1961.*

"The 'Forwarder' Concept." This concept had been reviewed internally in 1957, but had not been discussed publicly.

Since there was no industry-wide support for any machine development program at this time, a new approach seemed appropriate. In 1959, Canadian International Paper Company agreed with Dowty Equipment of Canada Limited, Ajax, Ontario, to design, develop and manufacture a forwarder according to the concept outlined by Bruce McColl. Dowty Equipment of Canada Limited was a newcomer to the forest industries in Canada, although it was a well-established British company, with particular expertise in hydraulic systems. It specialized in aircraft hydraulics, had a patented and widely used system of hydraulically operated pillars for use in coal mining, and produced the Dowty jet boat propelled by a water jet.

Figure 1.44 *A production model of the Dowty Forwarder.*

At this time, Bruce McColl left the Pulp and Paper Research Institute of Canada to join Dowty, to supervise the design and manufacture of the forwarder. The name "Forwarder" was copyrighted by Dowty Equipment of Canada, to describe their machines developed for the forwarding of pulpwood. Canadian International Paper Company took delivery of six forwarders in 1961 (Figures 1.41 to 1.44) (Casey 1963). The mechanical availability of these units was acceptable and the cost savings were as predicted. Soon, other companies began to manufacture forwarders.

Timberland's Timberbuncher

There was considerable interest in full-tree harvesting, spurred by the development of the Vit Feller Buncher in Quebec, and by the work carried out by Clark Horncastle at Heron Bay, Ontario. In 1959, Timberland Machines Limited of Woodstock, Ontario, made a proposal to the members of the Woodlands Section, CPPA. The proposal described the "Timberbuncher", the function of which was to fell and bunch trees to be skidded later. It was developed by Jack Boyd, who had considerable woods experience, having worked at Marathon, Ontario for a number of years before joining Timberland Machines.

The Timberbuncher was the first swinging boom-type feller buncher proposed to the industry by an equipment manufacturer. It was a high-speed swinging crane with a folding boom and a felling head

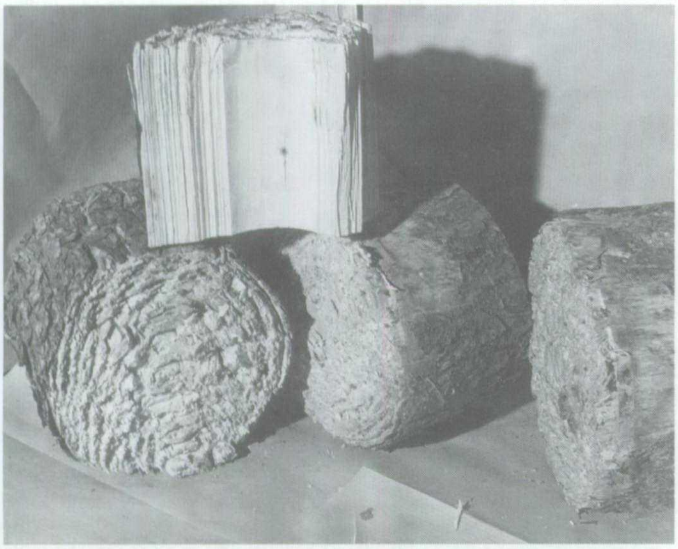


Figure 1.45 Specimens of a cut made by pulling wire rope through a tree.

and grapple for felling and bunching trees. Its development recognized that "prebunching" of small trees would reduce skidding costs. All existing skidding and forwarding equipment was able to handle more wood, but spent too much time making up loads or hauling partial loads.

The felling mechanism had neither a powersaw nor shears. Felling would be carried out by pulling a wire rope, using a large hydraulic cylinder, through the tree. The operation resulted in a square cut with surprisingly little tearing or splintering (Figure 1.45). Results from cutting tests proved satisfactory; less power than expected was required, and there were indications that the wire rope had a long life.

The wire rope was passed through sheaves in the two grapple jaws which clamped the tree. The same hydraulic cylinder used to cut off the tree continued to pull the wire rope, forcing the jaws together with very high force. With the high closing pressure available, only a short grip was required on the tree butt.

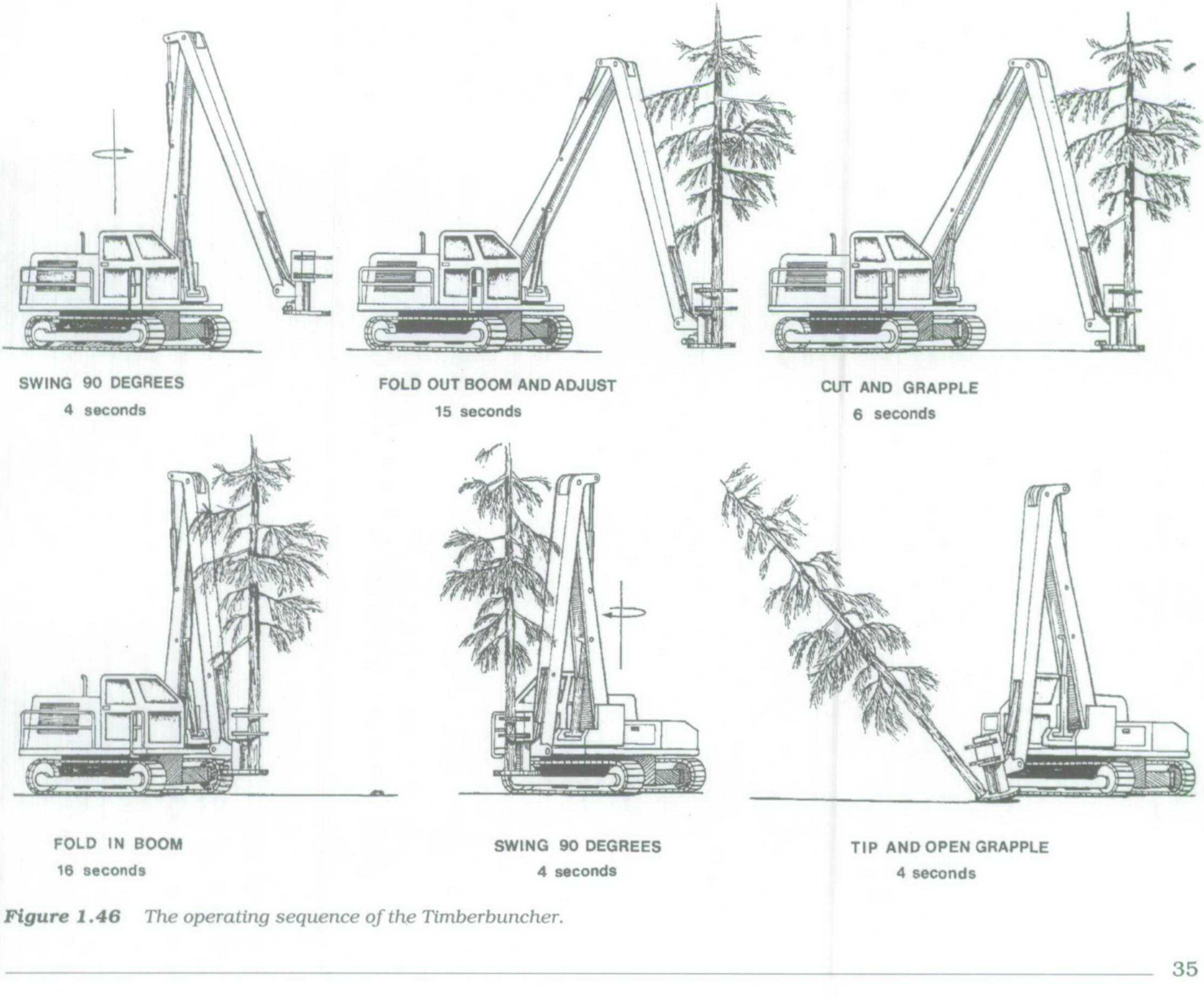


Figure 1.46 The operating sequence of the Timberbuncher.

Small hydraulic cylinders forced the jaws open when the cutting control was reversed.

The cutting rope would be less than three inches above the ground level, so stumps would be low. It was approximately ten feet long and had an estimated life of one week. Changing the rope took approximately one minute. When the tree was cut and grappled, it would be carried in an upright position, or tipped away from the standing timber to avoid hang-ups. The boom folded in, the machine was turned in line with the bunch, and the tree tipped while the grapple was opened (Figure 1.46). Production rates were estimated for stands of 25 cords per acre, with tree sizes averaging 15 trees per cord. At an estimated 75% mechanical availability, the eight-hour shift output was 28 cords. In stands of 15 cords per acre, the output was calculated to be 26.5 cords per shift.

While the Timberbuncher failed to find acceptance in the logging industry, it did made a significant contribution. It introduced the concept of a machine that used a felling head on the end of a boom to reduce machine movement through the forest, and to bunch wood.

Figure 1.47 *A Pope Harvester mounted on the C-frame of a D-7 tractor. The felling saw and main jaw are to the right, the delimbing jaw is in the centre. The machine approached a tree and grappled it with the main jaw, as close to the ground as possible. The tree was then severed from its stump, and held in a vertical position while the harvester moved to the chosen piling area. Then the main jaw was rotated 90°, allowing the tree to settle horizontally into the open delimbing-jaw. The arms closed around the tree and then the delimbing jaw was moved along its track, by means of a hydraulically activated cable and pulley system. All limbs were removed from the tree along the length of the track, which was 100 inches. The delimbing arms remained tightly fastened around the tree while the main clamp was opened slightly, so the tree could be pushed through by the return travel of the delimbing jaw. This action removed all remaining limbs and positioned the tree for bucking. The chainsaw had rotated to the bucking position when the main jaw had been rotated 90°. It then made the cut, and the 100-inch bolt fell to the pile (Hart 1958).*

Pope Harvester

A suitable stump-area shortwood harvester was needed for Canadian conditions. The Busch Combine, a development from the southern United States, was tested in eastern Canada and found unsatisfactory in the terrain, stand and weather conditions.

Another short-lived stump-area shortwood harvester was developed in Alberta and tried experimentally on the logging operations of Northwestern Pulp and Power Limited at Hinton, Alberta. It was conceived and fabricated in 1957 by John Pope of Hay River, Alberta (Anon. 1958). The Pope Harvester was designed as an attachment to the C-frame of a conventional crawler tractor (Figures 1.47 to 1.49). The attachment consisted of two hand-like jaws: a main jaw, capable of being rotated through approximately 100°, and a delimbing jaw, mounted on a track along which it slid. The third component was a hydraulically

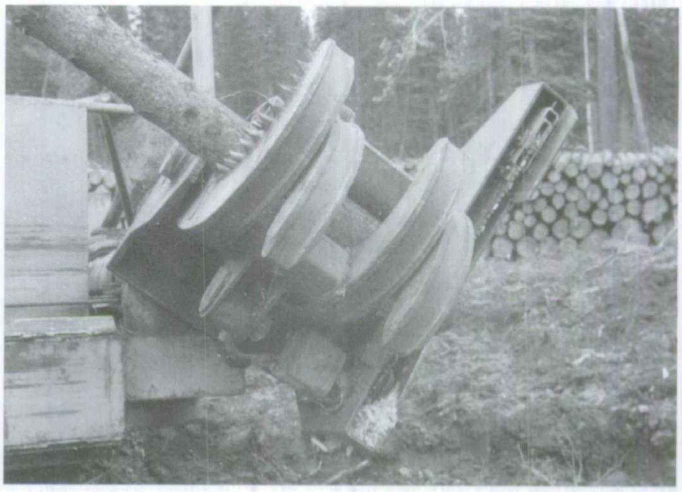


Figure 1.48 *The tree has been severed from its stump and is being rotated to a horizontal position into the open delimbing clamp of the Pope Harvester.*

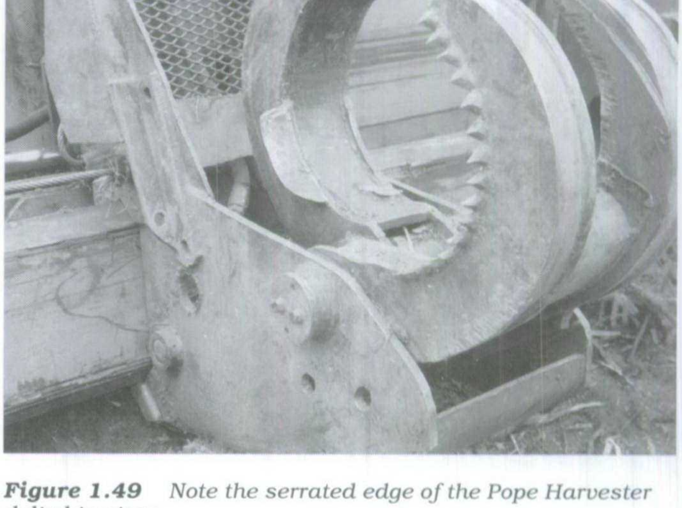


Figure 1.49 *Note the serrated edge of the Pope Harvester delimbing jaw.*

operated chainsaw, which rotated with the main jaw. The largest tree cut was 22 inches dbh and 95 feet tall. The quality of delimbing was excellent. Its productivity averaged one cord per hour. However, this unit never passed beyond the prototype stage, mainly because of the need to position the crawler tractor (D-7 class) at each tree to be felled, regardless of the size or terrain conditions.

Full-Tree Harvesting

The introduction of full-tree logging was strongly urged by Koroleff:

> *Full-tree logging depends on either the use or disposal of the residue yet it seems to offer many attractive opportunities for savings in cost wherever it can be applied. The conditions of work, the possibilities for full mechanization, the total yield per tree, the effectiveness of supervision, the safety of the work, the elimination of lost time, the housing of workers, the overhead economy, the protection of the forests from fire, and frequently silviculture, all these aspects of wood operation might gain considerably through a change from the conventional procedure to full-tree logging. But, of course, this technique should not be attempted when its benefits could be outweighed by disadvantages as, for instance, in single tree selection cutting, or where the leaving of slash on the cutover has been found to be of definite benefit (Koroleff 1954).*

In 1954, the Pulp and Paper Research Institute of Canada published a book by Alexander Koroleff entitled "Full-tree logging — A challenge to research." In his foreword to this volume, Gordon Godwin, Assistant General Woods Manager of the Ontario Paper Company Limited and Vice-Chairman of the Mechanization Steering Committee of the Woodlands Section, CPPA, wrote:

> *In 1950 Messrs B.J. McColl and W.A.E. Pepler presented to the Steering Committee an appreciation of the problems affecting the committee and later by the Woodlands Section Executive Council. Particularly notable was the approval given to the statement in the appreciation that...the full tree method provides the greatest possibility of successful mechanization (Koroleff 1954).*

Full-tree logging was begun experimentally in Siberia in 1948, and the Ministry of Forest and Paper Industries officially endorsed it in 1950. The report by Koroleff was primarily based on translated Russian material and dealt with all aspects of full-tree harvesting, including nutrient recycling, and chemical and mechanical utilization of residues.

Table 1.6 Direct Labour and Machine Hours to Deliver One Cord of Pulpwood from Stump to Landing (Simons 1961)

Operation	Man Hours	Machine Hours
Conventional four-foot	4.10	0.20
Tree length	3.05	0.77
Full tree*	2.60	0.82
Mechanized full tree	1.16	0.59

* Trees felled by chainsaw, bunched by horses and skidded to roadside with a wheeled or tracked skidder.

The Quebec North Shore Paper Company Limited hired Dr. Louis-Jean Lussier to head up an operational research division in its Woodlands Department in 1954. Dr. Lussier was a graduate of Laval University in Forest Engineering, and of the State University of New York at Syracuse, where he majored in operations research and industrial engineering (Lussier 1959). Using mathematical modelling techniques, Dr. Lussier and Rudy Vit, a forest engineer from Czechoslovakia, simulated a full-tree harvesting system based on two machines: one to fell and skid full trees to roadside, without any further processing in the forest; and the other to process the full trees at the roadside by removing their limbs and reducing them to the desired length. It was estimated that this full-tree system could be applied to 40% of the company's timber limits, with an anticipated cost reduction of 35% over the conventional four-foot logging system.

The basic principle of the full-tree system was to do as little work off-road as possible, and to do the remainder on prepared work areas. In other words, to use relatively simple equipment off-road and more sophisticated high-production equipment on prepared work areas (Bent 1969). The flow charts of the various logging systems in Figure 1.3 illustrate this principle. Table 1.6 shows a very significant reduction in man-hours per cord with full-tree logging.

Vit Feller Buncher

The machine designed to fell and skid full trees from Quebec North Shore's limits was called the Vit Feller Buncher. It was manufactured by Bombardier Limited, under agreement with the Quebec North Shore Paper Company Limited, and was patented in the name of Joseph Armand Bombardier (Canadian Patent 621,7831961). The first prototype was delivered in 1957.

The unit consisted basically of a Bombardier HDW rubbertrack-laying tractor on which was mounted a tree-grasping cradle, with a cutoff saw for felling and a toothed bar for holding the trees during skidding. This machine was the first mechanical tree harvester to operate successfully in eastern Canada (Figures 1.50 to 1.53).

Figure 1.50 *The operator of this Vit Feller Buncher has engaged the tree and is activating the felling chainsaw. To operate, the whole tractor approached the tree, lowering the holding cradle to a vertical position against the tree and opening its holding arms. The cradle was articulated and able to adjust itself to the exact location, lean, base height, etc., of the tree. The holding arms then closed and a slight uplift was applied to the tree. A hydraulic chainsaw with double chain and teeth emerged from a shield at the base of the cradle and cut a notch on the side of the tree nearest the machine. A second hydraulic chainsaw came out of a shield at the side of the base of the cradle and severed the tree from its stump. The cradle lifted, breaking the tree free from the stump, and lowered it over the back of the machine. The tree then rested on a toothed bar (braced to support and pull the tree), which extended across the machine about halfway back. A curved bar pivoted on the left side of the machine rose and nudged the tree across the toothed carrying bar to distribute the load. The whole machine then moved to the next tree, and repeated the process until it had a full load. Then it moved directly to the processing area or landing, carrying the butts of the trees on its back and dragging the tree tops. The toothed bar rotated 90° forward, freeing the trees of all restraints and the machine walked out from under them and returned to the cutting area.*

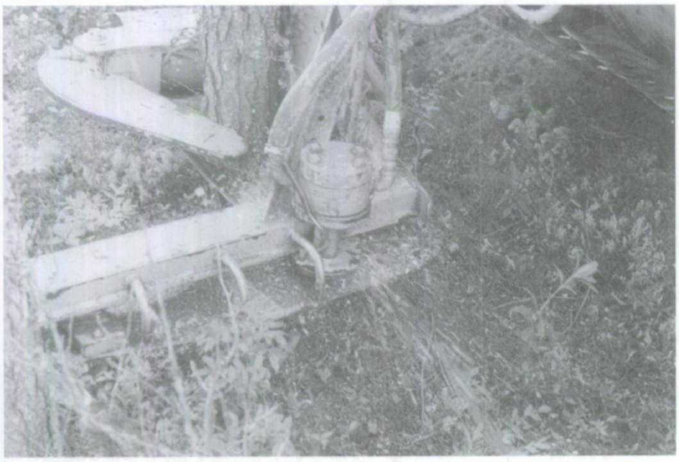


Figure 1.51 *The chainsaw felling head of the Vit Feller Buncher in action.*

The Vit Feller Buncher underwent extensive trials, not only on the operations of Quebec North Shore Paper Company Limited, but also at Espanola, Ontario, and by Logging Research Associates, Montreal. Eleven units were constructed between 1957 and 1966, of which six were exported to France (Figure 1.54).

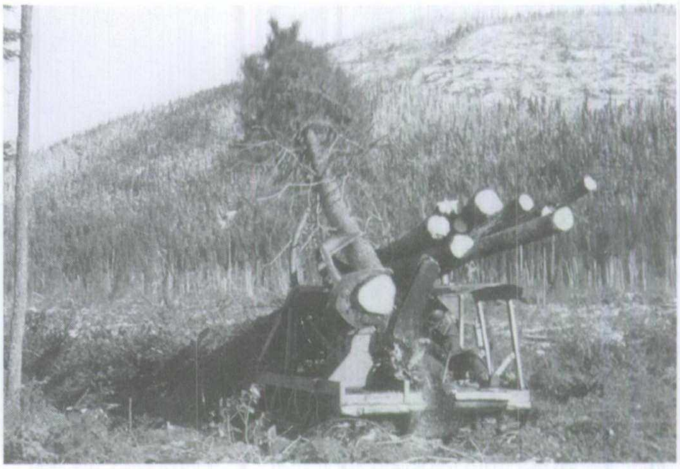


Figure 1.52 *Loading a tree over top of the Vit Feller Buncher cab into the holding rack.*

Figure 1.53 *The Vit Feller Buncher moving to the next tree to be harvested.*

The unit passed from the scene ten years after its conception, with a total production of about a dozen machines. The basic design concept was faulty in that it was essential for the machine to move to each tree it was harvesting. Studies showed that manoeuvering time amounted to 40% of the total manoeuvering, felling and loading time in the forest. The difference in concept between a machine that must wander through the forest, from tree to tree, and one that can travel in a more-or-less straight line, with the cutting head and grapple on the end of a rotatable boom, proved to be the difference between failure and success.

Larson Roadside Processor

In 1952, Bob Larson moved into the logging equipment business when, at the request of a local (Ely, Minnesota) contractor, he designed and built the industry's first hydraulic log-loading grapple. It was

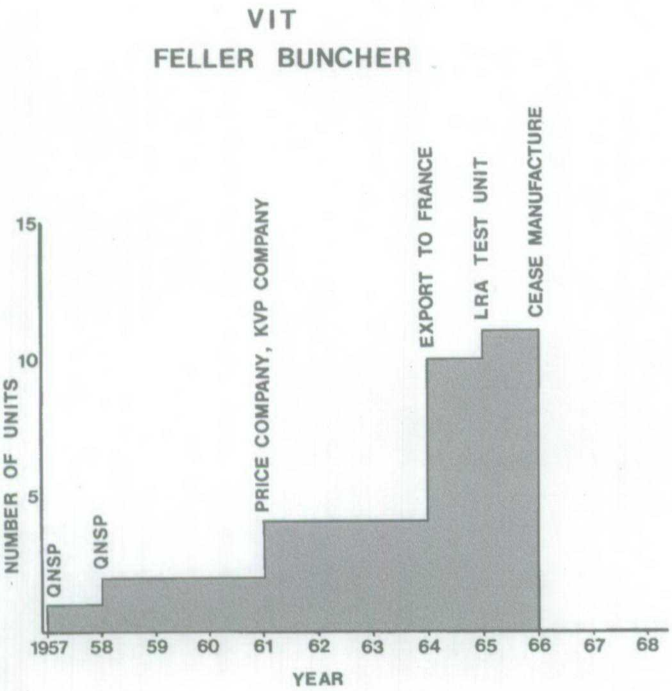


Figure 1.54 *The development period of the Vit Feller-Buncher.*

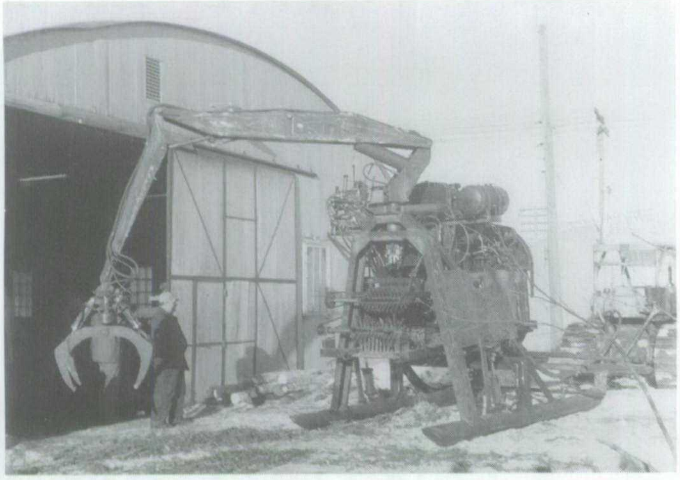


Figure 1.55 *Full trees fed into the Larson roadside processor were delimbed by chain flail and cut to eight-foot lengths. The unit was powered by the hydraulic system of a Caterpillar D-4 tractor.*

patterned after the Swedish HIAB crane and was aptly named the Hiabob Loader, reflecting its parentage as well as acknowledging Bob Larson.

Sales of this loader were good and his shop was hard pressed to keep up with demand. In 1958, at the request of Tomahawk Timber Company, who provided this funding, Larson built the first roadside-processor. This processor (Figures 1.55 to 1.58) was mounted on skids and was towed by a tractor attached to its rear end. The hydraulic system of the tractor also

Figure 1.56 *A full tree being fed into the Larson roadside processor.*

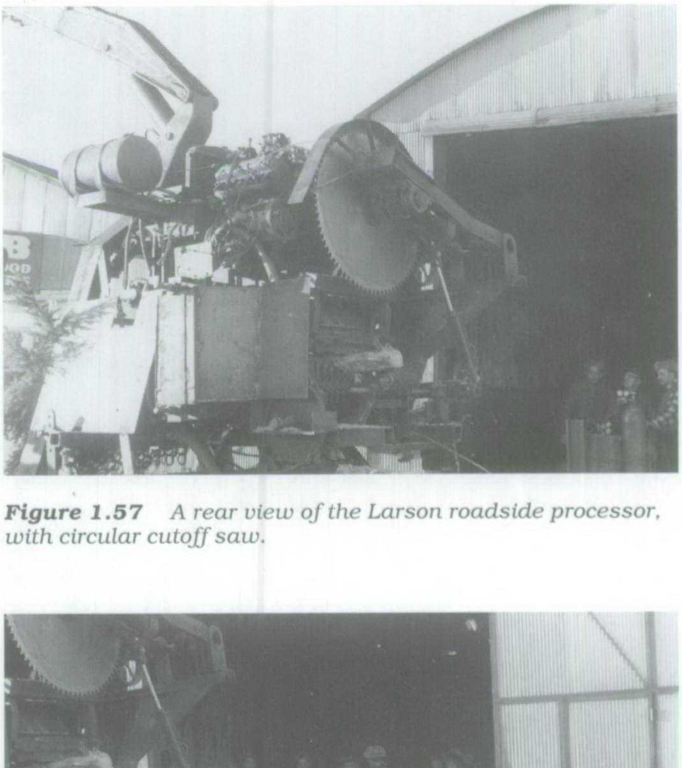


Figure 1.57 *A rear view of the Larson roadside processor, with circular cutoff saw.*

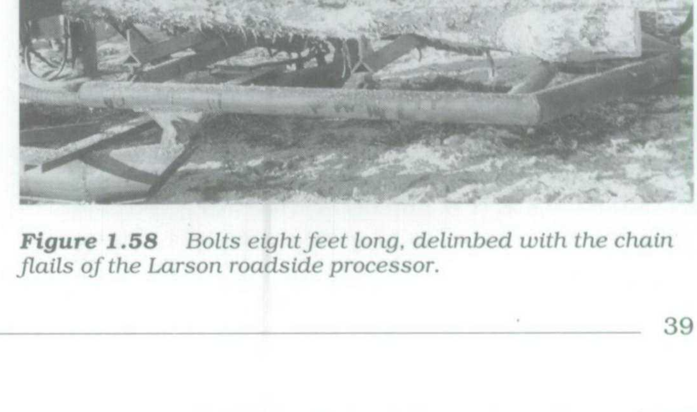


Figure 1.58 *Bolts eight feet long, delimbed with the chain flails of the Larson roadside processor.*

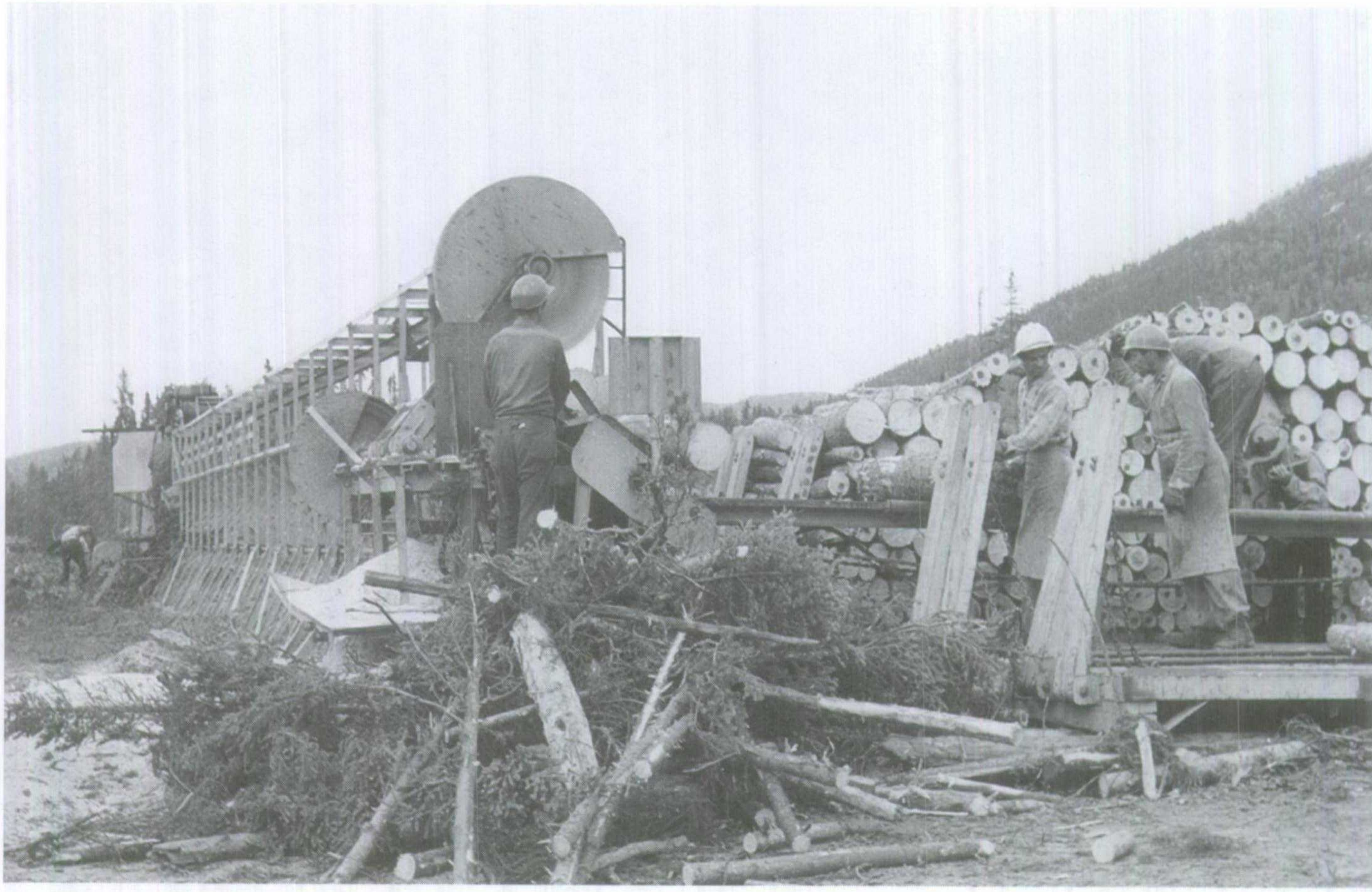


Figure 1.59 *A Bombardier Processing Unit, delimbing and bucking at the landing. With this new machine, full trees were dropped by the feller buncher under an overhanging trestle on the machine. The endless cable on the processor was slackened, dropping a choker, which was passed around the butt of a tree. The cable was tightened, raising the tree. At the same time, the winch advanced it to place the butt of the full tree in the open jaws of the delimber (two lengths of heavy roller-chain fixed at the bottom to a common pivot and at the top to two arms which are closed). The roller chain was wrapped tightly around the tree and the tree was pulled through the delimber by the winch, which operated at 450 feet per minute. The delimber chain was continually tightened to follow the taper of the tree. A high line-speed took advantage of the momentum of the tree to shear the larger branches. The winch was stopped, the winch line slackened, the delimbed tree-length was dropped onto the saw table trough and conveyor, and the choker was removed. The sawyer would advance the chain until the tree length hit a butting plate, a bolt was sawed off and the remainder moved ahead until the whole tree-length was utilized. The four-foot bolts were dropped onto a two-chain conveyor and were carried out between two pallet stations where the bolts were pulled off the chain into one of the pallets. When a pallet was filled, it was loaded onto a pallet truck, hauled to a river landing, scaled and dumped while another pallet was being loaded. The accumulation of branches was bulldozed out of the way.*

served to power the processor. The processing unit consisted of upper and lower spiked-feed-rolls at the input end of the machine, a chain flail delimber following the feed rolls and a cut-off saw for cutting the tree into predetermined lengths, a log-collecting cradle and an articulated boom and grapple assembly capable of feeding full trees into the processor and offloading the logs produced by it. This development led to the later design of the first tree-length harvester.

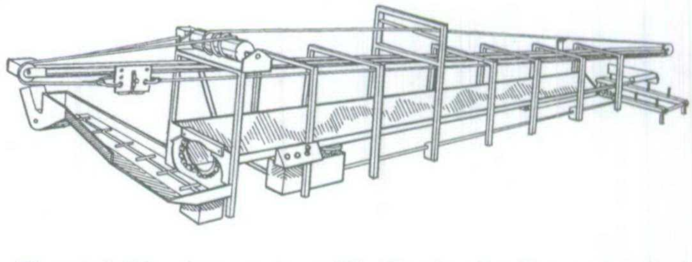


Figure 1.60 *An overview of the Bombardier Processing Unit showing the limb disposal conveyor, delimber and carriage mechanism.*

Bombardier Processing Unit

Quebec North Shore's second unit in their full-tree harvesting system was a roadside processor to remove limbs and buck tree lengths into four- or eight-foot pulpwood (Figure 1.59). In 1958, in cooperation with Bombardier Limited, the company developed a processing unit that was patterned on the endloading slasher principle. It differed from the more conventional slasher in that it possessed a

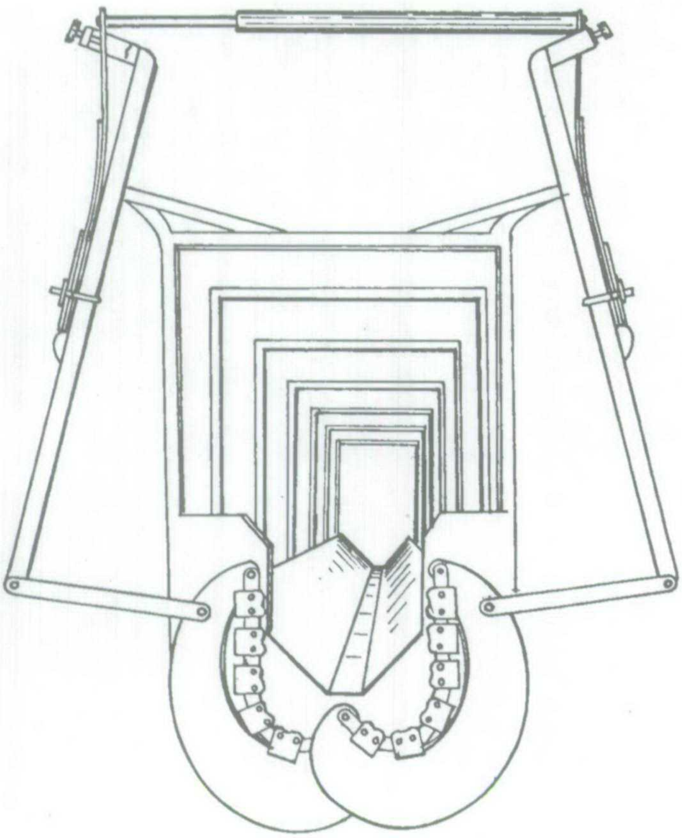


Figure 1.61 *An end view of the Bombardier Processing Unit showing the delimber and conveying trough.*

delimbing mechanism at the infeed end of the tree-length conveyor (Figures 1.60, 1.61). By means of a winch line working through a carriage, which travelled on an overhead monorail, trees were pulled through the delimbing device. At the delimber, a conveyor carried the limbs to one side, and at the saw end, a conveyor took the pulpwood bolts to pallets.

The Bombardier full-tree processing unit had a number of new elements. The delimber head was similar in principle to the chisel-chain of delimbing, which was also used on the Busch Combine; it used a standard mass-produced roller chain, and the sharp edge of the chain link was used to sever or tear off the limbs. The monorail or travelling carriage concept to handle a tree into and through the delimber already existed in the Godwin arch forwarder and in end-loading slashers. One of the first attempts at electronic scaling was tested on this unit. The scaling device that followed the cut-off saw measured the outside diameter of the bolt, and recorded this measurement as volume. It could take two readings per second. But all work on this full-tree harvesting development was stopped in 1963 (Sewell 1964), as it became apparent that both the feller-buncher and the processing components could not compete with the new technology, which allowed greater mobility of the system. Non-marketable material also was difficult to manage. Active interest in other tree-harvesting concepts was generated and indicated better opportunities for wood-cost reduction and control.

Horncastle's Chain-Flail Delimber

When the Quebec North Shore Paper Company was developing its full-tree harvesting system in eastern Quebec, its parent organization, the Ontario Paper Company of Thorold, Ontario, was also developing a full-tree harvesting system at Heron Bay. While supporting both developments, it was the conviction of woodlands management that the Ontario method would, in the long run, prove to be the most efficient.

In 1953, felling and skidding tests of full trees were performed to determine the production and costs for these two phases of a full-tree operation (Horncastle 1954). The trees were felled manually by power saw at about one cord per man-hour. The felled trees were bunched for arch-skidding with a D-4, using a Hy-speed winch and 25-foot A-frame,

Figure 1.62 *Skidding full trees with the Michigan Logger.*

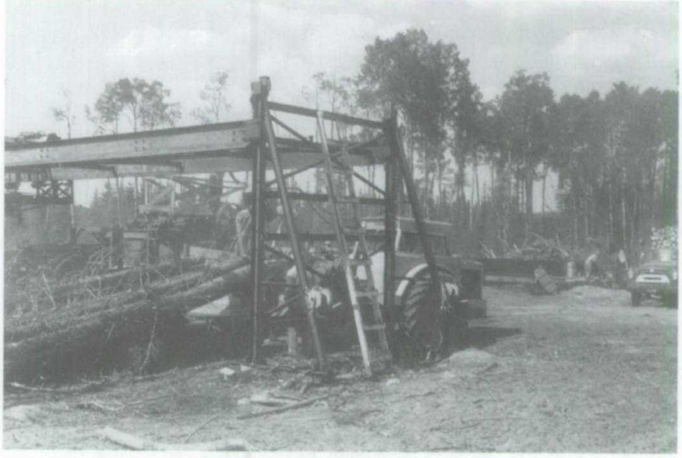


Figure 1.63 *A load being delivered under the travelling loader bridge.*

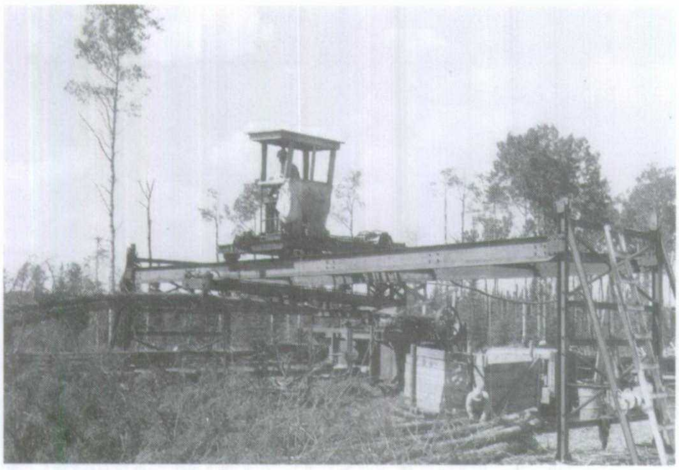


Figure 1.64 *A travelling loader with a heel boom grapple moving full trees sideways to the infeed conveyor.*

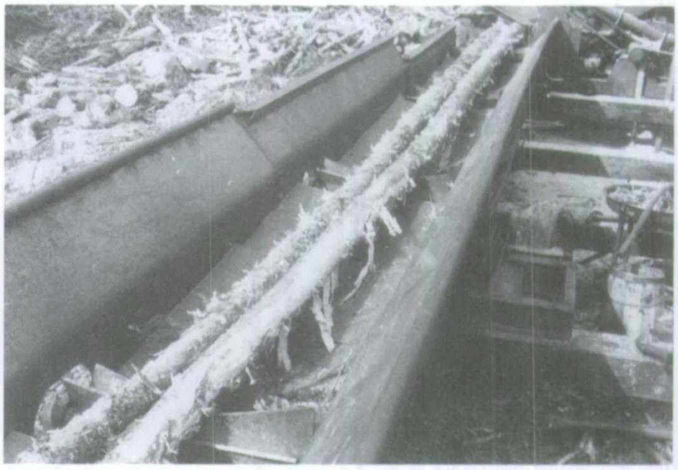


Figure 1.65 *Delimbed tree lengths in the outfeed conveyor.*

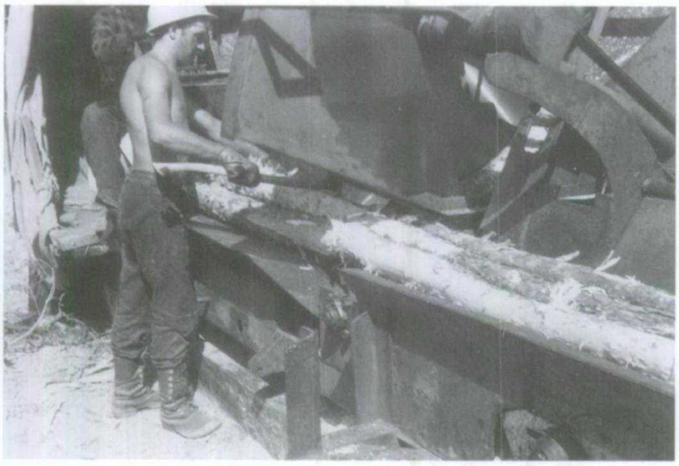


Figure 1.66 *Slashing tree lengths to four-foot bolts.*

Figure 1.67 *An elevating conveyor loads bolts into pallets.*

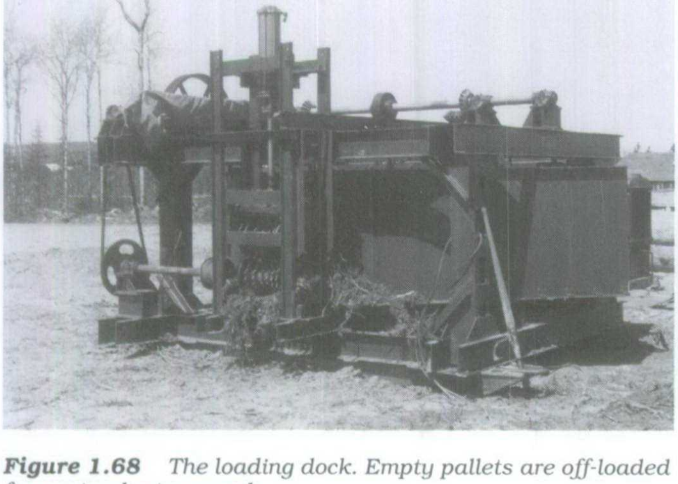


Figure 1.68 *The loading dock. Empty pallets are off-loaded from a truck at one end.*

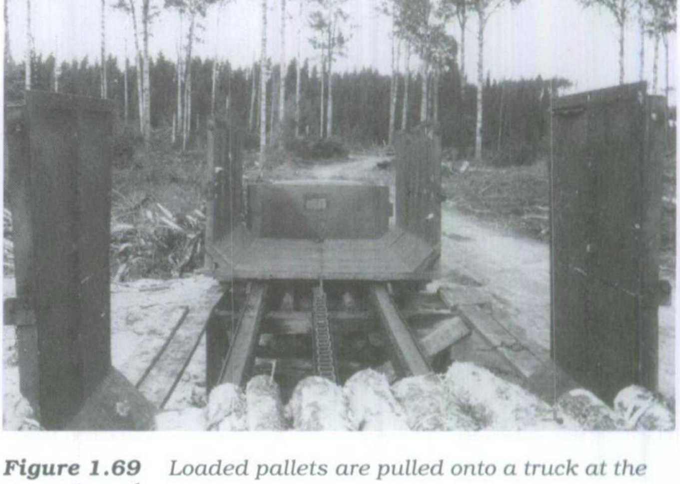


Figure 1.69 *Loaded pallets are pulled onto a truck at the opposite end.*

for distances up to 2 000 feet, at 20 cords per nine-hour shift. These bunches of full trees were moved to the landing with a TD-14 tractor and arch at 40 cords per nine-hour shift, over a distance of 1 000 feet.

By 1957, the operation had changed considerably. Instead of bunching and tractor-arch skidding, a Clark Pulpwood Logger was used to skid full trees directly from felling site to delivery loading terminal. Initially, the delimbing was carried out at the landing by axe and power saw, but in 1956 a mechanical flail delimber had been devised (Figures 1.62 to 1.65).

The Heron Bay delimber consisted of two drums, about 12 inches in diameter, to which four sets of chains in loops were attached. These drums rotated about 30 inches apart, similar to an egg beater. The tree was fed between the flails, which rotated in the same direction as the feed. The limbs were knocked off the tree and broken into one- to two-foot lengths. At the outfeed end, a pressure roll helped to pull the tree through the delimber (Horncastle 1956).

The delimber had a lineal feed-speed of 100 feet per minute. It was fed by a hydraulically operated grapple from bunches of trees lying parallel to the machine. The delimbed tree-lengths passed to a cut-off saw, which reduced them to four-foot bolts and loaded them into $1^1/_4$-cord pallets. These pallets were then pushed onto a truck for hauling to the final landing (Figures 1.66 to 1.69).

This machine was one of the first trials of a chain flail for delimbing. A somewhat similar device was under test by Bob Larson and the Tomahawk Timber Company at about the same time.

The Nineteen Sixties

The Move Toward Forest Engineering in Canada

Canada experienced a relatively serious recession during 1960 and 1961, but from mid-1961 underwent a period of rapid economic growth. Of particular help to the forest industry was the devaluation of the Canadian dollar in 1962. The level of unemployment dropped to below 4%, and wages and costs overall increased.

From 1965 onwards, a serious labour shortage developed in the woods. Montreal's Expo '67 sparked an unprecedented volume of heavy construction, including new autoroutes, subways, hotels, skyscrapers and other facilities. During this period, and under threat of strike action, construction workers received the largest and most rapid wage and fringe benefit increase ever negotiated in Canada. These high wages and fringe benefits attracted forest workers to the urban area, and many never returned to the woods.

Faced with the prospect of significant technological change, the Department of Manpower and Immigration in Ottawa began to investigate mechanized logging. Its report (Campbell and Power 1966) revealed that, among the major occupational groups in the country, loggers had by far the lowest education level, below both farmers and unskilled labourers. The report was unable to determine the degree to which technological changes in logging were displacing workers because of the high rate of voluntary quits in the industry.

The Forest Engineering Conference held at Michigan State University in East Lansing, Michigan in 1968 was an important event. It was sponsored by the American Society of Agricultural Engineers (ASAE) and represented the move by this group into the forest engineering and technology arena. The professional foresters' associations of both United States and Canada had had little to do with forest engineering, while the CPPA and the American Pulpwood Association, as national organizations, dealt specifically with various aspects of pulpwood production only.

This conference brought together engineers from equipment manufacturers, user companies, sawlogging and pulpwood logging to discuss new ideas and concepts in forest engineering, as it applied to forest management and harvesting.

Each year since 1968, the ASAE has had substantial representation in forest engineering at their annual meetings and has served as a focal point for developments in this area. The similarity between agricultural engineering problems and those in forestry engineering are self-evident. The ASAE has proven to be an effective forum and instrument for technology transfer. Developments and improvements in tree-length and shortwood harvesting machines have contributed to advances in the logging industry.

Tree-Length and Shortwood Harvesting Machines

A number of all-terrain and quadratrack vehicles were developed to skid tree lengths. In 1960, Bombardier Ltée of Valcourt, Quebec produced the Terrain Master (Figure 1.70) with a skidding-arch configuration for forwarding wood. Five prototype machines received wide testing in Eastern and Western Canada and in the southeastern United States (McIntosh 1971a). It was thought that such a unit would become a complement to wheeled units where the slopes were too steep or the ground-bearing capacity too low. However, a market never developed for these units, and the problem of variable loads causing variation in track tensioning persists.

The Nodwell Skidder appeared in 1960 with a soft-rubber track similar to the Bombardier units. There were two configurations: one carried a $1\frac{1}{2}$-cord bundle of eight-foot wood on its platform; the other skidded a one-cord load of tree lengths (Figure 1.71).

Go-Tract Systems Limited of Ste-Anne de Bellevue, Quebec, produced a tracked forwarder for eight-foot wood in the early 1960s, designated as the GT 220. This company was a member of the Rolls Royce group of companies.[31] The Go-Tract design was

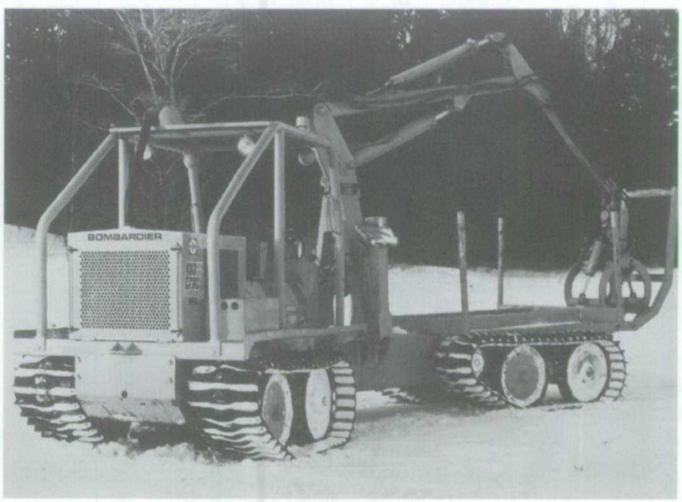


Figure 1.70 *A Bombardier Quadratrac Forwarder.*

Figure 1.71 A Nodwell Skidder.

considerably different from the continuous-band tracks exemplified by the Bombardier and Radisson, but only seven machines were built. Despite the Go-Tract's sophisticated track design and track-tensioning capability from the driver's station, both tracks became too tight when loaded and too loose when travelling empty.

In an effort to mechanize wood-harvesting operations, none of the conventional tracked-type vehicles proved satisfactory. The pin-type track, due to excessive wear in the numerous pin joints, was subject to considerable track elongation, which resulted in difficulties at the drive sprocket due to overpitching. The pinless-type of track, using the flexible endless band, was limited by the lack of strength and short service life of the band. Based on this reasoning, Logging Research Associates began an extensive project to develop a new track design, and a patent application dealing with their concept was filed in April, 1964 (Reid 1964). In spite of considerable success, Logging Research Associates finally gave up on tracks for their skidding and forwarding equipment, and turned to wheels.

The Dion F-4 forwarder (Figures 1.18, 1.19) was manufactured in 1967 by Adrien Vohl et Fils Ltee, St. Marc-des-Carrieres, Quebec, in cooperation with Domtar Limited. It was also produced in a skidder configuration. This machine was an articulated-frame-steered quadratrack machine with a low centre of gravity. It was designed specifically to operate in the steep terrain of the Laurentian Mountains, and had a vertical climbing ability of 65 to 68% and of 40% on sidehills. The Dion F-4 was narrow (67 inches) and could be used in selection cutting or in mixed wood stands where residual trees presented obstacles to wider machines. With power on all four tracks, the F-4 had the manoeuverability of a wheeled skidder or forwarder, since it had the same steering geometry in forward and reverse. Because of this, the machine could be driven empty in reverse into the cutting area, and then driven loaded in a forward direction, greatly reducing the need to manoeuvre in the forest. The major advantage leading to machine stability on steep slopes was the ability to change travel direction without turning along the contour.

The load capacity of the Dion F-4 was two cords of wood. Because all four tracks were powered, it was found that the life of the rubber-belted tracks was double that of tracks of similar construction on tractors pulling unpowered trailers.

Conventional Choker and Grapple Skidders

The introduction of skidders to an eastern Canadian pulpwood logging operation increased production tremendously. There were growing pains, and retrofits and modifications were necessary, but the spread of this innovation was rapid, and generated a multimillion dollar industry in a few years.

Timberjack Limited was the manufacturing success story in Canada in the 1960s. The first Timberjack model 200 skidder appeared in 1961 (Figure 1.72). The principals in Timberjack Limited were Wes Magill, a young trailer salesman from Woodstock, Ontario, Bob Symons, who joined with Magill in this venture, and Vern King, an industrialist from Woodstock, who provided much of the initial working capital.

Timberjack Limited grew so rapidly it became a victim of its own success. Their skidders were so popular that expansion of manufacturing facilities, inventory in process and accounts payable left them strapped for working capital. A marriage of convenience was arranged with one of their old and valued customers, Ellicot Dredge Company of Baltimore in

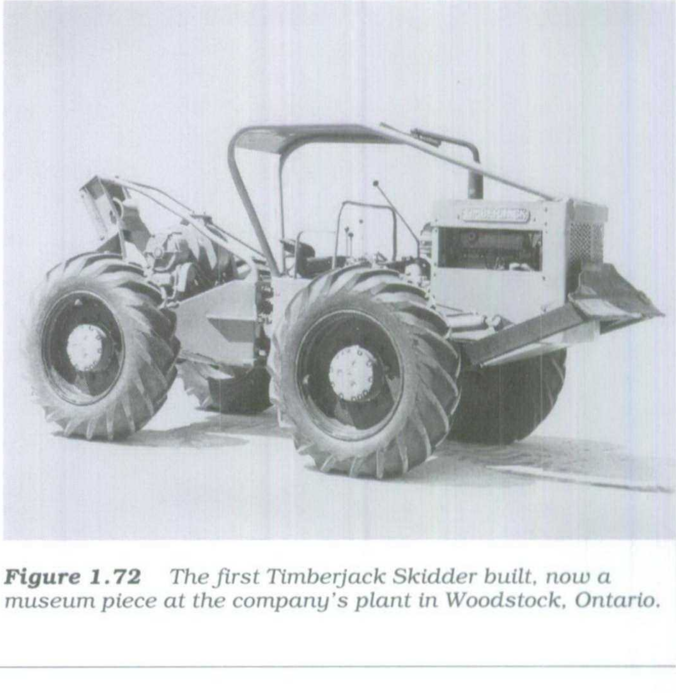


Figure 1.72 The first Timberjack Skidder built, now a museum piece at the company's plant in Woodstock, Ontario.

Figure 1.73 *The Beloit Grapple Skidder, developed as a companion to the Beloit Harvester.*

Figure 1.74 *The Clark 667 Grapple Skidder.*

Figure 1.75 *The Can Car Tree Farmer Grapple Skidder.*

Maryland, who used Timberland winches on the dredges they manufactured.

More than 27 000 skidders were produced for domestic and overseas markets. In a relatively short period, the demand for working capital became too great even for the resources of Timberland-Ellicot Limited, and the next move was to merge with the Eaton Yale and Towne corporate structure. The new organization was known as the Timberjack Division of Eaton Corporation.

Beloit Corporation brought out an articulated-frame-steered grapple skidder in 1964, as a companion unit to the Beloit Harvester (Figure 1.73). This unit did not prove very successful, and few were built. It was a heavy machine, almost double the weight of the conventional choker-skidder of the time. However, a unique feature of the unit, which was not duplicated by any other manufacturer, was the hydraulic heeling attachment that permitted the skidder to load the lengths directly onto trailers. Another unique feature was that the grapple support could be rotated from one side to the other.

The loading technique was simple. As the skidder approached the trailer from the rear and pulled up parallel to the trailer, the grapple was raised to an appropriate height (maximum 12 feet) and its load was swung into position above the rear bunk. As the skidder moved ahead, the tree lengths were drawn up onto the rear bunk until their butts were in position to be lowered onto the front bunk (Anon. 1964b).

Beloit also produced another skidder, which was ahead of its time. It was an articulated-frame-steered vehicle using a hydrostatic drive (Stefanides 1965). The hydraulic system was unique in that it used a fixed-displacement pump (double pump) at the engine, and pressure-compensated variable displacement motors on the axles. The system was split so that each pair of wheels was powered by a separate hydraulic motor; this made it possible to maintain constant horsepower by increasing the motor displacement.

The cable system on this skidder did not involve the conventional winch, A-frame and fairlead used by other manufacturers, but used a block and tackle system. It consisted of a fixed multisheaved block, and a moveable multisheaved block on the end of a harp-arm, which was moved through an arc by twin double-acting hydraulic cylinders. The movement of the sheave through an arc changed the length of the multiple cable strands reefed between the fixed and moveable pulley blocks. This movement provided a total travel of 65 feet.

Clark entered the picture several years later. Their first skidders, produced in competition with Timberjack and Can Car, were introduced in 1965. These were Models 664 and 666. Model 668 was produced in 1970, and in 1971, grapple versions of these appeared (Figures 1.74, 1.75). In 1972, Clark unveiled its Model 880, a mammoth 275 hp machine that weighed 26 tons, was 28 feet long and 12 feet wide, and had a line pull of 34 tons. This unit was designed for the

Figure 1.76 *The Michigan PL-75 Skidder.*

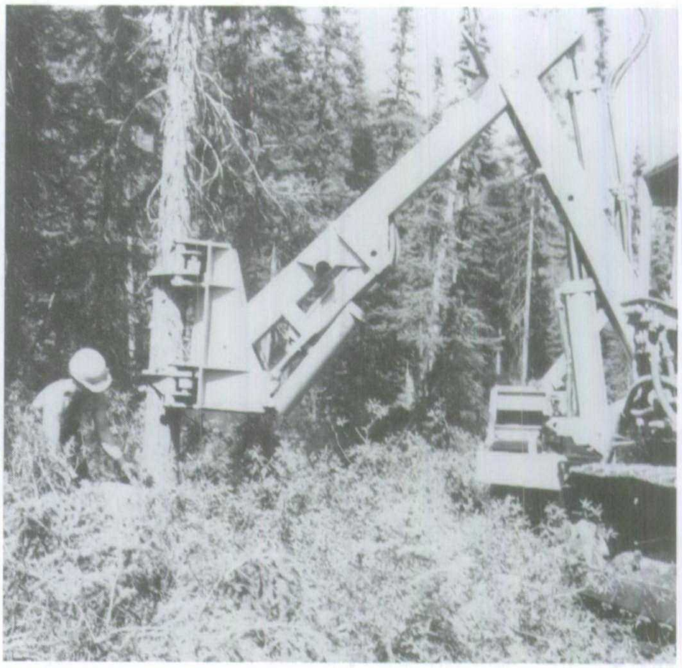


Figure 1.77 *A Feller Buncher grappling a tree while the cutter severs it from its stump.*

West Coast and for off-shore logging in tropical forests to replace elephants. In 1975 and 1978 new models of grapple skidders were produced.

It is interesting to speculate what the result would have been if Clark had followed up on the advantage it had in 1956 with the PL-75 based on the Bonnard Prehauler chassis (Figure 1.76). By 1965, when the company reentered the market, there were 8 800 skidders worldwide, and by 1971 this number jumped to 38 700.

Other manufacturers such as John Deere, Caterpillar, International Harvester and Massey-Ferguson also entered the field. These longline manufacturers held back until a market had been established, secure in the knowledge that the pioneers were basically assemblers who built their product with few of their own original components. The longline manufacturers made many of the skidder components for other products, which gave them a considerable manufacturing cost advantage.

Horncastle's Feller Buncher

The pulpwood produced by Ontario Paper Company Limited was shipped from Heron Bay through a boat loading plant to Thorold, Ontario. The fact that Ontario Paper was the only producer of four-foot wood may have been one of the factors that led Clark Horncastle and the resident manager, Bill Turner, to seek new concepts of wood production.

As part of the full-tree harvesting project, Horncastle invented a feller buncher, and supervised its construction and testing at Baie Comeau in 1960. The prototype was engineered and fabricated to his specifications by Timberjack Ltd. of Woodstock, Ontario (Figures 1.77 to 1.82). The feller buncher had no severing mechanism, although one had been included in the patent application. It was to be introduced once the tree-handling capability of this concept was proven. The sulky trailer had side arms that supported the cable upon which the butts of the felled trees were placed. A hydraulic winch on the sulky tightened the cable, which caused the side arms to flop over on top of the tree butts and hold them securely in place.

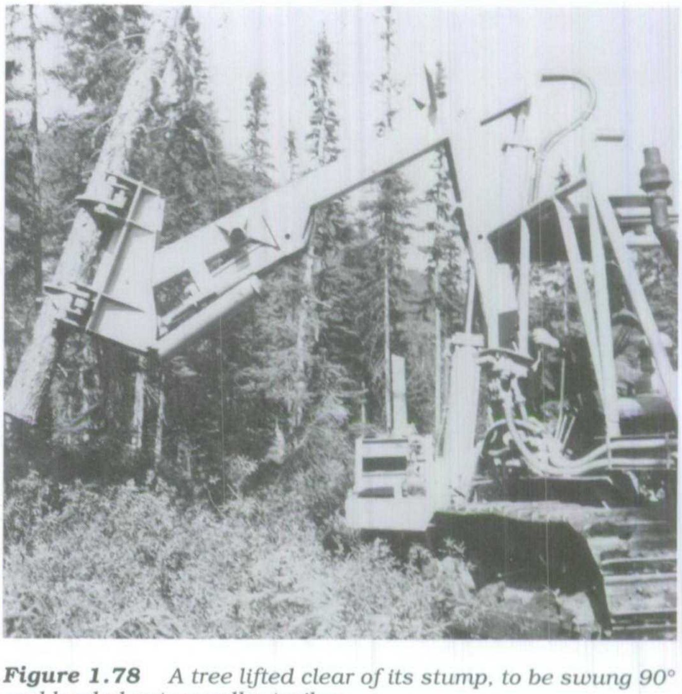


Figure 1.78 *A tree lifted clear of its stump, to be swung 90° and loaded onto a sulky trailer.*

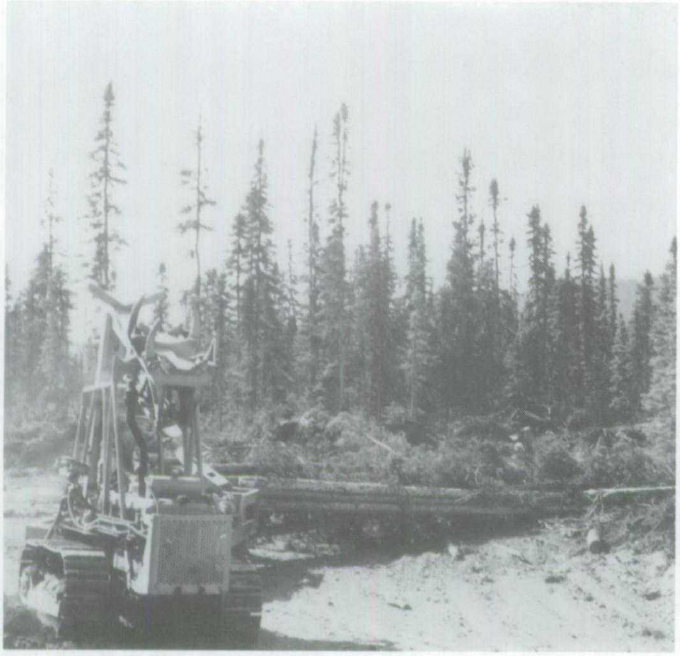


Figure 1.79 *A Feller Buncher skidding a load of full trees to the road.*

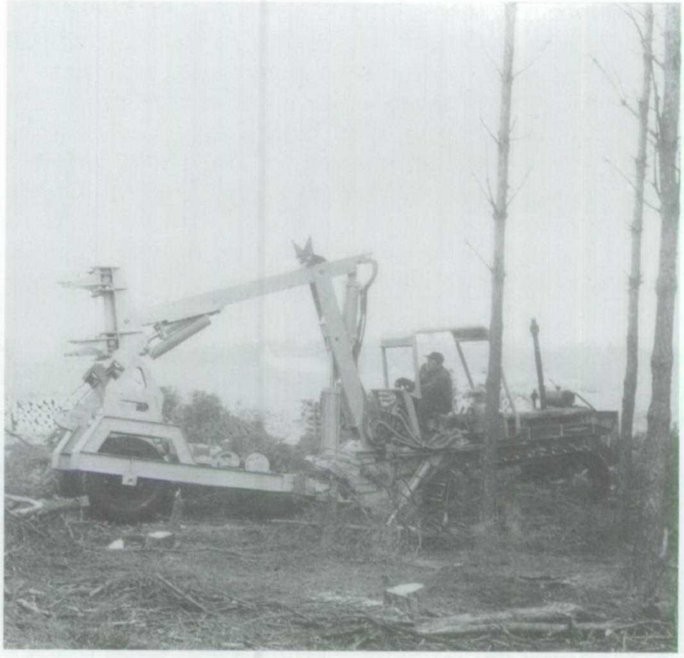


Figure 1.80 *A sulky being towed by a D-4 tractor.*

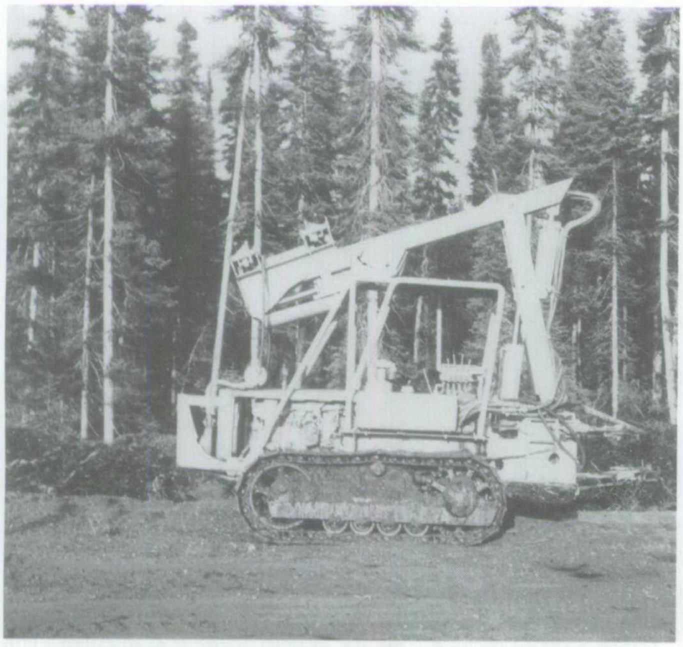


Figure 1.81 *A Feller Buncher mounted on a D-4 tractor.*

Figure 1.82 *A sulky trailer, a forerunner of today's clam bunk skidder. Tree butts rest on it and are encircled and held by a scable.*

Because the Horncastle Feller Buncher program was also developing the Vit Feller Buncher, it decided to discontinue work on the Horncastle feller buncher. It is interesting to speculate on what the future of the Horncastle feller buncher would have been if work had proceeded. Horncastle's feller buncher predated all the other feller bunchers, with a felling head at the end of an articulated boom, which has been the most successful concept in felling to date.

The Beloit Harvester

On the operations of Marathon Paper Mills of Canada Limited at Caramat, Ontario, a revolutionary tree harvester was put in the field in 1961. This machine was the first viable tree harvester to operate in significant numbers in the woods. The concept was truly revolutionary: it delimbed and topped the trees before felling them, which was the complete reverse of conventional practice. The idea of using the tree as a structural support during the delimbing and topping operation was new. A variation of it had been tried in Europe, but was found to be too slow, and controlling the delimbing and topping mechanism presented problems. But, having a light, tall mast to place alongside the tree, which could support and control the delimbing and topping mechanism, proved successful, and led to the development of the widely used Beloit Harvester.

The Beloit Harvester was originally conceived by the Woodlands Staff of Marathon Paper Mills as a key element in their logging mechanization program. It arose out of a need to eliminate the bolt-by-bolt handling of small trees. In 1958, the company looked at ways of circumventing the cutting and piling of small trees. It realized that during the short season, machine felling and delimbing could not economically compete with men operating power saws. If a machine was restricted to small trees, could work for a longer season, and was capable of multi-shift operation, it could successfully compete with men and power saws.

Figure 1.83 *Shears of a Marathon Spruce Harvester severing a tree from its stump.*

To improve skidding productivity and cost, and thus be competitive, a mechanical feller had to be able to bunch a number of trees in addition to felling and delimbing. If the proposed machine could also bunch the tree lengths, increasing skidding productivity, the combined cost for the tree harvester would be much more economical.

Figure 1.84 *A tree being swung to the side of a Marathon Spruce Harvester to be placed in a pile.*

Figure 1.85 *The delimber head of a Marathon Spruce Harvester part-way up a black spruce tree. Delimbing took five seconds, shearing the top took three seconds, shearing the tree from its stump took four seconds.*

Figure 1.86 *The top of the tree has been sheared by the Marathon Spruce Harvester and is falling point-downwards.*

Preliminary designs suggested that the total weight of the unit depended on the weight that the mast, tools and tree imposed on the carriers and booms at maximum reach. A mathematical time analysis indicated that the machine could not afford to move from tree to tree, but must reach to a number of trees from one position. The model also indicated that the tree should be delimbed and topped before it was severed from the stump.

Based on this preliminary work, Marathon Paper Mills entered into a cooperative agreement with Bob Larson to design and fabricate a prototype unit. A design priority established that top and bottom shears, a mast to carry delimbing tools and shears, a boom to extend the tool assembly to the tree, a carrier for the working components, and a delimbing tool, capable of shearing limbs while following the contour of the bole, were essential.[32]

In November, 1960, Larson delivered a prototype of this tree-length harvester to Marathon Paper Mills of Canada Ltd. Though the original concept of this harvester was put forward by members of Marathon's Woodlands Department, it was Larson who converted the ideas into hardware that worked.

The first working components were mounted on a modified TD9 tractor base. In 1961, after several months of experimentation, the assembly was redesigned and mounted on a crane base (Figures 1.83 to 1.86). The unit produced 41.2 trees per productive-machine hour, including moving time, and had a mechanical availability of 67.4%.

A second prototype went into service at Marathon in 1962. This unit was mounted on a Warner-Swasey Gradall, with an Insley undercarriage. Dick Harkness of Marathon expressed dissatisfaction with this unit, because of the excessive weight of the mast and tools, and the limited boom reach.[33]

A second pre-commercial prototype (Figure 1.87) was placed in operation with Great Lakes Paper Company Limited in 1962 (McDonald 1962, Seheult 1962). This model differed from those at Marathon. It was mounted on a rebuilt Caterpillar, model D-7, chassis that had been used for 11 000 machine hours as a bulldozer. It was designed to harvest larger trees than the original units. A fourth machine, still a

Figure 1.87 An early-model Beloit Harvester with a light lattice-type boom.

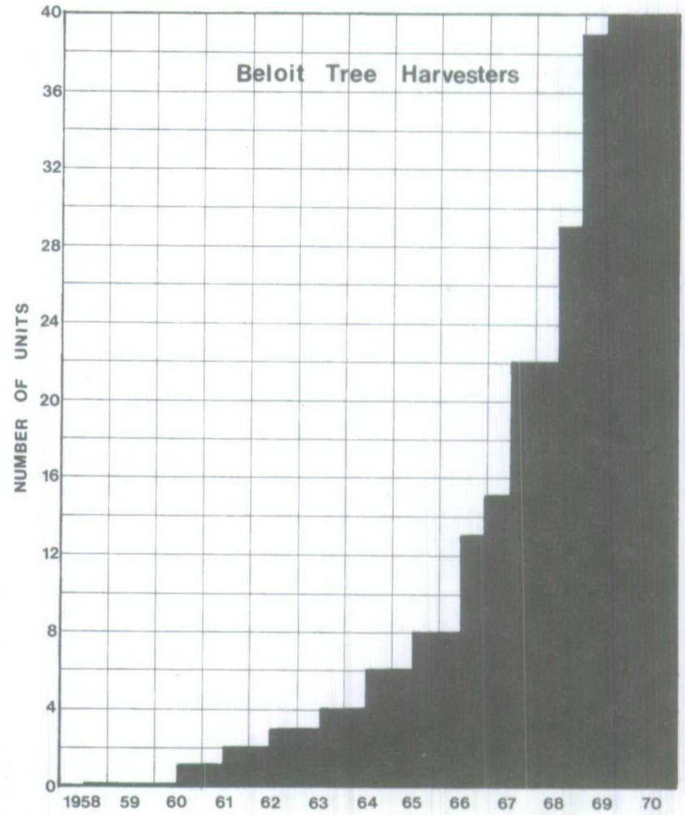


Figure 1.88 Number of Beloit harvesters produced, 1958–1970.

pre-production model, was purchased by KVP Company, Espanola, Ontario, in 1963 (Anon. 1964a).

Changes in the design of components gradually evolved. The first prototype had scissor-like curved shears that, when closed, had the blades overlapping. These were changed to blades with straight edges that met, but did not overlap. These blades also had curved collars welded at right angles to their surface to hold the butt of the tree after it was severed from its stump.

The original delimbing tool consisted of a flexible band of cutting chisels that wrapped around the tree, moving upwards to cut off the limbs. It was hydraulically adjusted to the taper of the tree. This device was similar to the delimbing tool on the Busch Combine so, rather than become involved in licensing or facing an infringement suit, the delimber was redesigned. The result was a much simpler two-piece tool, which gave as good quality delimbing as the displaced tool had.

The basic Canadian patent for this harvesting machine was filed on June 3, 1963, and issued as patent number 3,353,575 on November 21, 1967, in the name of Robert W. Larson, Ole E. Olson, Wilfrid D. Harkness and William E. Mair. Larson owned Larson Enterprises, which manufactured the early prototypes; Olson was the Mechanical Superintendent, Woodlands Department of Marathon Paper Mills of Canada Limited; Harkness and Mair were Logging Engineer and Assistant Woodlands Manager, respectively, for Marathon (Larson et al. 1967). The paper company's rights to this development were turned over to Larson Enterprises. But the patent was not assigned, perhaps because the agreement was made between the filing and the issuing date of the patent.

Because of the widespread interest in this harvesting machine, and the potentially large amounts of capital required to satisfy demand, Bob Larson sold his company in 1963 to Beloit Corporation of Beloit, Wisconsin. The Hiabob Hydraulics Corporation of Ashland, Wisconsin, became the Woodlands Division of Beloit (Hensel 1964, Keen 1965, Castagne 1967). Larson remained with Beloit Corporation in charge of woodland equipment development (Michell 1964) until he formed Larson Woodlands Research Limited in 1967. It's headquarters was located in Port Arthur, Ontario (now Thunder Bay).

Forty Beloit harvesters were made before its manufacture ceased (Figure 1.88). It was probably the application of the concept, rather than the concept itself, that was wrong. The original intent was to develop a small-tree harvester, but in the final application of the concept, the delimbing-topping tools were supported by a 5 000 pound mast 65 feet high, held at the end of a boom. It was a machine weighing 62 000 pounds, which seriously limited its mobility. This, plus the fact that the productivity of the machine was related to tree size (Aird et al. 1970) and was only economic in stands that were above-average in size for eastern Canada, limited the application of the unit (Silversides 1971).

Testing Machine Concepts Mathematically

In 1967, Dr. Monty Newnham of the Forest Management Institute of the Canadian Forestry Service, produced one of the first harvesting-machine simulation or mathematical models (Newnham 1967a, 1967b, 1968). This created considerable interest, primarily with equipment manufacturers, because they were a relatively inexpensive means of testing machine concepts and juggling their parameters to establish their limits of productivity.

Initially, the models dealt with two different types of harvesters: the Beloit Tree Harvester and the LogAll. The Beloit delimbed standing trees, topped them, cut them from their stumps and piled the tree boles in bunches. The LogAll felled trees and collected them on the back of the machine to skid out to the roadside. These machines were either track mounted or wheel mounted and had a rotating boom capable of reaching out and harvesting trees within a certain radius.

The operating efficiency of a harvesting machine depends on a number of parameters. Specifically, the time required to perform certain functions, such as moving from point to point, positioning the cutting head, delimbing and topping the tree, swinging the tree from the stump to the bunch, and positioning the tree in the bunch and returning to the next tree, affects the productivity of a tree harvester. The physical characteristics of the machine, such as the maximum and minimum reaches of the boom, and the arc within which the boom can operate, determine how the unit operates in the field. The working environment, such as the distance between successive passages through the stand (the strip width) also have a direct impact on the efficiency of a machine.

Mathematically it is possible to simulate a machine's productivity by varying only one factor and keeping all the other variables constant. This is almost impossible to do empirically with a machine in the forest. Newnham's simulation models were useful in the design and development of new logging machines. For the Beloit Harvester, tests indicated that slewing speed and maximum reach had the most effect on harvesting time. In October 1970, J.C. Huntingdon of Clark Equipment of Canada Limited, stated that they had modeled 30 different harvester concepts using Newnham's technique.

Second Generation Beloit Tree Harvester

In 1968, Domtar Woodlands Ltd., in cooperation with Larson Woodlands Research Limited, developed a second-generation tree harvester named the Domtar Combine. By automating all constant functions, and operating where conditions were favourable, the prototype produced 248 trees in a test hour (at the rate of 40 centiminutes per tree placed in piles of 200 cubic feet). Because the prototype's automatic controls had not been fully perfected, the operator had to override the automatic control system if trees were not uniform in shape. However, the test operator, despite the fatigue he had to deal with, was able to operate the Combine at less than 10% productivity delay for the full test hour. Stand uniformity is apparently an essential factor when employing automatic control. (Figure 1.89).

Placing a tree in the rack initiated an automatic process in which the tree was delimbed, topped, and accumulated in a storage magazine designed to hold up to 40 tree lengths on end. When the storage magazine was loaded, the operator lowered it to the ground, thereby depositing a compact pile of tree-length wood behind the machine (Bjerkelund 1965).

Only one of these second-generation Beloit Harvesters was constructed. It was introduced to the operations of Domtar Limited at Lebel-sur-Quevillon, Quebec, but

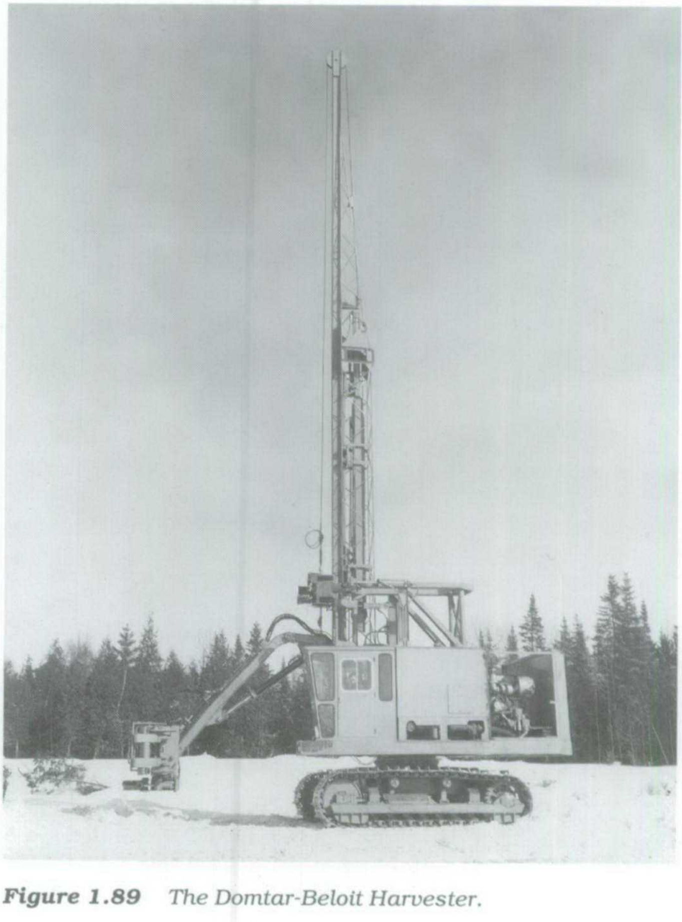


Figure 1.89 *The Domtar-Beloit Harvester.*

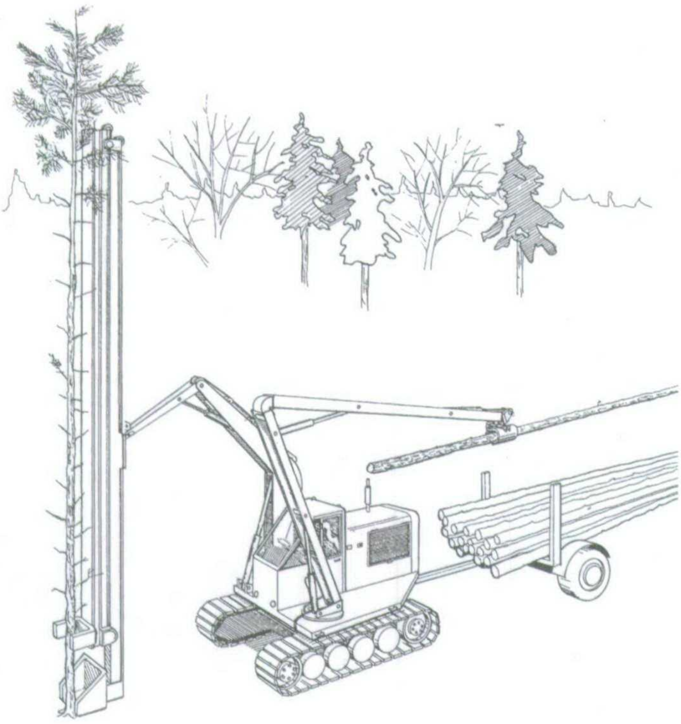


Figure 1.90 *The Beloit Feller-Limber-Buncher concept.*

was destroyed by fire in 1970. Soon after, the Beloit Corporation withdrew from the forest operations equipment manufacturing business. Finland had met all of its retribution responsibilities after WW II by building paper-making machinery of the highest quality. It then sought to minimize its losses by entering the international paper-making market. Beloit Corporation was not prepared to meet this market intrusion, and as a result, Finnish interests (financially supported by their government) won all six sales in the US. Beloit therefore had to sell some of its assets to survive.

The Domtar Combine was a variation of the stillborn concept shown in Figure 1.90. This concept appeared in a publication called *Newspaper Facts* (Anon. 1967b) and showed a machine with one operator controlling the harvesting head and the other, the transfer arm. In the Domtar-Beloit unit, the transfer was automated. Instead of accumulating tree lengths on a trailer or semi-trailer, as shown Figure 1.90, the Domtar-Beloit machine collected the harvested tree-lengths vertically in a magazine, and deposited them on the ground in grapple-skidder-sized loads.

The postscript to this report is that, in 1981–82, Domtar Limited at Lebel-sur-Quevillon was still operating six machines, Nova Scotia Forest Industries at Port Hawkesbury was operating nine, and Scott Paper Company's S.D. Warren Division in the northeastern United States operating five, some with over 100 000 operating hours behind them. In short, more than a decade after their production ceased, 70% of the units manufactured were still in operation. Perhaps the industry gave up on a good idea too soon. According to Dick Harkness: "The Beloits were giving us the cheapest wood of any system we had but we just couldn't get parts for them anymore. If the parts had been available we'd still be using them" (Anon. 1974d). Domtar Woodlands Ltd at Nipigon used two Beloit Harvesters (two shifts per day) and eight to ten wheel skidder crews of two men each to form a tree harvesting unit. These units had a Unit Superintendent, a foreman and field mechanics (usually two). The Beloits harvested stands most suitable for mechanization (e.g. larger limby trees, underbrush, and deep snow). Wheel skidders harvested those stands most suitable for motor-manual fell to full tree. Stroke delimbers processed skidder trees to tree lengths. This two-option unit added considerable opportunity for efficiency.

Koehring Load Aligner

When a loading grapple-loads of eight-foot pulpwood onto trailers, the loads were frequently uneven, with many bolts protruding. Studies showed that the overall width of loads of eight-foot pulpwood was sometimes 14 feet. Jack Eynon, forest operations development superintendent for the Lakehead Woodlands Division of the Abitibi Power and Paper Company Ltd. in Thunder Bay, Ontario, solved this problem. He constructed two large horizontally corrugated drums, free turning on their axles and unpowered. They were mounted on pantograph structures that permitted the drums to move upwards and outwards while maintaining their vertical orientation. Trucks and trailers cross-loaded with eight-foot bolts passed between the drums without stopping. This process lifted the wood, centred it and pushed in all the projecting bolts.

Development of this unit, which is known as the Koehring Load Aligner (Figure 1.91), was assigned to Eynon's employer and licensed first to Can Car, and then to Koehring Canada Ltd. It has found wide application in the logging industry.

Figure 1.91 *The Koehring Load Aligner.*

Vertiloggers

Another item developed by Eynon, the Vertilogger, was a tree harvester that delimbed and reduced the tree to 16-foot bolts or logs while it was in the vertical position (Figure 1.92). Traditionally, logging residues, calculated to weigh up to 45% of the merchantable wood, were disposed of before any work was done on them. The most efficient way to forward wood was considered to be in compact bundles of optimum and uniform cubic content. Eynon reasoned, however, that the "stump processing" concept offered the greatest promise for minimum production costs. In principle, "the vertical logging machine" would proceed through the forest, reaching out with its harvesting mechanism, with a reach of 28 feet, to selected trees, process them where they stood into 16-foot log lengths, accumulate these into optimum-sized bundles, and deposit them on the ground (Figure 1.93).

The Vertilogger concept never got past the drawing-board stage. Eynon's employer, Abitibi Paper Company, was already committed to supporting the developments of Logging Research Associates, and no equipment manufacturer expressed interest in the Vertilogger. The concept of vertically processing a tree downwards was used successfully in the Koehring Shortwood Harvester, but in this instance the processing was carried out aboard the harvester.

Vertical tree-processing did appear in several other developments, but none developed past the prototype or test bench stage. One of these developments was initiated by the Cincinnati Milling Machine Company of Cincinnati, Ohio. The concept was patented in the name of Robert Winblad and issued in 1967. Winblad's patent abstract reads like a description of Eynon's Vertilogger: "A tree harvesting machine which advances to a tree and holds the tree in an upright position as the tree trunk is severed therefrom, the trunk being drawn downwardly as sections are severed, limbs being cut from the trunk as the trunk is drawn downwardly, the sections being transferred to a bin which travels with the machine."

Another variation of this concept was the Probst Harvester, funded by four American pulp and paper companies: Hudson Pulp and Paper Company, ITT Rayonier Inc., Brunswick Pulp and Paper Company, and Continental Can Inc. The principle of operation was the same as Eynon and Winblad had used: to grapple a tree, process it downwards in vertical position over the stump, and collect the severed bolts in containers that would be dumped in piles on the ground. Four pre-production models were fabricated, one for each sponsoring company.

Eynon Feller-Limber-Buncher

Jack Eynon proposed a new concept for a feller-limber-buncher in 1967, which consisted of three components: a harvester, to prepare tree lengths in bunches; a grapple skidder or some other type of forwarder to move the wood to roadside; and a mobile

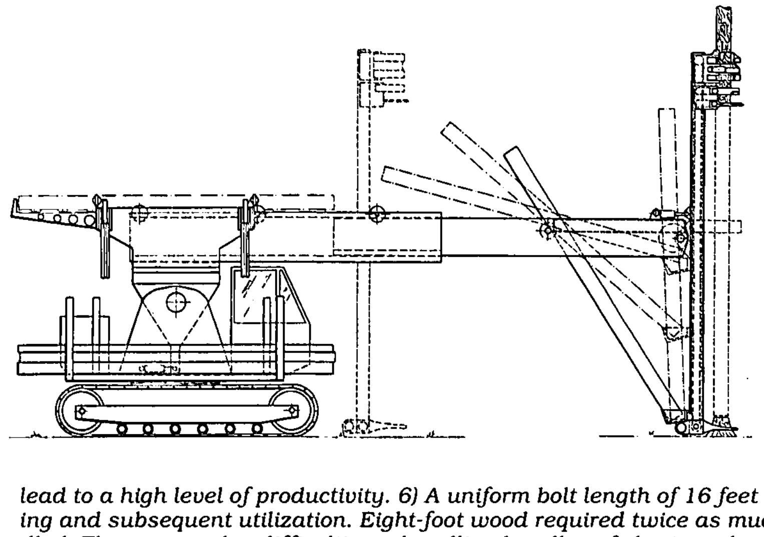


Figure 1.92 *The Eynon Vertilogger. In April 1964 Eynon itemized the many advantages he saw in the operation of this machine. 1) No work was done on waste material, which was left where it was least troublesome — at the stump. 2) 'Vertical logging' conserved space. There is seldom room to fell trees, pick them up and align them for processing. The proposed machine would permit selective cutting or cutting under virtually any residual stand condition, provided there was room for the carrier to pass through. 3) The machine took full advantage of the kinetic energy available by virtue of the tree's position; the hardest operation — delimbing — was performed as the tree descended. 4) Processed logs were transferred continuously to the carrier proper, without interfering with the slashing cycle. No boom movement or swing was required. 5) Tree cycles could be overlapped; the positioning of the boom and slashing track for the next tree was carried out during the latter part of the previous tree cycle. The machine could reach for the next tree while the first tree was still being processed; this continuous operation would lead to a high level of productivity. 6) A uniform bolt length of 16 feet was chosen as the optimum length for efficiency in processing and subsequent utilization. Eight-foot wood required twice as much shearing, and twice the number of pieces had to be handled. There were also difficulties rehandling bundles of shortwood much in excess of one cord. Eight-foot bolt lengths could not be used for anything but pulpwood, while 16-foot log lengths could be used as sawlogs. 7) A two-cord bundle of 16-foot logs would be a most efficient package to forward either on tracks or wheels. This would require a forwarder designed for the job. However, there is ample evidence in the success of high-capacity units such as the Dowty, that such machines were entirely feasible and could be readily designed and built once the need became evident. The two most significant factors in low-cost forwarding are the maintenance of maximum payload and the time taken to load and unload. The pre-packaged bundle of approximately two cords that can be loaded and unloaded in one motion fully satisfies these requirements. 8) Land-based wood would be transported, to a very large degree, to mills in chip form. The 16-foot production, once forwarded, could be transferred by intermediate haul to a central concentration yard where logs could be effectively sorted if required and subsequently fed into a barker-chipper plant, the screened output from which could be retained in large hoppers for rapid loading of high-speed haul units. Here again the advantages of the 16-foot log are obvious, sawlogs could be sorted out. The 16-foot length was a very desirable one for barking and chipping.*

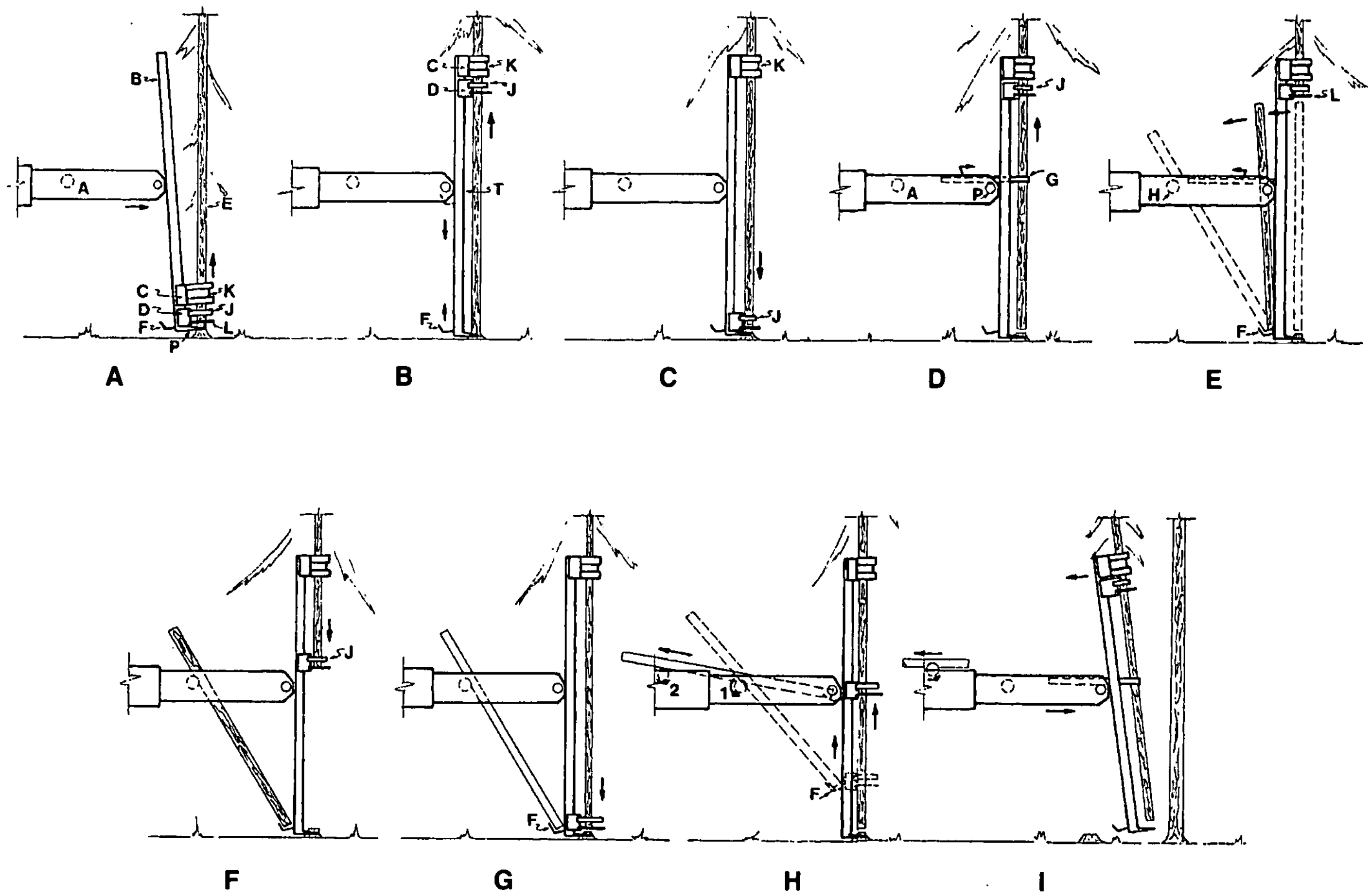


Figure 1.93 *The sequence of operations of the Eynon Vertilogger.*

multi-stem slasher to produce wood in the desired lengths (Figure 1.94). Eynon believed his concept would overcome the limitations that the Beloit Harvester had with respect to terrain and timber stand.

In operation, the tree was sheared and placed on a support deck on top of the cab, where a delimbing boom was activated, and the delimbed tree-length was deposited in the clam bunk at the rear of the machine. Eynon envisioned that up to two cords would be accumulated before being deposited on the ground. This machine needed a much lighter boom to control the felling of the tree and to raise the butt than the Beloit Harvester required. One track-mounted version was constructed by Warner and Swasey, and underwent some tests at Thunder Bay, but work on the project was never completed.

Larson L-11 Tree-Length Forwarder

Larson Woodlands Research Limited joined with Great Lakes Paper Company Limited to develop a tree-length forwarder in 1967. It was designed to operate with the Beloit Harvester, which produced tree lengths in bunches of up to 70 trees, or approximately three cunits (Bérard 1967). The unit was mounted on Caterpillar D-7 tracks with 24-inch shoes; each track was driven by a Staffa Mark IV hydraulic motor. The forwarder was powered by a Caterpillar D333 engine and could travel at two speeds: 1.4 mph in low gear and 3 mph in overdrive.

The grapple was eight feet wide and had a 17-foot loading height. The distance between bunks on the forwarder was 17 feet. A hydraulic motor engaged a swing gear mounted on the carrier, to provide 360° continuous rotation. The tree lengths were picked off the ground by the grapple and lowered onto the carrying bunks. The superstructure turned 90° to transport the tree lengths on the axis of the tracks. The operator's seat had powered 90° rotation as well.

The unit forwarded tree lengths over distances up to 600 feet, with a productivity of nine to ten cunits per hour over short forwarding distances of 200 to 300 feet. This unit was used on operations for about a year, but was shelved because the same functions could be performed with readily available front-end loaders, wood loss due to breakage was high, especially in cold weather and when trees were small, productivity was low because of the slow travel speed, and the investment was considered to be too high without an efficient buncher (Figures 1.95 to 1.98).

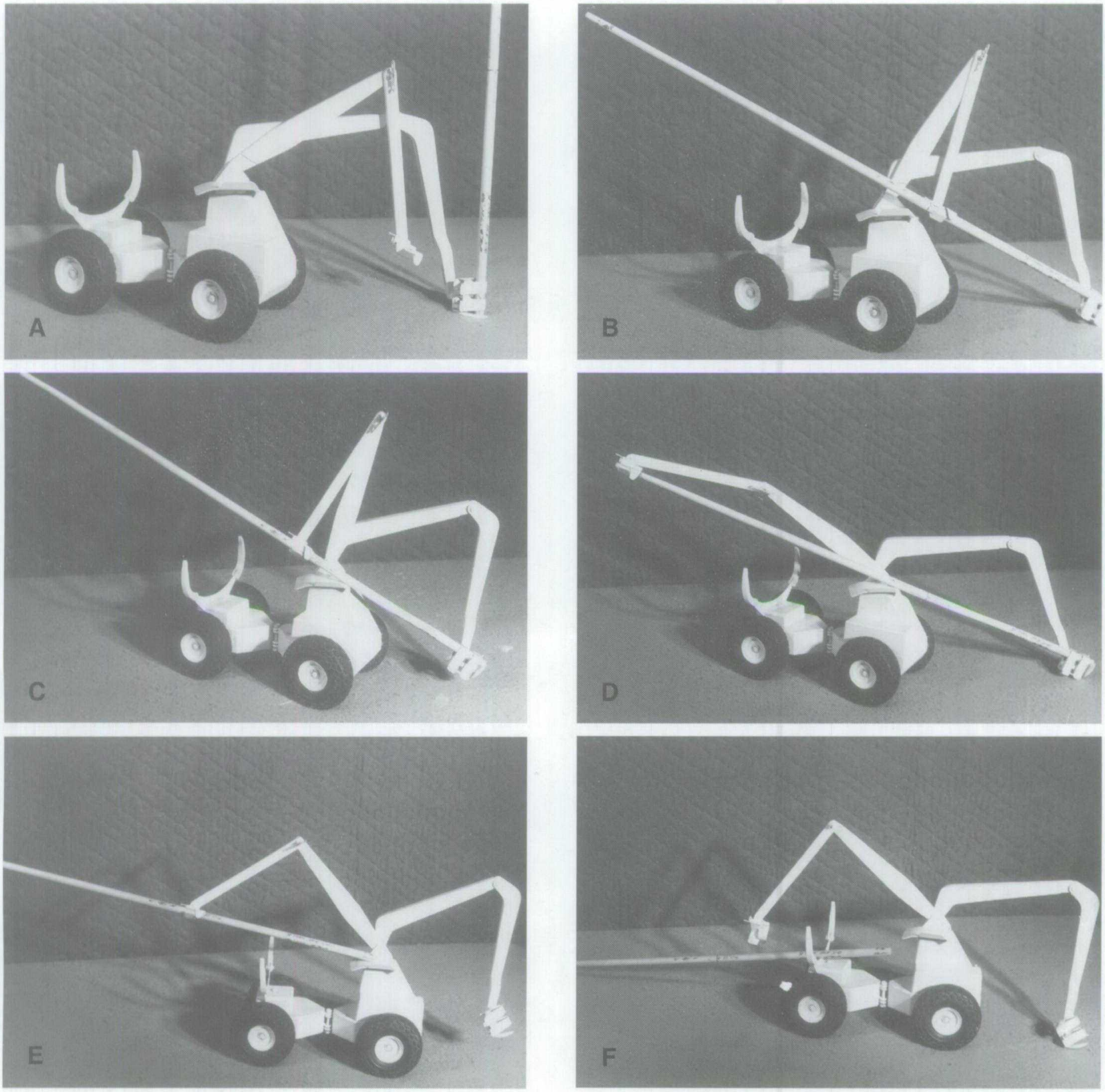


Figure 1.94 *The Eynon Feller-Limber-Buncher. A) Felling a tree; B) Felling head holding the tree butt while the delimbing head engages the tree bole; C) The delimbing arm past the support deck; D) The delimbing head tops the tree; E) The felling head releases the butt; F) The delimbing head moves the tree length to the rear of the machine and places the butt end on the clam bunk.*

Mobile Slashers

Multi-log slashing on logging operations existed in the 1920s, when long logs were slashed to four-foot lengths prior to the river drive on small streams (Koroleff 1929). Electric stationary or fixed slashers that could process logs at a high rate cheaply were a component of almost all mill woodrooms.

As logging operations became more mechanized, and with the change from shortwood to tree lengths, the need for slashing or cross-cutting trees to four-, eight- or 16-foot lengths arose. In 1944, the Montagu Slasher-Loader, imported from Alabama, was introduced on the operations of Marathon Paper Mills of Canada Limited. This machine was not electrically powered. The trees were simply rolled onto a set of

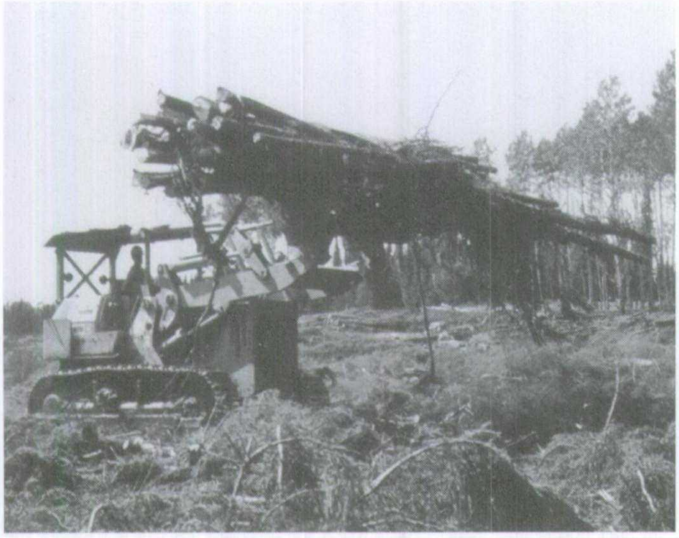


Figure 1.95 *Forwarding bunched tree-lengths produced by Beloit Harvester with a Caterpillar 955.*

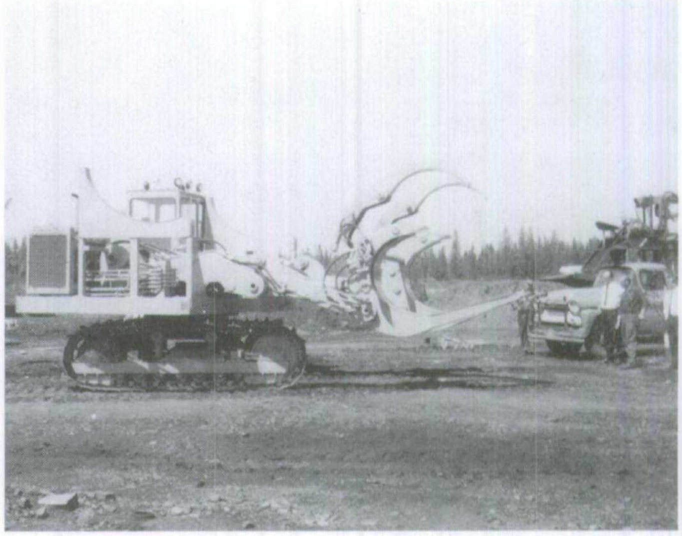


Figure 1.96 *The Larson L-11 tree-length forwarder in position to pick up tree lengths.*

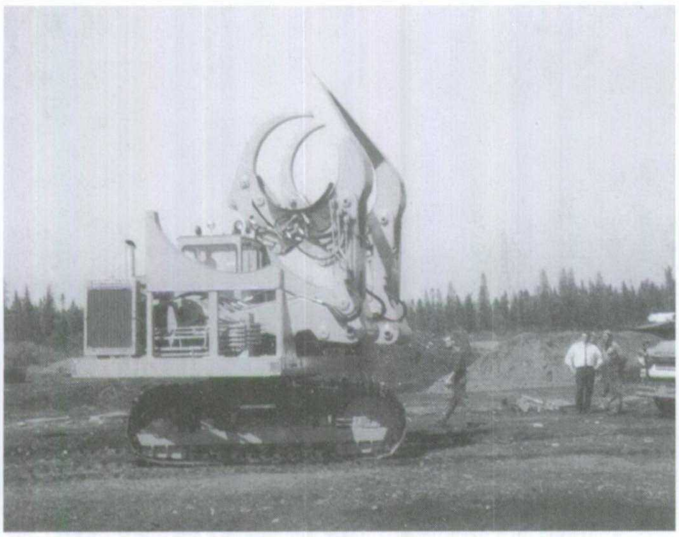


Figure 1.97 *The Larson L-11 in position to lower tree lengths onto bunks.*

Figure 1.98 *The Larson L-11 forwarding a load of tree lengths.*

wooden rollers by means of winch and cable, and were pushed ahead by hand as they were cut into eight-foot bolts. The top-loading conveyor was raised and lowered by hand, and the hydraulic saw activated by a man standing beside it (Olson 1951).

This slasher lacked flexibility and had low productivity. These drawbacks were overcome with modifications developed by Ole Olson, the Woodlands Department master mechanic. The slasher was mounted on runners, which permitted easy movement from site to site. The stockpiles of tree lengths were cable yarded, butts first, into large circular piles with a clearing in the centre, where the yarder, and later the slasher, were located. The slasher had an overhead I-beam track, along which a carriage travelled that permitted tree lengths to be pulled in to end-load them on the slasher deck. This change from side-loading to end-loading increased average productivity from about 35 to 50 cords to about 80 cords per shift.

The original end-loading slasher was constructed by Northern Engineering and Supply Company (NESCO) of Fort William, Ontario, to Olson's specifications in 1948. In 1953, an improved slasher was produced by the same team in the Caramat workshop on Marathon's operations. This unit was mounted on rubber tires and was self-propelled. During 1954–1955, NESCO built two more of these self-propelled Slashmobiles for Marathon, and they averaged 105 cords per shift, with maximum levels of 190 cords.

The units were mainly confined to Marathon's operations until 1959, when the end-haul concept was

Figure 1.99 The NESCO Slashmobile.

Figure 1.100 The Tanguay Slasher equipped with a Sund Delimber.

discarded and replaced with a Hiabob tree-length articulated-boom loader.[34] Only one man was needed to operate the hydraulic Hiabob loader, so the end-haul unchoker and a winch operator were eliminated. In 1965, the first NESCO slasher equipped with the Hiabob loader was put into operation as a production unit, and by 1967, all the remaining end-haul slashers on Marathon's operations were converted to Hiabob loaders (Figure 1.99). Production with these units increased to 130 cords per shift, and by 1972 were averaging 200 cords per shift.

Slashers had originally been developed as components of specific logging systems, but as the systems changed, slasher designs had to be modified.[35] By the mid-1960s, the cable-yarding system was phased out and replaced with rubber-tired skidders, which put the tree-lengths on roadside skidways rather than in circular cold decks. The rubber-tired slashers could then operate along roadside skidways, producing roadside piles of eight-foot wood, or loading directly onto trucks.

By 1965, NESCO had as much business building slashmobiles as it could handle. Thus, the Quebec logging companies turned to another source, Tanguay Industries Limited of St. Prime, Quebec, for help. The first Tanguay slasher was built in 1966. It was a clone of the NESCO, with two exceptions: the main infeed conveyor was reversible, and the outriggers were hydraulically operated. This unit was purchased by La Compagnie Price Limitée, a company that had cooperated both technically and financially with Jean Paul Tanguay during the slasher's development.

The demand for Tanguay slashers increased to the point where Tanguay Industries almost ran out of working capital. By 1971, Tanguay had built 46 machines, and it was only by the cooperative policy of Price that he was able to keep going. Suppliers of loaders for the slashers could not meet his demands, and so he designed and manufactured his own. While the NESCO slashers produced 100-inch wood and discharged it into pockets to be off-loaded with a knuckleboom grapple, the Tanguay mobile slasher used an elevating conveyor to load wood directly into truck boxes.

In some models, the four-foot slasher was the same as the eight-foot slasher, except that it had a fixed circular saw in the middle of the lateral conveyor. In other models, twin synchronized swing saws were used. Handling eight-foot wood into baskets and unloading with grapples presented little problem. With four-foot wood, however, the baskets were divided into two sections, and hydraulic pushers were used to align the bolts and hold them in a tight package (Legault 1970). In each case, the slasher was built exclusively to meet the special need of the client (Figure 1.100).

In 1971, Price Limitée had Tanguay design and build a large riverside slasher. Tree lengths were trucked to the slasher in 11-cunit loads. The tree lengths were off-loaded onto ramps, transferred to live decks and fed to a conveyor leading to a cutoff saw, which cut the tree lengths into 24-foot pieces. These were fed to a slashing deck that had five circular saws, which cut these lengths into four-foot bolts. They were dumped off the end of a conveyor into the Peribonka River. The slasher could process ten cunits per hour, and the wood falling off the end of the conveyor appeared as a steady stream.

Forano Ltée Slashers

Forano Ltée of Plessisville, Quebec was also a major manufacturer of slashers. Initially, the slashers were stationary, but in 1971, the company began to produce mobile slashers. In 1976, Forano produced a slasher that was installed on the operations of Rexfor at Baie Comeau, which had cost about

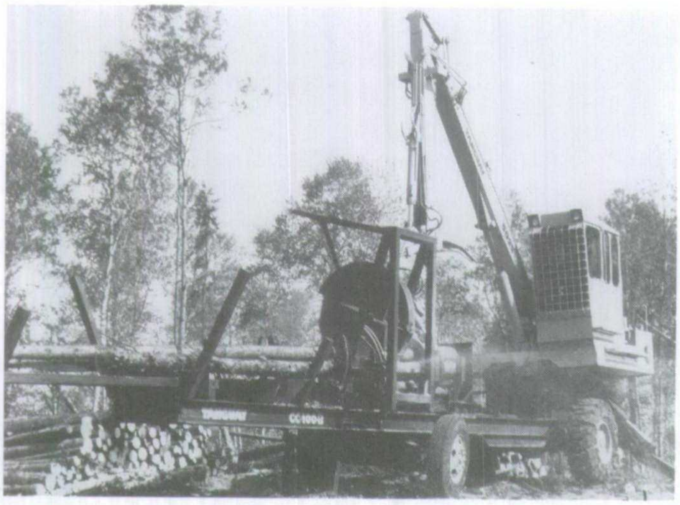


Figure 1.101 *The Tanguay One-Man Slasher.*

$1 million in research and development. It employed a continuous shear system rather than saws, so sawdust was eliminated. The shear arrangement incorporated an upper and lower track, with a wider opening at the infeed than at the discharge. Paired knives circulated on the tracks; these were 20 inches apart at the infeed and almost touching at the discharge. The slasher was 32 inches wide and had a feed speed of 250 feet per minute. The spacing of the paired knives was variable so that bolts from four to eight feet long could be produced. The output of this unit, on a two-shift-per-day basis, averaged 70 cords per hour, with peaks of up to 90 cords per hour.

Slashers in various forms are still emerging and being used on operations. The Prentice Sawbuck, Siiro, Copeland, Hydro Sawbuck, Tanguay and others have reduced the slasher to a one-man machine that feeds in tree lengths, cuts them to length with a circular saw in a frame, and off-loads the bolts into stockpiles (Figure 1.101).

The O and M Slasher

In 1960–61, the Fort Frances group of the Ontario and Minnesota Pulp and Paper Company Limited designed and built a processor that bucked tree lengths into eight-foot bolts, and piled them on landings or at roadside (Hunt 1963, Anon. 1963a). The machine was the brainchild of Bob McLennan, a logging engineer, and much of the development was carried out by Jack Langtree, the Woods Department master mechanic. Bob Larson also assisted.[36] The prototype was built from surplus material, including an old FWD (four-wheel drive) chassis, hydraulic pumps and engines (Figures 1.102, 1.103).

The slasher consisted of feed rolls to move tree lengths through the unit, a measuring device to measure 100-inch lengths, hydraulic shears to cut the tree, and a kicker mechanism to eject the bolts. A rather complicated hydraulic circuitry operated these components automatically. A Hiabob loader with a modified grapple was mounted on the chassis to feed the tree lengths into the slasher.

Figure 1.102 *The O and M tree processor picking up a tree length by its butt and feeding it into the machine.*

Figure 1.103 *Bolts eight feet in length are discharged into the pile at the rear of the O and M tree processor.*

In operation, the machine moved across the face of a cold deck or skidway of tree lengths, selecting individual stems to feed into the slasher. It was able to sort spruce and jackpine, and could segregate these species at the landing rather than in the forest. The unit was equipped with lights and worked on a two- and three-shift basis.

The operating crew consisted of an operator and a helper. The operator controlled the grapple and infeed mechanism. Once the feed rolls engaged the butt of the tree, the balance of the cycle operated automatically. The helper straightened the eight-foot bolts when necessary, and moved the unit ahead as the operation progressed. Production averaged 35 to 40 cords per shift, and occasionally reached 50 cords per shift. In a balanced operation it could keep three wheeled skidders occupied.

A total of 10 000 cords of wood were processed before the unit was scrapped in 1964, due to the high cost of maintaining the old components, and the problems encountered with the complicated hydraulics circuit. The productivity of the unit was limited because it was a single-tree slasher, and speeding it up was considered impractical (Cox 1965).

Arbomatik Slasher

Logging Research Associates gave serious consideration to the production of a self-propelled mobile tree-length slasher, using the flying shear principle, to compete with NESCO and Tanguay. This project was undertaken in 1964 in cooperation with International Paper Company (US) and Soderhamn Ab. (Sweden). However, studies showed that even though the Arbomatik Slasher had a capital cost that was only 60% of the NESCO, and that it required one less person to operate it, the cost of wood produced by the Arbomatik was only marginally competitive, and so the development was dropped.

The Arbomatik Slasher suffered the same drawback as the O & M Slasher. It could only process one tree at a time, or if they were small, two trees. This was a serious constraint on productivity, especially since the NESCO and Tanguay could slash an entire grapple-load of tree lengths at a time. Because of this, the Arbomatik Slasher never passed beyond the drawing-board stage, even though it had low capital and operating cost and was very mobile.

The Anticosti Monster

Consolidated Paper Corporation introduced a new processor on its Anticosti Island operations in 1961. Nicknamed the "Anticosti Monster" (Caplan 1962), the unit was designed and fabricated by Forano from recommendations put forth by company operators, including Julien Desy, Supervisor, Woodlands Mechanical Department.

The machine was designed to produce bark-free four-foot pulpwood, and pile it at roadside ready to truck to the boat-loading plant at Port Menier. It was mounted on tandem axles with a hitch to form a trailer unit, making it mobile but not self-propelled. When it was stationary, hydraulically operated outriggers were lowered to provide stability.

A Hopto loader lifted tree lengths onto the receiving deck, where they were kicked individually into a conveyor and advanced to a butt plate. This activated a circular saw, which cut off an eight-foot bolt. The bolt was then flipped sideways onto a conveyor running in the opposite direction, and passed into a Cambio barker. Emerging from the barker, the eight-foot bark-free bolt was cut into four-foot lengths by another circular saw. These bolts were rolled sideways into a basket from which they were off-loaded by a second Hopto loader into stockpiles at the roadside. It was fully automatic from the time the tree length was deposited on the infeed deck until the four-foot bolts rolled into the off-loading basket; a crew of four could process six to eight cunits of tree lengths per hour. Unfortunately, this machine was plagued with mechanical problems and its career was short.

The Busch Combine

The Busch Combine, a tree-harvesting machine developed by Tom Busch of the Southern Kraft Division of the International Paper Company, was initiated in 1953. Prototype units began to appear in the southeastern United States about 1959 (Anon. 1960). After extensive trials, the unit was licensed to Timberline Equipment Company of Dallas, Texas, which built approximately 40 machines.

Under favourable conditions of tree size, tree species, stand density and terrain, this unit performed well in the woods. Production rates of two to three cords of 63-inch pulpwood per man-hour were common (Busch 1965, Chappell and Taylor 1971). The combine consisted of a heavy-duty tractor with four-wheel drive. It had both articulated-frame steering as well as a pivoted or oscillating centre joint, which permitted the four wheels to maintain constant contact with the ground. Mounted on the tractor were two hydraulic cutting heads, one to shear the tree at the base of the trunk and the other to buck the tree-length into bolts. The cutting heads were single-bladed shears capable of cutting through pine trees up to 19 inches in diameter.

Trees felled were directed towards the front of the machine. A curved-steel arm was mounted forward on the machine, on which the tree would fall. This arm lifted the tree onto a carriage that clamped the tree and drew it through a delimbing device into the bucking shears. The delimber was a 12-inch-wide flexible steel belt, known as a "chisel-chain," hydraulically operated, which wrapped around the trunk as the tree was pulled through. It could cut off limbs up to five inches in diameter. The chisel-chain was spring-loaded (as well as being heavy) so that, as the tree progressed through it, the belt followed the taper of the tree. The bucked logs were dropped into a cradle at the

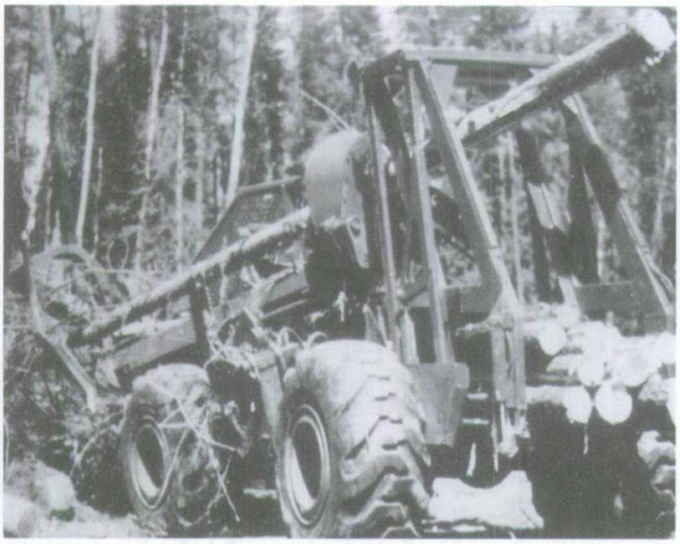


Figure 1.104 *A Busch Combine modified to produce eight-foot bolts.*

Figure 1.105 *A Busch Combine piling down at the roadside.*

Figure 1.106 *A Packjack (Timberjack Ltd) for forwarding eight-foot wood (1972).*

Figure 1.107 *A Bissonette Forwarder, with a five-cord capacity for four-foot bolts.*

rear of the machine. When a load was complete, it was dropped on the ground, on end like a sheaf of grain, held together by means of a steel strap.

In 1961, quite independently, both Canadian International Paper Company and Abitibi Power and Paper Company Limited purchased modified versions of the Busch Combine to produce eight-foot pulpwood (Figures 1.104 to 1.105). The two units operated from mid-1961 until mid-1963, when Canadian International Paper Company returned their unit to the manufacturer and Abitibi Power and Paper Company sold their unit to a pulpwood producer in Minnesota (Anon. 1961). The machines had never reached the anticipated levels of productivity and costs. In late 1967 and early 1968, Timberjack Limited and Great Lakes Paper Company Limited ran extensive tests on the machine, thinking they might reintroduce it in Canada, but these plans were dropped when tests proved that the machine was technically obsolete (McCauley 1967).

The Busch Combine suffered the same conceptual weakness as the Vit Feller Buncher. It had to approach each tree and position itself alongside it. The terrain and forest conditions encountered in eastern Canada were sufficiently different from those in the southeastern United States that the unit could not achieve the expected productivity or cost. As well, considerable damage was inflicted on the wood when the logs were frozen.

In spite of its short-lived appearance in Canada, the Busch Combine made a number of major contributions to machine concept and design. The ability of the chassis to be oscillated as well as being articulated made it more mobile.[37] The hydraulic shears had a number of features that made them more efficient than most single-bladed shears of that time. The delimbing mechanism was unique and was subsequently copied or licensed in other tree harvesters. Although unusual, the idea of collecting wood and dumping it in bundles on end was effective.

The CIR Treemobile

Canadian Ingersoll-Rand Company Limited of Montreal was a newcomer in the field of logging equipment development and, after three years of engineering design and bench-testing, it withdrew without having produced a single prototype. The development of a tree harvesting machine was promoted by Dave Spanjer, Manager of the Product Development Division.[38] He envisioned this new development fitting well with the company's manufacturing capabilities as a major supplier of mining and pulp and paper machinery.

The Treemobile concept Spanjer put forward looked very promising. The only potential competition at that time was the Vit Feller Buncher-Bombardier Processing Unit, and the Busch Combine, both of which were in the prototype stage. The only production unit in operation was the NESCO Slashmobile.

The disadvantage of the original Treemobile concept, initiated in 1958, was that it felled trees forward into the uncut stand. In 1959, a revised Mark II version was designed. A third and fourth version were produced in 1960, and the Mark IV design was accepted for manufacture (Figures 1.108, 1.109).

The design version of the Treemobile was on tracks, operated by one person. It advanced in a straight path with its felling boom, mounted at the front end of the machine, permitting it to clear a 12-foot swath. The swinging tree-felling head was clamped to the base of the selected tree and the tree was automatically severed from the stump. The tree was lifted free of its stump and swung through an arc rearward into a horizontal position, to lie in a rack above the machine. The

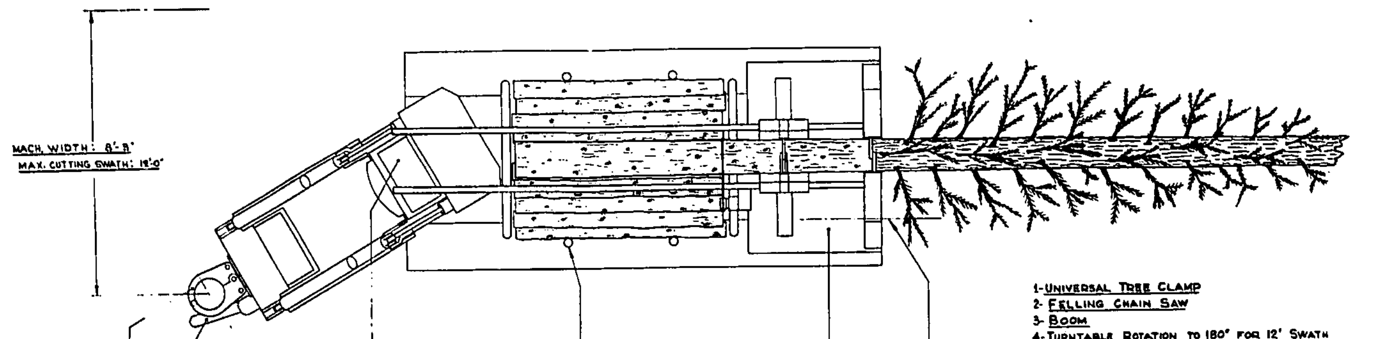


Figure 1.108 *The Treemobile IV.*

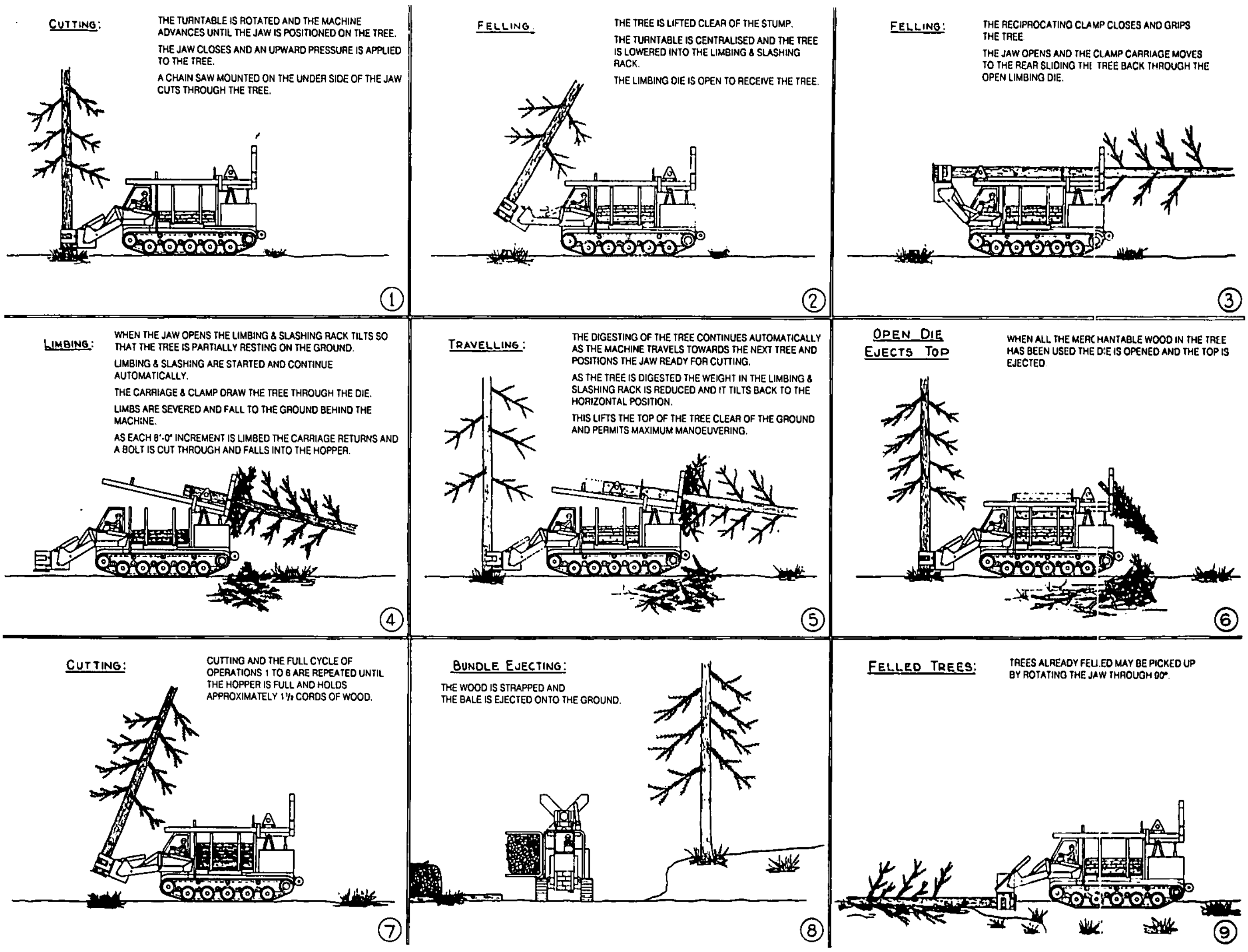


Figure 1.109 *The Treemobile IV in operation.*

rack was designed to tilt under the weight of the tree, so the top of the tree could rest on the ground at the rear of the machine. The delimbing head then closed and the tree was drawn through the die, so that the limbs would fall to the ground behind the machine. As each eight-foot increment of the tree was pulled through the die, it was cut to length and the bolt dropped into the collecting hopper. When the diameter of the tree reached the selected minimum, the top was ejected.

Once the processing of the tree had commenced, it was continuous and automatic, so the operator could move to, grapple and harvest the next tree. When this tree was cut, it was held by the felling head until the top of the tree being processed was ejected, the delimbing die then opened, and the next tree was lowered into the processing rack. When a load of approximately 1.5 cords had been collected in the hopper, it was strapped and the bale ejected from the side of the machine. Alternatively, the load of wood could be ejected into a loose pile.

Three concepts were incorporated into the design of the Treemobile that were unique at the time. First, the felling head on the boom was designed so that the tree could be grasped, and then swung and placed precisely in the processing mechanism. The Vit Feller Buncher performed similarly, but its felling and grasping mechanism demanded that the whole machine move to the tree to be harvested. Second, the delimbing carriage was similar in principle to that of the Pope Tree Harvester,[39] with reciprocating jaws moving over a measured distance to delimb and sever bolts from the tree. However, the concept of the delimbing die was new. A series of dies, with apertures varying from 16 inches to 4 inches, were activated hydraulically to follow the taper of the tree and permit the removal of limbs flush with the trunk (Figure 1.110). Trials undertaken at Windsor Mills to test the die

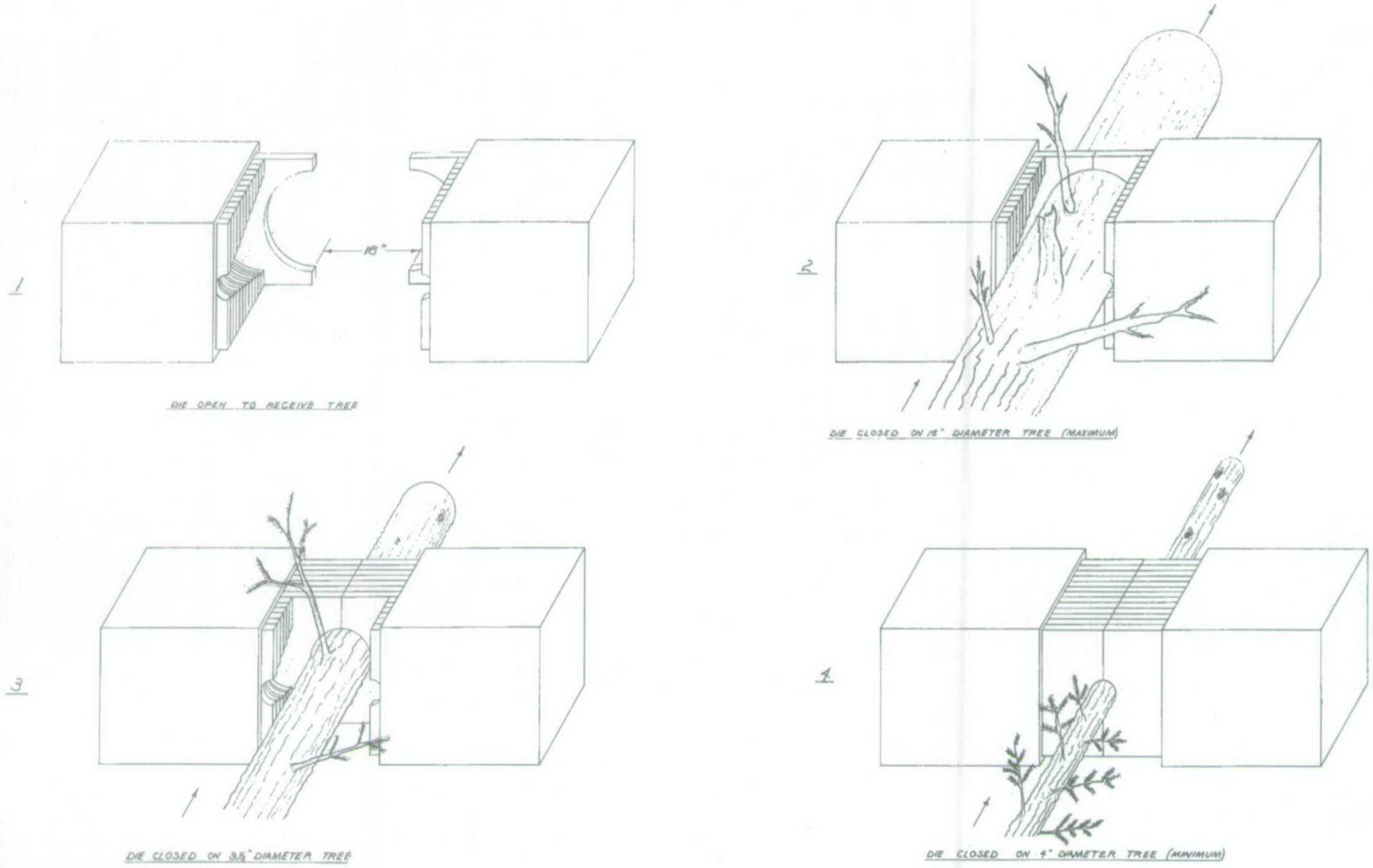


Figure 1.110 *The Treemobile's contracting delimbing die.*

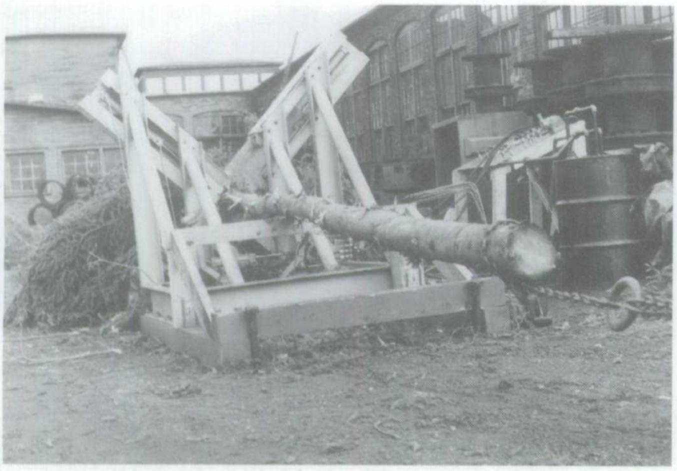


Figure 1.111 *Rear view of delimber test bed. A full tree is being pulled through the delimbing head by tractor.*

Figure 1.112 *The front end of the delimber test bed showing knives removing limbs.*

concept for delimbing are illustrated in Figures 1.111 and 1.112. The trees were pulled through the delimber by a tractor, and the resulting forces were measured. Third, this was the first harvester design to embrace the concept of overlapping operations. The operator could concentrate on the movement of the machine and the harvesting of trees while the subsequent processing occurred automatically. This overlapping of functions played an important part in the success of later tree harvesters.

Even though considerable support was offered by major companies in the pulpwood industry, the Canadian Ingersoll-Rand Company decided not to proceed with the manufacture of tree-harvesting equipment for internal reasons.

The Levesque Shortwood Harvester

The Levesque Shortwood Harvester was specifically designed to work on soft terrain in stands of small-diameter black spruce in the claybelt region of Ontario and Quebec in 1971. Three companies were involved in its development: Cochrane Logging Limited, owned by the inventor, Lucien Levesque; Timmins Springs Limited of Timmins, Ontario, owned by Andy Larochelle; and L & L Logging Research Limited, a company formed by Levesque and Larochelle to develop the prototype and manufacture the product. Jules Guillemette, Engineering Technologist with L & L Logging Research Limited was a key man in the development of the harvester.

The prototype chassis was a soft-track machine similar to those manufactured by Bombardier Limited. The tracks were 42 inches wide and the wheelbase was 13 feet. It weighed less than 30 000 pounds and had an estimated ground pressure of 2.5 psi. The developers claimed that because of its light weight and low ground pressure, their machine could operate 12 months of the year in wet muskeg or deep snow. The harvesting-processing head was mounted on a Prentice boom, which could operate in a 42-foot arc through the timber stand.

To operate, the machine extended its boom, placed the felling head at the base of a tree, and closed its arms firmly around the tree. The shear cylinders were then activated and the tree was severed from its stump. The tree was picked up by the boom, which swivelled into position, and laid down horizontally with its top pointing away from the machine, so the tree butt would be processed first. The tree was then pulled by feed rolls through the delimbing knives, which removed the limbs. The tree continued to move until it struck a butt plate at a measured distance from the shear knives. These knives cut off the measured length of tree, which was dropped in a pile. The feed rolls started again and drew in and sheared another measured length until the top became too small. At this point, the unusable top was discarded.

When it was being developed, the Forest Management Institute of the Canadian Forestry Service applied mathematical simulation modelling techniques to this unit. The studies considered two stands averaging 4.24 and 6.36 cubic feet per tree, and arrived at an average productivity rate ranging from 3.5 to 4.9 cunits per hour at 100% mechanical availability and efficiency. Allowing for a mechanical availability of 85% and efficiency of 85%, the average production rate was calculated to be about 3.0 cunits per hour. Actual field trials yielded slightly higher rates than this.

At least two prototypes of the Levesque Shortwood Harvester were built between 1971 and 1973, but the Levesque did not develop into a commercially viable shortwood harvester. The patented processing head, however, was very successful. It was developed and used as an attachment to a conventional crane-type chassis, with a hydraulically operated knuckleboom, as a feller-delimber-buncher, and became known as the Timmins "Fel-Del" Harvester Head (Folkema and Novak 1976). By the middle of 1976, over 200 Fel-Dels had been sold. The Iroquois Falls Division of Abitibi Paper Company purchased several units and mounted them on wide-track hydraulic cranes. They performed very well on the black spruce swamps for which they were designed (Clemence 1975).

Koehring Shortwood Harvester

Bruce McColl, while still employed as a consultant by the Pulp and Paper Research Institute of Canada, prepared an in-house report in 1958 entitled "An Appreciation of the Problems of Full Tree Logging." In this report, he discussed three methods and equipment concepts for timber harvesting. The first was a head-reach system for material-handling equipment that could reach out from a vehicle and retrieve trees over ground too difficult for the vehicle to travel. The second was a set of vertical, angled and horizontal tree-processing stations on the vehicle. The third was a series of multi-operation processing machines for pulpwood. Only five copies of his report were produced. Its circulation was deliberately limited to protect some of the patentable concepts included therein.

It was in 1962 that Koehring Canada Limited embarked on a program to develop timber harvesting machines. By October, the concept for what was to be called the Koehring Shortwood Harvester had gelled. The inventors were Edwin O. Martinson, Vice-President of Research and Development at Koehring Limited in Milwaukee, and Phil Huffaker, Chief Engineer at Koehring Canada Limited.

The Dowty Forwarder[40] came on the market for sale, and Koehring Canada Limited purchased the patents, drawings and technology from Dowty in 1964. Bruce McColl, in the meantime, had left Dowty in April, 1963, to form his own consulting firm in Whitby, Ontario. The highly mobile chassis of the Dowty Forwarder formed the basis for the new Koehring harvester.

The following design specifications for an eight-foot logging system were drawn up by Jim Bell, Sales Manager for the Koehring (Bell 1965).

> *The forwarder must have an efficient system for loading in the stump area and for offloading at roadside directly onto trailers. It must have a big payload which will permit long forwarding distances and reduce haul road cost. The processor must have a tree-cutting boom with a long reach so that trees are brought to the*

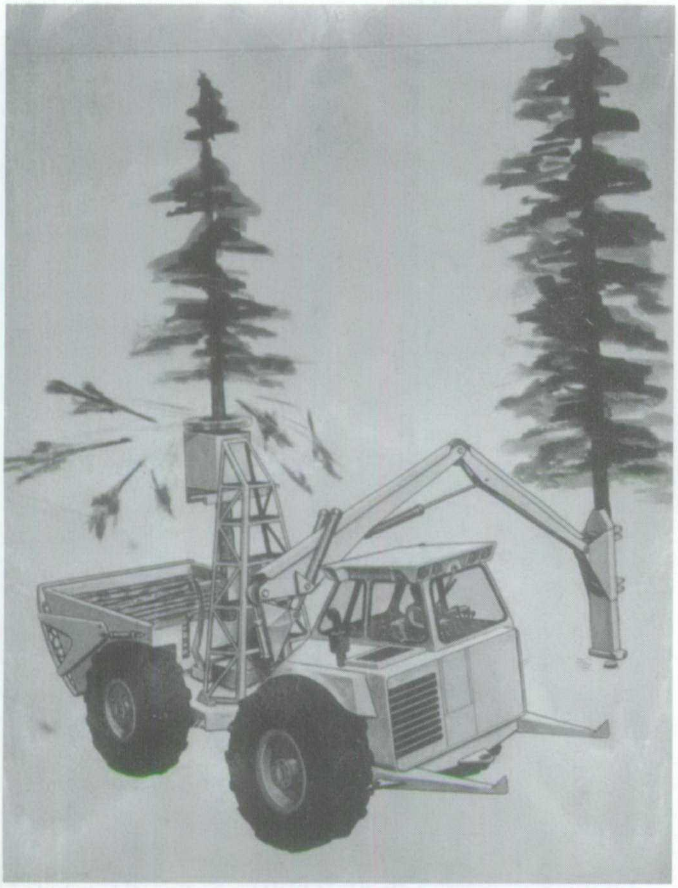


Figure 1.113 *Drawing of the Mark II Koehring Shortwood Harvester.*

Figure 1.114 *The Mark II Koehring Shortwood Harvester prototype in the shop.*

machine. It must be a multi-function machine capable of processing a tree and cutting the next tree or manoeuvering simultaneously. It must have sufficient accumulating capacity so that piles left in the stump area can be efficiently loaded by the forwarder. Both the forwarder and the processor must be high mobility off-road vehicles. Both machines must be capable of continuous year round operation day and night, and in all weather. Because the processor's productivity is dependent on tree size, and the forwarder's productivity dependent on stand density, it is essential that these machines operate independently of each other.

The original development work on the Mark I prototype began in 1965 when a processing tower was fitted on the rear of a forwarder. It was tested on Canadian International Paper's operations at Landron, Quebec, but was found unsatisfactory and was dismantled. The forwarder chassis, too small and light to be stable, was not suitable as a platform.

Design work began in 1965 on the Mark II prototype which was built in 1966 and tested at Val d'Or in 1967–68, where it was proven to have a number of shortcomings as well (Figures 1.113, 1.114). After a redesign of most aspects later in 1968, the Mark III preproduction machine included a processing tower that leaned, to solve the problem of falling debris during processing. This concept was inspired by two Koehring engineers, John Kurelek and John Denovan (Kurelek and Denovan 1969). In 1969, the Mark III operated in Dryden, Ontario for a year, at semi-productive levels. Dryden Paper Company Limited took delivery of two K IIIB preproduction units and operated them through the winter of 1969–70. In 1970, they took delivery of two more units, and in June of that year the K IIIB was designated as a production model (Coombs 1972).

The Evolution of the Koehring Harvester

The original concept of a two-stage harvesting system, using one machine type to fell-to-buncher eight-foot logs, and a second machine type to forward these logs to delivery loading terminals, was changed to meet the opportunities presented by a single machine system. This concept change rendered the Forwarder system obsolete following prototype studies of the Mk II near Val d'Or, Quebec in 1968. The tree-harvesting machine was designed to proceed through the forest, reaching out with its felling boom with a reach of 18½ feet, severing and seizing trees at the butt and placing them in a vertical processing head on the chassis proper. The tree descended vertically through the processing head, and was delimbed and sheared to eight-foot lengths in one-cunit bunches behind the harvesting machine. Later, the forwarding machine was eliminated, and the harvester forwarded its crop to roadside. The originally conceived two-machine system had evolved into a one-machine system.

During its evolution from the Mark I to the Mark IIIB prototypes, some major changes were made that contributed to the success of this tree harvester.

Originally, the harvesting and forwarding units were to be mounted on the same model of chassis, so both units could operate over the same terrain. The Mark I harvester was mounted on a Dowty forwarder chassis, but that proved too small and lacked stability. The wheelbase of the new chassis was increased from 12 to 17.5 feet and the width from 10 feet 2 inches to 15 feet 5 inches. The ground clearance was increased from 27 inches to 34 inches.

In the Mark I prototype, the tree was to be lowered into the processor head until its butt was engaged by two sets of feed rolls, at which point the felling grapple was released. Each feed-roll set consisted of three individually powered rolls, 12 inches in diameter and 3 inches in width, with milled teeth, to admit a 16-inch-diameter tree and follow the tree taper down to 3 inches diameter. In the final model, the butt of the tree was placed into a side-opening processor head, where it was seized and held by a clamp.

The delimbing device on the upper end of the processing tower in the Mark I prototype consisted of 6 angular arms, each with a delimbing tool at one end and a fly weight at the other. These arms were pivotally mounted between two plate rings so that rapid rotation of the rings threw the weighted end of the arms outward by centrifugal force, forcing the delimbing tool against the tree bole. A spring returned the arms to an open position when the rotation ceased. The actual delimbing tool was in the form of a vertical chisel or knife, the upper end of which had two separations or teeth, but there was not enough tractive effort in the feed rolls to pull the tree through the delimbing head. In the final model, the delimbing head consisted of a series of knives, curved in arcs to permit close contact with the circumference of the tree. These knives were pushed upwards, cutting off the limbs by means of a hydraulic piston operating with a force of 2 000 psi.

In the original concept, it was thought that a debarking unit, which would follow the delimbing action, could be installed. No development was ever undertaken in this regard.

The Mark I shear consisted of two flat opposed blades, about 1/4 inch thick, with a straight-chisel cutting edge. The relatively thin shear blades were mounted in heavy arcuate yokes, with provision for pretensioning the blade to avoid distortion during shearing. At the base of the processing tower, eight feet below the shear, was a butt plate with a control mechanism that activated the shear. When an eight-foot bolt was severed from the tree, a rotator mechanism moved the bolt through 90°. As it reached a horizontal position, a pair of transfer arms moved the log rearward into the log carrier.

In the Mark III unit, instead of the tree being driven downward by two sets of feed rolls, the tree was held stationary and the processing tower moved upward, removing the limbs from the tree for a distance of eight feet. Simultaneously, the processing tower moved sideways 35° to the vertical. This allowed the limbs, top, and some bark to fall to the ground, clear of the machine. During the eight-foot delimbing stroke, the tree was clamped by the lower or holding set of arms. At the top of the delimbing stroke, the arm pressures were automatically reversed and the processing tower telescoped until the tree butt was eight feet below the open log-shear. At this point, the log shear closed, arm pressures were reversed and the delimbing arms repeated the cycle with another delimbing stroke.

The carrier on the Mark I had a one-cunit capacity, and was located partly over and behind the rear wheels. It had fully enclosed sides and a tailgate. When a load of processed eight-foot bolts was to be dumped, the carrier moved rearward and downward in an arc around the rear tires and, when near the ground, the arcuate tailgate was raised, depositing the wood in a pile on the ground.

In the Mark III unit, the concept of producing small loads and depositing them on the ground to be forwarded by another unit was abandoned. The pre-production unit, and those following, had a load capacity of six cunits of wood. Studies showed that with this size of payload, it was more economical for the harvester to also be the forwarder. Rather than dumping the load onto the ground, the Mark II had an additional knuckleboom and grapple mounted on it so that it could off-load onto parked trailers or into stockpiles.

The change from a two-machine system to a one-machine system was a major decision, since the company had made a substantial financial investment in forwarder technology, and this change rendered it obsolete. By 1970, they had sold 35 Koehring forwarders, mainly to Canadian International Paper Company; a few went to other companies beginning to mechanize their operations. The Koehring Shortwood Harvester (K IIIB) is considered to be the most successful machine of its kind. More units were sold of the K IIIB than of any other harvester of its generation, which greatly slowed the trend away from the shortwood system towards tree length.

The increases in the price of the harvester became a major factor in the decline of its sales.[41] While the capital cost increased, the machine productivity remained fairly constant. The result was a steady increase in the cost of wood produced until it became uncompetitive, even though its man-day or man-hour productivity was the highest in the woods at that time.

The range in productivity of the Koehring Shortwood Harvesters working in the forest was wide. Initially, productivity of up to 6 cunits per hour was claimed (Bell 1965), but this was before the change to a one-machine system. Other studies established productivity levels considerably below the expected potential (Anon. 1970b, 1974b; Newman 1975).

It was fortunate for the logging industry, and for the logging machinery manufacturers, that just when machine developments intensified, the Woodlands Research Division of the Pulp and Paper Research Institute of Canada established a program to evaluate logging machine prototypes. The evaluations provided information on the technical characteristics, performance under measured conditions, potential productivity and a reasonable range of expected costs.

The Koehring Harvester was studied intensively under this program, and the results were widely dispersed through the industry. This means of technological transfer proved very useful in separating fact from fancy. The reports were objective and served to counteract both the manufacturers most optimistic claims as well as distorted information passed by word of mouth, and sour grapes from the competition.

The first report on the Koehring Shortwood Harvester was issued in 1970 (Bredberg 1970c) and the last in 1975 (Boyd 1975). As part of this machine evaluation project, a bi-weekly reporting system was established to record the repair statistics for machines on ten different operations. This reporting system covered 30 different machines over a period from March 1971 to June 1974. Seventy-five reports were issued, based on daily records of repairs to each of 114 components in 14 assemblies of the machine.

A major factor in assessing a new machine's success is the amount of downtime in its operation due to repairs, services, delays and waiting. Boyd described the importance of considering downtime when evaluating machines:

> *Downtime may result in losses of time, production, money, or any combination of the three. Since most harvesting machines are large and costly, it would be expected that the importance and cost of downtime would be much greater than encountered previously with small conventional logging machines. Wood cost considerably in excess of projections was, in fact, encountered with many new harvesting machines even when productivity approaching design rates was achieved during productive machine time.*
>
> *While considerable research on downtime had been carried out in such sectors as aviation, aerospace, military vehicles, electronics and process machinery, the relatively recent introduction of costly, complex and sophisticated machinery to the logging industry found both mechanic and manager facing new problems. More and better information on downtime and wood cost due to downtime had become an important industry need (Boyd 1975).*

Boyd concluded that the uniformly high level of maintenance time among the different company operations suggested strongly that it was the reliability of the machine itself that determined much of the repair and service downtime. Even with highly trained mechanics and excellent facilities, the lack of component reliability made repairs necessary, during which machines were unproductive. It was evident that cold weather operation usually resulted in a 25% or more increase in downtime. Machines required more mechanical staff in winter, whether or not they received it.

Boyd, in a letter dated July 23, 1974, gave credit to Koehring Canada Limited for their initial willingness to participate in this study and their continuing support for it. As he pointed out, most developers of new machines wanted to keep new machine problems secret, but Koehring neither requested nor received protection from unfavourable early reports. The net result of their open participation was improved performance and wider acceptance of their machine.

An example of a productive Koehring Shortwood Harvester operation (Figure 1.115) was Neal and Savard Forest Products Limited of Doaktown, New Brunswick. This company produced pulpwood as a contractor for the Acadian Pulp Division of Jannock Industries. It operated two K IIIB harvesters on a round-the-clock basis, six days a week (144 hour per week). In a nine month period with an eight man crew, Neal and Savard delivered 29 000 cords of wood to trucks at roadside landings. The total engine-hours for the two units was 8 062, with an average productivity of 3.6 cords per engine metre-hour. The average forwarding distance was 600 feet across level terrain, with pockets of soft ground.

The introduction of the Koehring Shortwood Harvester on different operations led to interesting changes in labour organization. Machines were normally worked in groups, with the operators supported by mechanics,

Figure 1.115 *The Koehring Shortwood Harvester on the operations of Neal and Savard Forest Products Ltd, Doaktown, N.B.*

welders, clerks and supervisors. Machines worked 24 hours a day, seven days a week. Production schedules were established on a monthly basis, and production bonuses were developed (Anvik 1977).

Using the month as the basis for scheduling production gave the foreman latitude in his day-to-day operating decisions. It avoided squabbles about favouritism in the choice of stands to be harvested and machines to be used. Including mechanics and welders in the bonus package was considered essential because their services, skill and commitment dictated the success of the operations. By giving them the same level of incentive bonus as the operators, the importance of mechanics to the successful operation of sophisticated and costly logging machines was recognized.

Beloit Feller-Skidder

Beloit International produced a prototype feller-skidder in 1964. The unit was designed to handle trees up to 16 inches dbh, 130 feet in height and 8 000 pounds in weight (Figure 1. 116). The chassis was a D-7 Caterpillar tractor operated in reverse. The operator was located beside the engine, beneath a sloping guard on which the butt ends of the trees were placed. The felling head consisted of a hydraulically operated turret, which supported a telescopic boom with a reach of nine feet. The turret head was rotatable through 180° to permit the feller-skidder to fell and handle trees in an 18-foot swath. The felling head at the end of the telescopic boom was at least 5 feet in height and had grapple arms at the top and felling shears at the bottom.

This particular development did not proceed further; Beloit concentrated instead on a wheeled feller-buncher in 1968. This unit was similar to the Logging Research Associates LogAll, with the exception that the LogAll had a specially designed rear-bunk on which the butts of trees could be held as they were collected.[42] The Beloit Feller-Buncher simply laid the trees on the ground in piles, to be moved at a later time.

Figure 1.116 *The Beloit International Feller-Skidder (1964).*

Drott Feller-Buncher

The time was now ripe for the introduction of mechanical tree fellers. The most popular one proved to be the Drott. Erv Drott, of Drott Manufacturing Limited of Tomohawk, Wisconsin, and his family had been involved in logging and the development of logging equipment for many years. The Drott skid loader, built in 1954 as an attachment for crawler tractors, found wide acceptance on eight-foot pulpwood operations. This attachment was basically a front-end loader, strengthened so that it could pick up a cord pile of wood and move it, either along the ground or just above it, to a haul road where it could be piled down or loaded directly onto a truck.

Drott Manufacturing Limited was sold to the J.I. Case Company of Wausau, Wisconsin, a heavy equipment manufacturer, which brought out a full-tree feller-buncher attachment in 1968. This attachment was mounted on a tracked hydraulically powered knuckleboom crane. The felling head attachment consisted of a six-foot vertical column on which was mounted the tree-gripping arms and the shear-cutting mechanism. The felling head was attached to the boom by a hinge pin, about which it could be hydraulically tilted. The shear was of the scissor-type with the two blades forced together by a single hydraulic cylinder. The two tree-gripping arms, mounted one above the other, were each powered by an hydraulic cylinder. The shear could cut trees up to 18 inches in diameter, and the boom could reach out 26 feet from the centre of its swing (Horncastle 1969, Hensel 1969a).

In operation, the Drott Feller-Buncher felled a tree, swung the severed stem upright to a convenient position, and deposited it in a pile. The machine was able to reach and fell across a 50-foot face of standing timber. As the felling proceeded, the operator piled the full trees in convenient piles ready for skidding to the nearest haul road. Production with this unit averaged about 92 trees per hour (Figure 1.117).

As information on the high productivity and low cost with this type of unit spread through the industry, many other feller-bunchers were developed and sold. The feller-buncher machines soon took over from the tree-felling machines, and from manual felling with chainsaws, because of their ability to pile or bunch the trees felled. The synergistic effect of felling and producing bunches of full trees greatly increased the productivity and lowered the cost of the next phase of operations: skidding. The piles or bunches permitted the use of grapple skidders, which eliminated the requirement that the skidder operator dismount and mount his machine to set chokers. Studies showed that choker skidders travelled 30 to 40% of the time while grapple skidders travelled 90% of the time, with up to twice the productivity (Johnson 1976a, Bredberg 1970a).

Figure 1.117 *The Drott Feller-Buncher.*

Sund Full-Tree Processing System

The Sund Full-Tree Processing System was designed and manufactured by Sunds Verkstader, a logging equipment development company belonging to the Swedish Cellulose Company, Sundsvall, Sweden (Anon. 1963b, Swan 1966). It was imported into Canada in 1965 by the Robert Morse Company of Montreal, and was immediately put on demonstration for Consolidated Bathurst Corporation at their Perriche Camp in the Lower Trenche region of the St. Maurice watershed (Dufresne 1965, Lachance 1966). In mid-1966, two more systems were imported from Sweden as demonstrators. The various trials are outlined in Table 1.7.

The Sund Full-Tree Processing System is made up of four machines: a feller skidder, a wheeled tractor, a delimber, and a slasher.

Feller Skidders. In the second trial by Consolidated Bathurst, the Sicard Feller Buncher was used in conjunction with the Sund system. It achieved production rates as high as 500 trees per shift and averaged 28 cunits per shift, with an average skidding distance of 600 feet to a central landing (Anon. 1969b). With other trials, trees were manually felled by chainsaw and skidded to the landing with conventional skidders (Figure 1.118).

Table 1.7 The Various Trials Conducted to Test the Swedish Full-Tree Processing Systems Imported to Canadian in 1966 (D. Sproule, pers. comm.)

Oct. 1965	Consolidated Bathurst Corporation, Lower Trenche region, Quebec, demonstrates producing eight-foot pulpwood for a period of two months.
Jan. 1966	Canadian International Paper Company, Upper Trenche region, Quebec, demonstrates producing tree lengths for a period of two months.
Jun. 1966	Fraser Companies Limited, Newcastle, New Brunswick, rents a system for 16 months to produce eight-foot pulpwood (Swan 1966).
May 1967	Price Brothers Limited, Chicoutimi, Quebec, rents a system for eight months to produce random length sawlogs and 16-foot pulpwood.
Jan. 1968	Nova Scotia Pulp Limited, Caledonia, Nova Scotia, rents a system for five months to produce eight-foot pulpwood.
Jan. 1969	Consolidated Bathurst Corporation, St. Michel region, Quebec, rents a system for three months to produce four-foot pulpwood directly to water.
Jun. 1969	Canadian International Paper Company, Lower Trenche region, Quebec, rents a system for six months to produce four-foot pulpwood directly to water.

Wheeled Tractors. The full trees were fed into the delimber by a wheeled machine especially designed for the Sund System by BM-Volvo. The wheeled tractor had a pair of overhead arms extending from the top of the operator's cab, each fitted with hydraulically operated tongs or grapples. The machine fed one or more treelengths, depending upon their diameter, into the mouth of the delimber (Figure 1.119).

Delimbers. The delimber proved to be the element in the system with the best production potential. It consisted of eight cylindrical milling cutters that encircled the stem to remove the limbs. These cutters, opening and closing hydraulically, like the shutter of a camera, embraced the circumference of the tree trunk (Figure 1.120). The milling cutters were driven by standard electric motors; the processing speed was normally 200 feet per minute.

Slasher. In some of the trials, the slasher proved to be the bottleneck, with a capacity of only 60% of the delimber.

The Sund Full-Tree Processing System exemplifies the problems faced by the introduction of new concepts and equipment onto conventional operations. There were difficulties in motivating operators and supervisors of a multi-machine system, which required a level of organization and discipline to which they were not accustomed. As well, some of the trials were too short and the operators never reached a level of proficiency. In some of these, the test period

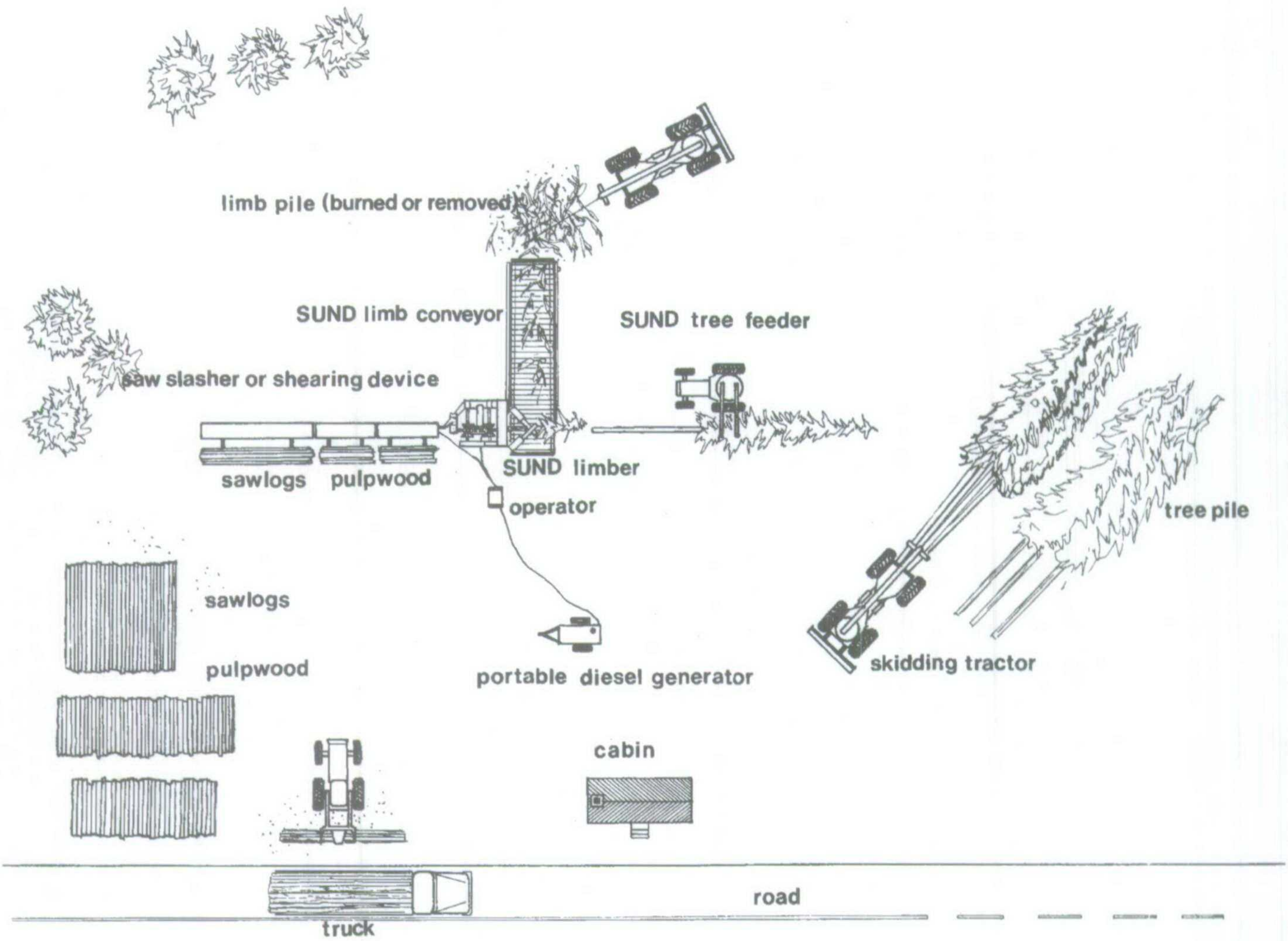


Figure 1.118 *Layout of the Sund processor system on the landing.*

Figure 1.119 *Tree feeder inserting a tree into the Sund delimbing head.*

was considerably reduced due to bad weather or mechanical breakdowns. The tree feeder was operated well below its rated capacity, due both to operator inexperience and to lack of coordination between the skidder operator and the tree-feeder operator. The delimber seldom operated at its productive capacity, being limited by the input of the feeder or the output of the slasher. The quality of the delimbing was uniformly good, but it was part of an unbalanced system. In spite of these problems, the cost of the wood produced compared favourably with conventional systems, with an overall reduction in labour input of 33%.

A total of three and one-half system-years of trials over a four-year period, both as demonstrations and rentals, did not result in the sale of a complete system. However, some companies did purchase components, and adapted these to their own particular requirements. Consolidated Bathurst Inc., for example, working with Les Ateliers Tanguay, constructed a large slasher designed to accept full trees, delimb them

Figure 1.120 *The Sund Delimber.*

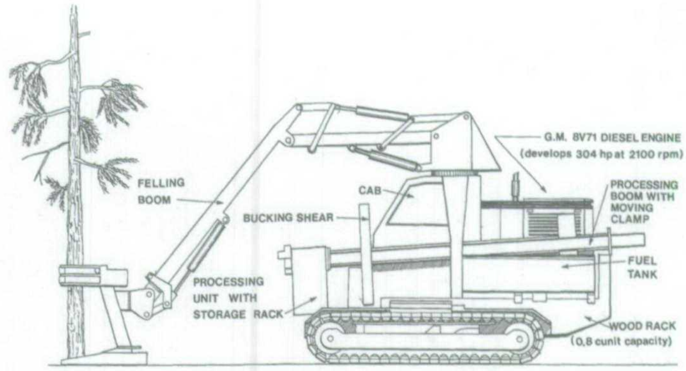


Figure 1.121 *The Timberjack-Anglo Shortwood Harvester. To operate, the machine moved to a position from which one or more trees could be harvested. The felling head was extended to a tree and grappled and sheared it at its base. The tree was lifted vertically and positioned in front of the machine, where it was lowered into a horizontal position with the butt drawn towards the machine. When the tree was lined up over the storage rack, the grapple and shear were opened so that the butt of the tree fell onto the storage rack. The reach of the felling boom was 22'9", which permitted the machine to harvest a swath approximately 30 feet wide along the cutting face. When the processor was free, the tree, resting on the storage rack, was kicked sideways into the processor, and the automatic processing cycle began. The fixed clamp and the delimber were simultaneously closed around the tree. The bucking shear and the moving clamp moved forward and closed on the butt of the tree. The moving clamp pulled the tree along the processing boom for 150 inches, as the bucking shear moved back to its original position. The bucking shear was activated, the moving clamp was opened and the bolt dropped into the wood bunk located between the tracks. The bucking cycle was repeated for each bolt. A sensor in the delimbing head signaled when the minimum diameter bolt had been reached, which opened the delimber and the fixed clamp. The top of the tree was tossed to the left of the machine by the top ejector. The automatic processing began again when another tree was kicked into the processor. When the wood bunk was full, the load was dropped on the ground between the tracks and the machine moved forward. As soon as the harvester was clear of the pile, the bunk was closed.*

with a Sund delimber, and cut the tree lengths into four-foot pulpwood bolts. The bolts were transferred by an elevating conveyor into truck boxes, in a pell-mell fashion, or onto a riverside dump.

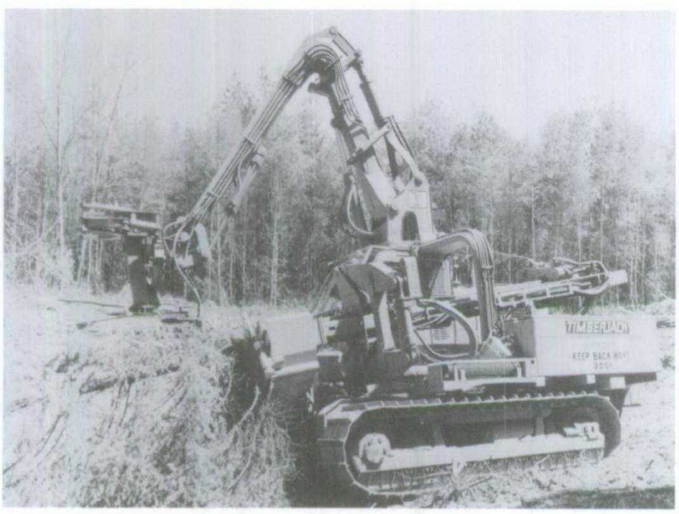
Timberjack-Anglo Shortwood Harvester

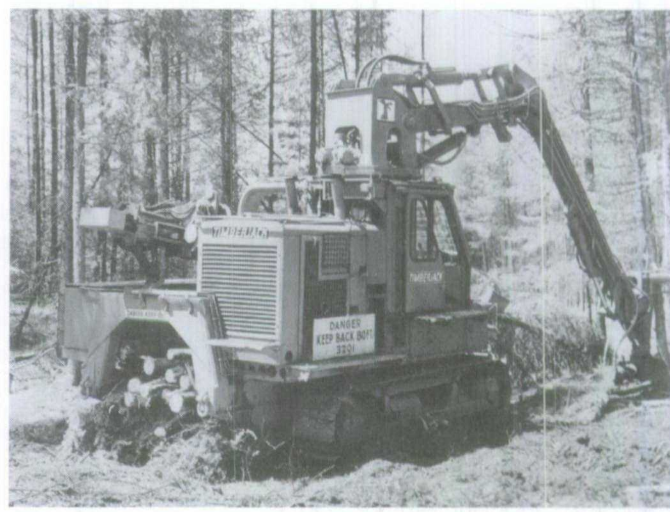
The Timberjack Division of Eaton Yale in Woodstock, Ontario, began the development of a shortwood harvester as a joint venture with Anglo-Canadian Pulp and Paper Mills Limited in 1965. It was a track-mounted stump-area harvester-processor that could fell, delimb, slash and bundle wood in eight-foot bolts, or any multiple of four-feet thereafter. Its inventors and developers were Jack Boyd of Timberjack Limited, Keith Robinson of Dryden Paper Mills Limited and Ken Greaves of Anglo-Canadian. The principal designers of the second prototype were Ted Golob and Stan Jasinki of Timberjack.

Initial discussions began between Anglo-Canadian and the Dryden Paper Company about the possibility of developing a shortwood harvester began in January 1966. By March of that year, after the specifications for a machine were agreed upon, Timberjack agreed to support this development on a joint venture. Design commenced on the Mark I prototype in June 1966, and two years later, in June 1968, initial tests of the Mark I prototype were conducted at Woodstock, Ontario. By October 1968, field testing of the Mark I prototype began on the limits of the Dryden Paper Company.

The test led to the Mark I prototype being set aside in favour of a new program. The design of the Mark II prototype commenced in February 1969. Initial testing of this prototype began in May 1970, and field testing commenced in June 1970 (Anon. 1970c). The field tests of the Mark II prototype were halted in January 1971 and the project was shelved, the victim of funding problems. By this time, five years had passed since development on the machine began. This was much longer than the principals had ever dreamed when they began the project.

The machine consisted of a felling head mounted on the end of a hydraulically operated knuckleboom and an automated processing-head capable of delimbing and bucking full trees (Figure 1.121), and contained several interesting developments. The tracks were 20 inches wide and, instead of using upper idlers, they were supported on hardwood blocks.





Figures 1.122, 1.123, and 1.124 *The Timberjack-Anglo Shortwood Harvester.*

The undercarriage, driven hydrostatically by Staffa motors, was similar to the undercarriage of cable yarders constructed by Timberjack. The delimbing head and the bucking shear were licensed from Timberline Equipment Limited, which had the manufacturing rights to the Busch Combine. The delimbing head was moved at a speed of 720 feet per minute by compressed air stored in accumulators. The storage rack enabled the tree-felling function to be divorced from the processing function. At any one time, the harvester could have a tree being felled, a tree on the storage rack and a tree in the processor (Figures 1.122 to 1.124).

Arbomatik Stump-Area Harvester

Clark Horncastle of Ontario Paper Company Limited, one of the directors on the board of Logging Research Associates, submitted a proposal to the board for its consideration in 1966. The proposal was to combine some of the components already designed and tested into a new machine for stump-area processing. This proposal ran counter to the main thrust of Logging Research Associates' development program, which was focussed on a full-tree harvesting system. It was not until 1968 that they began work on the design of the stump-area shortwood harvester, parallel to development on the feller-skidder roadside-processor system.

Horncastle's rationale for the stump-area shortwood system reinforced that put forward by Bruce McColl, Jack McNally, Bob Larson, John Kurelek and others. Energy would not be wasted transporting limbs and tops to roadside, lowering landing and limb, top and bark disposal costs. One operator could control both the infeed and outfeed, if the infeed was automated when the full tree was placed in a feeding rack by the felling head of the harvester, eliminating the need for a second operator. In the forwarding operation, grapple loads could be alternated to build more even piles than was possible in roadside processing, in which all butts faced one way. There would be only two phases instead of the four required by the Arbomatik full-tree system: stump-area processing, forwarding and off-loading; and felling and bunching, skidding, processing and loading. Since peeled wood dries more quickly in bundles than in skidways, the weight-loss advantage would prove important in long distance transport, especially on public roads. Freezing-in of full trees, either prior to skidding or on the landing prior to processing, would be eliminated. Natural regeneration would probably be better because of better seed distribution and shade afforded by limbs for spruce germination. Horncastle also listed two disadvantages to the shortwood system: processing productivity would be lower in the stump area; and the risk of forest fires would be higher than if full trees were removed to roadside.

The design of the Arbomatik Stump-Area Harvester was much simpler than the Arbomatik roadside processor (Anon. 1972a). It was to be based on the wheeled LogAll, which was a feller-buncher or feller-skidder, and did not include a barker (Figure 1.125). The removal of the bunk from the LogAll was proposed, to be replaced by a bottom-dump cradle (on a pantograph-type support between the rear wheels) that could be pivoted out and down to the ground for emptying. The processing unit would be mounted on a C-frame support behind the cradle, which would permit the gradual raising of the unit as the cradle filled. This would allow good piling and permit raising the processing assembly when dumping a load from the cradle.

In essence, the harvester was conceived as a machine that could work on two trees at the same time, reach out and gather several trees from one position, move while processing, drop cut sticks directly into the cradle with no transfer operation or high drops, and dump piles of eight-foot bolts directly on the ground, with minimum disarrangement of the sticks. It was estimated that the productivity of this unit would range between two to three cunits per productive-machine-hour, when harvesting trees in the four- to eight-cubic-foot size range.

Using many components already available, the only major developments required concerned the feed mechanism and the delimber-shear mechanism, Still this unit did not progress beyond the design state.

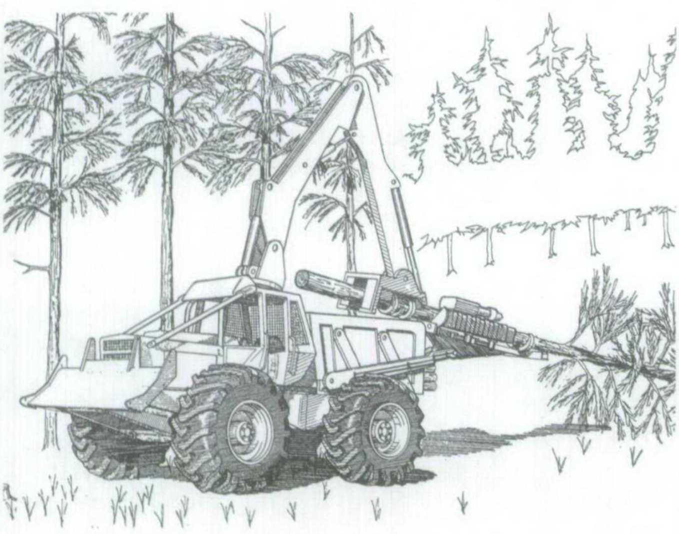


Figure 1.125 The Arbomatik stump-area harvester concept.

The Hahn "Can Car" Processor

Ray Hahn, a logging contractor from Shroeder, Minnesota, designed and built a novel tree processor, almost entirely from second-hand parts. It was licensed for manufacture in Canada by Can Car Fort William Limited, and their first unit appeared in 1967 (Doel 1969). The machine had a hydraulic loader and a delimbing head mounted on a hydraulically powered sliding carriage. It was also equipped with a shearing device or guillotine for cutting tree lengths, a kickoff device for ejecting processing bolts, and a powered rear-axle for manoeuvring stabilizers (Rolston 1967).

The butt of the tree was fed into the delimbing head, where hydraulically operated curved jaws closed on it (Figure 1.126). The delimbing head was advanced, powered by a large ten-foot-stroke hydraulic piston. When the butt of the tree was brought into position under the knuckleboom frame support, hydraulically operated dogs closed on the butt, holding the tree firmly. The flow of hydraulic fluid to the cylinder powering the delimbing head was reversed, and the head was pulled along the bole of the tree, removing the branches. The curved jaws holding the butt were released and the delimbing head was brought forward, advancing the tree until its end hit the butt stop, which triggered the guillotine,

Figure 1.126 The Hahn "Can Car" Processer.

cutting off a 100-inch-long bolt. The bolt fell into a cradle-like attachment on the side of the machine. The process was then continued until the tree was delimbed and cut into lengths. Finally, the accumulated pulpwood in the cradle was then picked up with the hydraulic loader and piled in roadside skidways or directly onto parked trucks (Thibault 1971).

The processor was relatively simple in design and had a rated capacity of 2.5 cords per PMH, although this varied considerably with tree size. It could produce and sort sawlogs as well as pulpwood. Initially, the sawlogs were handled with the loader grapple, but one of the contractors for Scott Maritimes Pulp Limited improved on this feature (Lawyer 1970). He placed two arms that could be hydraulically extended across the collector cradle, permitting the sawlogs to roll free and fall onto the ground.

Because of its low capital investment compared to other processors, the Hahn found a limited market with logging contractors. Can Car gave up its license, so the manufacturing rights entirely reverted to Hahn Machinery Inc. Over the next decade, they sold many machines and made frequent changes in its design. It became a two-man machine. The hydraulically powered carriage was replaced by a reciprocating chain-driven delimber head with an 18-foot stroke. The guillotine was replaced with a hydraulically driven chainsaw. The new model, tested by Great Lakes Forest Products Limited, was considered a viable alternative to single-function delimbers and slashers. No significant differences in wood cost were found between the Hahn and conventional methods. The Hahn also worked more easily with other equipment than did other machines (Andersson 1982). In retrospect, it now seems that Can Car did not push hard enough to sell this unit.

Caterpillar 950 Tree Harvester

The Caterpillar Tractor Company began to give serious consideration to the development of a tree harvester in 1966 (Pickard 1972a). The first design began in 1967 and continued until 1968. A test unit was constructed and tested at the Peoria Proving Grounds in 1969, and was sent to Wisconsin for field evaluation later the same year.

Design work began on a second test unit, which was constructed in 1970, and field-tested until 1971. Tests took place in Wisconsin, Louisiana, Georgia, Florida and Minnesota. In 1971, the first preproduction unit was built. Additional preproduction units were sent out for field evaluation and testing in early 1972. These machines were tested in Canada on the operations of R.W. Kangas Limited, some 200 km (125 miles) northwest of Thunder Bay, on Domtar Woodlands Limited operations at Val d'Or, Quebec (Haynes 1972) and on J.D. Irving Woodlands near Fredericton, New Brunswick. Full production began late in 1972.

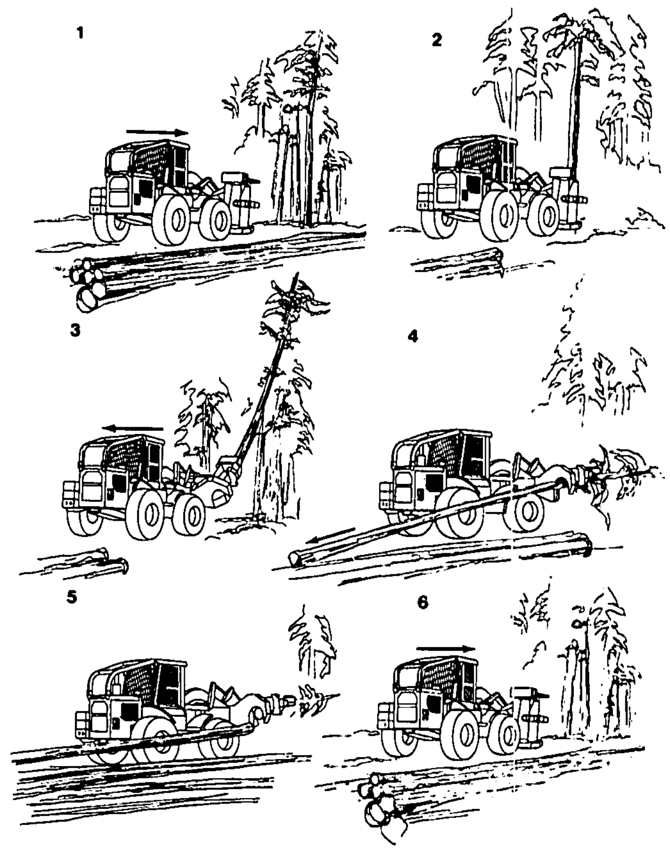


Figure 1.127 *The Caterpillar 950 Tree Harvester. The operating cycle of the Caterpillar 950 tree harvester begins as the machine (1) approaches tree with felling and processing head in the vertical position with grapple arms open. Next (2) the grapple grasps the tree and the felling head shears it at the butt, following which (3) the tree is lowered to the horizontal position as the machine backs up to the pile. Then (4) the tree is propelled through the delimbing arms by a drive mechanism and (5) the shear tops it to the desired length. As the tree is placed on the pile, the harvester moves forward (6) with the harvesting head returning to the vertical position and the grapple arms opening as the machine approaches the next tree.*

The unit and its operating cycle are illustrated in Figure 1.127. The machine is the basic Caterpillar 950 front-end loader with a harvester head added to produce the tree lengths. The harvester head was composed of a shear for both felling and topping, grapple arms to control the tree, and a delimbing mechanism. When a tree was grappled and severed from its stump, it was tilted forward. This motion activated the drive chain to propel the tree through the delimbing mechanism. As the tree moved butt first along the side of the machine, it passed through delimbing knives which sheared the branches from the trunk. The belt of delimbing knives, which wrapped around the tree trunk, was originally designed by Tom Busch of International Paper Company in the 1950s.

The Cat 950 Tree Harvester was accepted and purchased in numbers by Prince Albert Pulp Limited of Prince Albert, Saskatchewan, and Procter and Gamble of Grande Prairie, Alberta. These machines operated in extensive stands of small timber on relatively flat land (Stevens 1974). However, in 1974–75, limitations in the design and operation of the harvester became apparent and the units began to be removed from regular production and converted to front-end loaders. The relatively small tires provided only limited flotation on soft ground, so the units had to be restricted to firm ground to achieve their desired productivity. An inherent defect in the original concept was that the machine had to approach each tree to harvest it. Another major problem encountered was the ergonomic or man-machine relationship. This was outlined in Boyd's and Powell's studies of 14 machines:

> *Despite the promising introduction of the harvester to logging operations in eastern Canada, there have been problems of availability and maintenance, and, more important, with operators. The problems with availability and maintenance are similar to those encountered with most new logging machines. The operator problem results from the unwillingness of men to continue to work in what they consider to be unpleasant conditions. Boyd suggested that the motion of the harvester was severe and continuous, and this is considered to be the major objection of some operators. The continuous severe motion is the result of the need to travel to and from each tree that is harvested.*
>
> *In the longer element of the harvesting time, namely 'moving and processing', the operator is required to look behind him while the machine is backing up. This twisting around and severe pitching and rolling caused by moving over rough terrain are repeated for each tree harvested during a shift, and long-term production figures for the machine studied indicate a harvesting frequency of one tree per minute. For an 8-hour shift, such a frequency must cause this motion to be regarded as unpleasant and uncomfortable. The workplace conditions of the operator can be considered as undesirable and the reluctance to continue to work regularly under such conditions easily understandable. The importance of the operator in achieving and maintaining high production from logging equipment such as this underscores the need for comfortable workplace conditions, together with effective selection and training. In addition, when selecting operating areas for the machine, consideration must be given to its limitations with regard to terrain and stand conditions, if effective application of the machine is to be achieved (Powell 1974a).*

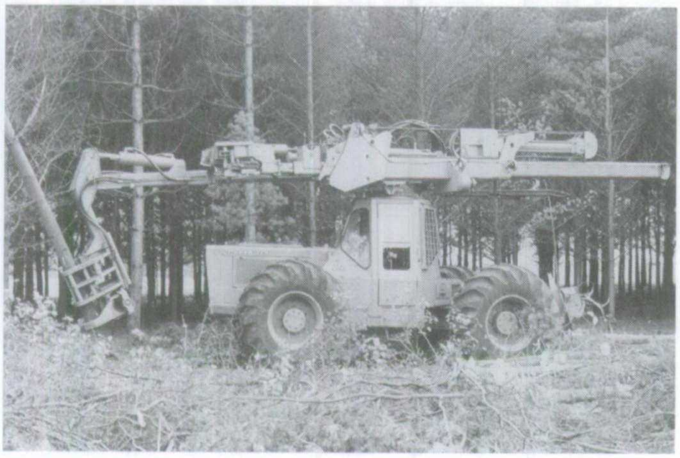
Timberjack Tree-Length Harvester

Timberjack Limited of Woodstock, Ontario, began the development of its own tree-length harvester in 1967 (Figures 1.128 to 1.130). The initiative for this project came from Spruce Falls Power and Paper Company, which was seeking a solution to the problem it was encountering in the production of tree lengths in the Clay Belt of northern Ontario. Seventy-five percent of the terrain was heavy clay, overlaid with one to six feet or more of peat, with pure stands of small black spruce predominating (Anon. 1969a).

Timberjack Limited was chosen, from a number of companies, to develop this machine in cooperation with Spruce Falls. The general specifications established by Spruce Falls included a relatively low capital cost, light weight with high flotation and the ability to fell, delimb and top small trees economically (Bell 1969).

The engineering and design of the unit took 13½ months and the manufacture and assembly took an additional four and a half months, so that 18 months after the project was initiated, a prototype machine was produced. This unit underwent an additional five months of field-testing at Turkey Point, Ontario, before being shipped to Camp 86 on Spruce Falls' operations for further testing. Because mobility of the machine was critical, the Muskeg Research Institute at the University of New Brunswick, headed by Dr. Norman Radforth, was retained to test the machine. The tests established that in its standard configuration, equipped with dual tires on the rear axle, the harvester had adequate flotation to enable it to move with ease in all treed muskeg areas.

The main components of the unit were an articulated wheeled-skidder frame, a 130-hp diesel engine; a felling, delimbing and topping mast assembly mounted a top the operator cab, and a grapple-equipped collector bunk at the rear to hold processed tree-lengths (Anon. 1971b). The machine moved along the face of the stand, cutting successive swaths of timber through an effective radius of 10½ feet. From three to six trees were harvested at each stop. When the operator positioned the harvester, he placed the transmission in neutral, which automatically engaged the walking beam stabilizers to provide a rigid working platform for the harvester. As each tree was felled, it was moved in a vertical position towards the rear of the harvester, where it was lowered to a horizontal position. The felling head was then retracted in the telescoping boom, drawing the tree alongside the delimber head. At this point, the felling head rotated 90° to allow the delimber knives to grasp the tree stem. The delimber boom then telescoped outwards, shearing off the limbs, while the topping knife automatically topped the tree at a 3½ inch diameter. The delimbing boom was activated by a cable passing through multiple sheave blocks fastened to the end of a hydraulic piston. This was the same principle used on the Beloit Harvester for activating its delimbing head. The delimbing boom then retracted, the felling head rolled back 90°, and the processed tree was released into the



Figures 1.128, 1.129, and 1.130 *The Timberjack Tree-Length Harvester.*

holding bunk. The bunk accumulated between 13 and 20 trees in approximately one-cord loads, which were then bound manually with a 13-foot-long cable choker. In the final stage, the bundle of tree lengths was then ejected from the bunk as the harvester moved ahead.

As machines were produced, they were sent out to different operations for field-testing. Because vehicles designed for forest operations on low ground-bearing-capacity soils are often effective on the opposite conditions (steep slopes), Timberjack Limited combined with Abitibi Paper Company in the Lac St-Jean region to test this harvester's stability when travelling on steep slopes. Jack Hughes (of Abitibi) was responsible for this trial and reported very satisfactory results to a meeting of the Logging Operations Group, CPPA Woodlands Division. Another was received by Quebec North Shore Paper Company at Baie Comeau in late 1971, but deep snow and mechanical problems halted the test after 34 hours of operations (Horncastle 1971). Other tests were conducted on the operations of Georgia Kraft Limited near Palmetto, Georgia. This test, supervised by personnel of the American Pulpwood Association Harvesting Research Project, took place in stands of loblolly pine. The harvester had a production rate of 75 trees per operating hour which, at 16 trees per cord, amounted to 4.6 cords per operating hour.

In spite of showing considerable promise after the manufacture of five production machines in November 1972, the Forestry Equipment Division of Eaton Yale Limited (formerly Timberjack Machines Limited) decided to abandon this development. The precise reasons are not known, but it is speculated that developing both a tree-length and a shortwood harvester at the same time overloaded Timberjack's development engineering staff and its budget.

Larson L-56 Shortwood Harvester

The Larson Shortwood Harvester was conceived by Bob Larson and built by Larson Woodlands Research Limited of Thunder Bay, Ontario. The first prototype appeared in the fall of 1968. The design, fabrication and field-testing of the harvester were carried out in close cooperation with personnel of the Woodlands Department, Great Lakes Forest Industries Limited. Murray Seeley, Vice-President, Woodlands, gave continuing support to Larson in his attempts to mechanize pulpwood harvesting, as did Gerry Seed, Manager, Woodlands Development, and Morris McKay, Woodlands Manager. Close contacts with industry contributed greatly to the flow of ideas and concepts, some of which were incorporated into prototype or production machines, while others remained on the drawing board.

The first prototype (Figures 1.131 to 1.133) was equipped with a relatively small cradle for collecting eight-foot pulpwood bolts. The final cradle design was a large inverted, hydraulically operated, grapple that could lift the load of wood, move it rearwards and downwards to place the wood in a pile on the ground.

Larson produced six shortwood harvesters before financial difficulties halted development. Two prototypes were tested on the operations of Great Lakes Forest Products Limited. The third unit, the first to be sold, was purchased by Great Lakes in 1969 (Seed 1971). Larson rebuilt his second machine and built two additional units: two were sold to the Scott Paper Company in Winslow, Maine (Godson 1973), and the other to Great Lakes. One prototype unit was tested on the limits of the Maniwaki Division of Canadian International Paper Company, but was returned to Larson after the test period.

This shortwood harvester generated considerable interest because its potential productivity was greater than any other unit at that time. At Great Lakes, they averaged 2.8 cords per PMH (Seed 1971); at Scott Paper Company, 3.2 cords per PMH; and at Canadian International Paper Company, 3.0 cords per PMH. The potential production rate was calculated to be at least 4.5 cords per PMH (Hensel 1969b) when the machine design was stabilized and the operators were suitably trained (Starks 1972). Unfortunately for Bob Larson, the pulp and paper industry was in one of its cyclical downturns at this time. In spite of the considerable promise his development held, he was unable to generate the financial support needed to make a viable operation.

Figure 1.131 *The first prototype of the Larson Shortwood Harvester had a relatively small collecting cradle.*

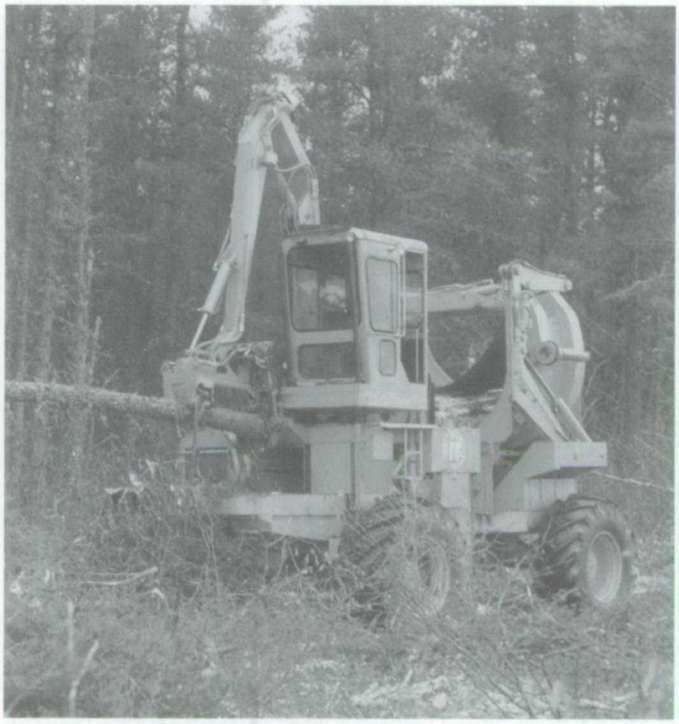


Figure 1.132 *The Larson Shortwood Harvester operating in forest stand. The operating sequence for this harvester was similar to most of the others developed in this period (Bredberg 1970b). The machine moved to a position from which one or more trees would be harvested. The felling boom was extended to a tree, the felling head was positioned and the tree severed from its stump. The severed tree was lifted vertically and swung into position directly in front of the machine. The tree was lowered and held in a horizontal position until the automatic processing of the preceding tree was completed. The tree was then lowered into the open delimber and carriage arms and the automatic processing cycle started again. Simultaneously, the manually controlled felling began again. In the automated processor, the delimber arms and the carriage arms were closed around the tree. The tree was advanced by the carriage until its butt end was 100 inches past the guillotine shear and the tree was then sheared. During the forward movement, the branches were sheared off by the knife edge of the delimber arms. The bolts produced were carried forward under the grapple-cradle and were loaded into it from below by an hydraulic "stuffer." (This manner of accumulating a load was similar to the Koehring Shortwood Harvester, which had appeared in 1968.) The carriage returned and then advanced the tree another 100 inches, removing limbs and cutting to length. The cycle was repeated until the complete tree was processed to the minimum top diameter, at which point the unmerchantable tree top was ejected. The full load was forwarded to roadside and off-loaded and piled in one lift of the hydraulically operated cradle.*

Figure 1.133 *The loaded Larson Shortwood Harvester travelling to roadside landing. Final design of the cradle is essentially a large hydraulically operated grapple.*

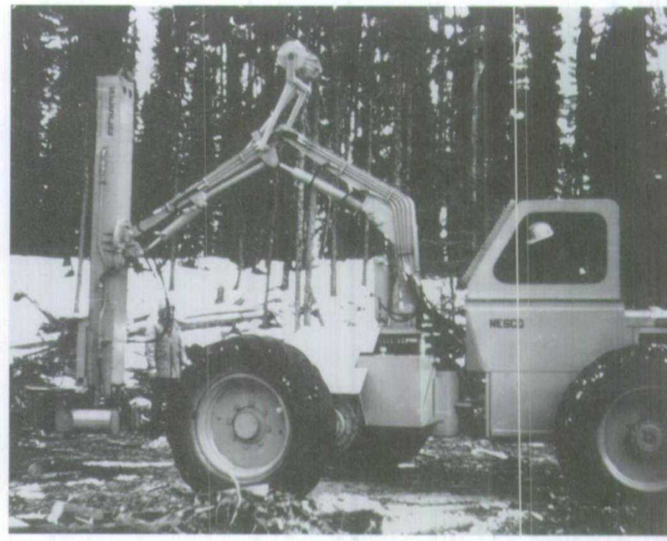


Figure 1.134 *A NESCO Woodsmobile 100 on a Can Car Tree Farmer chassis.*

A serious problem with short-run manufacturers, such as Larson Woodlands Research Limited, was that they often had more creative ideas than they could deal with. The financial pressures became so great that their ideas were transformed into hardware too soon. The result was that new equipment had to undergo periodic modifications, which involved more cost and a loss of production. Each preproduction, and even production machine, turned out to be a prototype, as modifications were introduced. This lack of standardization created problems that often reflected poorly on the manufacturer. A major problem with the tree-harvesting development during the 1960s and beyond was the lack of effective methods for systems analysis. Unfortunately, "opinions" often prevailed and recommendations from potential customers were confusing.

The NESCO Woodsmobile 100 Harvester

NESCO of Fort William, Ontario, participated in the early development of slashers, particularly in cooperation with Marathon Paper Mills of Canada. Following their success in marketing slashers, NESCO turned to other logging equipment. The NESCO Woodsmobile 100 Harvester was such a unit (Figure 1.134). It was designed by Ed Maradyn, head of engineering at NESCO, to be mounted on a proven wheeled-skidder undercarriage. The prototypes were tested over an extended period on the operations of Great Lakes Forest Industries Limited in 1967–68.

The felling-processing head was mounted on a hydraulically operated knuckleboom. A shear severed the tree from its stump and cut the bolts to length after they were delimbed. A clamp, above the shear, held the tree butt while the delimbing arms moved along a track for a distance of 100 inches. The butt clamp was then loosened and the delimbing arms, holding the tree tightly, retracted, extending the delimbed portion of the tree through the shears. The shears cut off the bolt, which dropped into a pile on the ground. The cycle was repeated until the tree was delimbed, bucked and piled neatly. During processing, the tree was supported at an angle of approximately 45° so the limbs and debris could fall freely on the ground.

The harvester was designed to operate economically on small trees; the shear capacity was 12 inches. While the unit was mounted on a standard skidder chassis, the rear axle of the skidder was extended to a width of 11 feet. This was done to stabilize the machine over the 260° swing-range of the boom and processing head. Contrary to what might be expected, the extra width of the rear axle did not cause any apparent loss of mobility.

The mechanical availability of this harvester averaged above 80%, which was high. The cycle time per bolt was timed at less than ten seconds, which translated into 1.5 minutes per tree or 40 trees per hour.

The quality of the wood processed was good, and free-fall bunching was acceptable. In an average stand, after the harvester had felled two strips, the wood was in good order for forwarding. In spite of this impressive performance, only one prototype and two preproduction units were manufactured before this development ceased.

The Siiro (Omark) Shortwood Harvester

Pulpwood harvesting techniques in the Great Lake states of Michigan, Wisconsin and Minnesota were similar to those in eastern Canada, particularly Ontario, and developments moved readily back and forth across the border. The concept of a boom-mounted felling-processing head is a good example

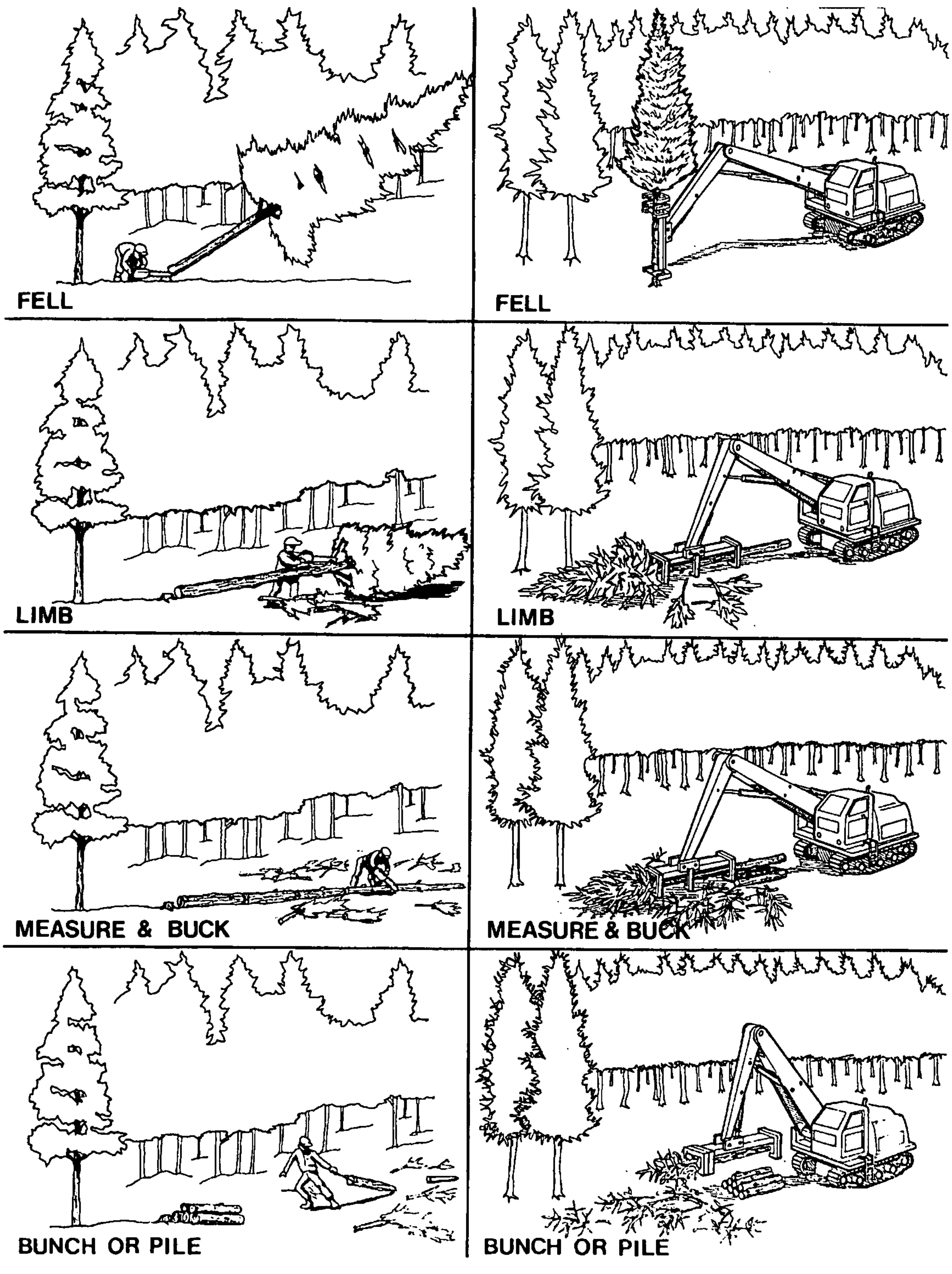


Figure 1.135 *The concept of a boom-mounted felling-processing head (NESCO and Siiro) compared with manual operation. The Omark (Siiro) Harvester and the NESCO Woodsmobile had the same processing sequence. The operator swung the harvesting head on the end of the knuckleboom and secured the upper and lower clamps to the tree. The tree was severed from its stump with a hydraulically powered chainsaw. The tree was lifted vertically, swung to the desired processing area and lowered to a horizontal position. A third clamp, called a "pulling grapple," pulled the tree through the upper and lower clamps for a distance equal to the wood length desired. Serrated knife edges on the upper and lower clamps cut the limbs off of the tree as it was measured passing the saw assembly. The hydraulically powered chainsaw cut the bolt, allowing it to drop into a windrow pile or onto a pallet. The process cycle was repeated. The limbs and unmerchantable top fell in piles, separate from the piled bolts.*

Figure 1.136 *The Siiro Harvester prototype mounted on tank chassis.*

Figure 1.137 *The Siiro felling and processing head.*

of this (Figure 1.35). In Thunder Bay, NESCO was developing its Woodsmobile at approximately the same time as Nestor Siiro of Angora, Minnesota was developing his prototype harvester (Figures 1.136 and 1.137) (Anon. 1969c). The two were similar in concept.

Siiro built his prototype harvester, attaching the harvesting head to a Prentice knuckleboom mounted on a used TD-9 tractor. He sold it to the General Logging Company, a subsidiary of the Northwest Paper Company of Cloquet, Minnesota, who experimented with it in 1966. General Logging then financed the construction of two harvesters mounted on M-60 army tank chassis. Later in 1966, Siiro built two more units. In early 1967, Siiro sold his development and patent rights to Omark Industries Inc. which, in the same period, purchased Prentice Hydraulics. Omark built and tested a preproduction unit in the winter of 1967–68. They built four production models the next year: three units to harvest 100-inch pulpwood and one to harvest 63-inch pulpwood (Wallinger 1969).

The knuckleboom used was a modification of the Prentice D100 log loader. The harvesting-processing head, which was interchangeable with a loading grapple, was designed to cut trees up to 20 inches at the stump. The boom lift capacity was 2 700 pounds at 20 feet, 6 500 pounds at 15 feet and 10 000 pounds at 10 feet. A hydraulically driven chainsaw did the cutting. Productivity of the unit was a function of tree size and, under test conditions, produced a bolt every 30 seconds. Depending upon the number of bolts per cord, productivity varied from 2 to 4 cords per PMH (Gabriel and Travel 1968).

Some of the features of the harvesting-processing head differed from other developments of this period. First, it had hydraulic clamps at the ends of the head that grasped the tree firmly during the felling and bucking process. Knife edges that were welded to these clamps sheared off the limbs as the tree was pulled through the clamps by the pull grapple. The pull grapple was moved by a hydraulic cylinder through a mechanical rope linkage, with 10 000 pounds of pull force. The pull grapple travelled on roller bearings up and down a track between the upper and lower clamp. It grasped the tree firmly to draw it through the delimbing clamps. Slippage, caused by an unyielding large limb or bark, that occurred while the tree was advancing through the processor resulted in some variation in bolt length. The collection of debris (bark and limbs) between the indexing mechanism and the indexing stop could also result in short sticks. Second, all cutting was done with a hydraulically powered chainsaw, though at this time the use of shears for cutting wood was prevalent. However, Omark also manufactured saw chains. Omark reasoned that the cost of a chainsaw was much less than that of a shear, and it weighed less. With a 25-foot reach to the felling boom, the weight was considered to be critical factor. In operation, a small hydraulic cylinder extended and retracted the saw. This cylinder was activated by oil that came from the saw-chain drive. A small cam-actuated pump oiled the saw chain twice during each sawing cycle. Third, the means of mounting the sawbar, with of a pair of spring clips, was unique. If the saw bound in a tree, or if the tree slipped, the pressure merely knocked the bar and chain off the head. The operator only had to loosen one bolt, slip the bar and chain back in place and tighten the bolt, and the harvester was back in operation.

Logging Research Associates

No history of logging mechanization in eastern Canada would be complete without reference to Logging Research Associates and its companion organization, Logging Development Corporation (LDC). A letter of intent forming Logging Research Associates (LRA) was signed by the Presidents of Abitibi Paper Company, Canadian International Paper Company and Quebec North Shore Paper Company on July 16, 1962, retroactive to April 1, 1962. In this letter, a specific five-year program, to terminate on March 31, 1967, was established. As well as a time schedule, a financial budget was proposed and approved.

LRA was a joint-venture partnership and served as a channel through which the support companies financed their logging research and development programs. A separate corporate entity, Logging Development Corporation, was also established at the same time to exploit the results of LRA as a commercial venture. LDC entered licensing agreements with outside agencies and was the channel through which earnings could be returned to the supporting companies.

In 1957, Canadian International Paper Company began the development of a full-tree harvesting system consisting of a self-loading skidder and a full-tree processor, which would remove limbs and bark, cut the stem into predetermined uniform lengths and pile the pulpwood bolts in piles at roadside. Forano Limited of Plessisville, Quebec, constructed the first prototype processor in 1960, and Canadian International Paper Company demonstrated it to the public in 1961.

Doug Hamilton, who was in charge, outlined the premise on which this full-tree harvesting project was based. The objective was to develop a compact, high-speed machine that would remove limbs and bark from a full tree, calculate the volume of the bole and cut it to length. The original prototype, described below, was primarily a test on which to prove the various processing elements.

> *The processing equipment comprises a limber, barker, feed rolls and a shearing device mounted in tandem, in that order, on a common means of support. The whole assembly is mounted to pivot on the deck of the combine. At the present time, the barker and feed rolls are provided by a Cambio 35 Barker. The delimber and shears are original designs. Maximum permissible butt diameter is 14 inches. Maximum permissible feed speed is 100 feet per minute.*
>
> *The feeding mechanism consists of a telescopic boom equipped with a tree grapple. It is mounted on a supporting frame which positions it over and parallel to the processing machinery. It pivots vertically about the forward means of support. Its maximum reach from the center of the combine is 40 feet, the extensible portion being 30 feet. The maximum boom speed (extension and retraction) is 250 feet per minute. The boom lifting capacity at full extension is 800 pounds.*
>
> *The prime mover of the power system is a Ford 223 gas engine. Almost the entire power distribution is hydraulic. Three axial piston-pumps produce 40 gallons of oil per minute at 3 000 p.s.i. This oil drives 7 hydraulic motors located on the limber, feed rolls, barker, boom, slewing mechanism and two in the undercarriage to drive the tracks. It also drives 7 hydraulic cylinders located on the grapple, boom lift mechanism and shears. One hydraulic accumulator is used for storing power for the shears.*
>
> *The undercarriage consists of a steel deck mounted to rotate on top of a set of tracks from a Bucyrus-Erie $^3/_4$ yard shovel. The deck can be slewed relative to the tracks, a maximum of 270 degrees. The tracks powered by hydraulic motors can move the machine forward or reverse at a speed of $1^1/_2$ mph.*
>
> *There is cradle or other receiving device attached to the rear of the machine to collect wood (Hamilton 1961).*

Development of this device eluded Hamilton's engineering team for about five years.

The machine moved to within 40 feet of the felled trees (Figures 1.138 to 1.140). From this point, the boom retrieved them one at a time and fed them longitudinally into the processing machine. Once the butt of a tree was engaged in the feed rolls, the processing machinery, being free to pivot, took up a position in line with the tree. In this unit, processing was continuous. The shear moved along with the tree as it cut, and a recovery mechanism brought the shear back to the starting position when the cut

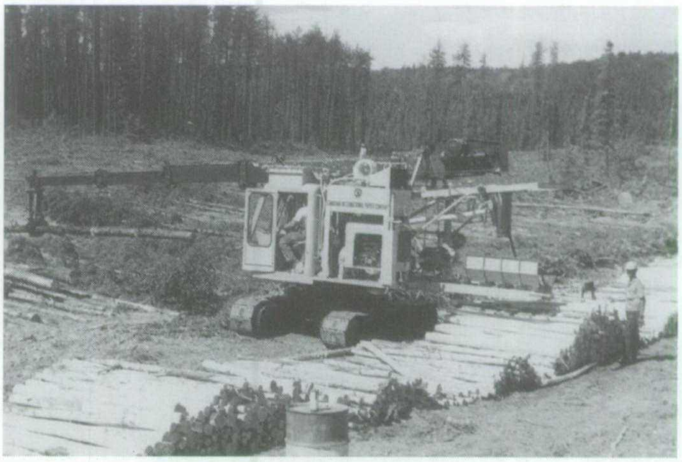


Figure 1.138 *The Arbomatik Processor producing eight-foot bark-free wood.*

Figure 1.139 *A later model of the Arbomatik Processor with large collection basket for rough wood.*

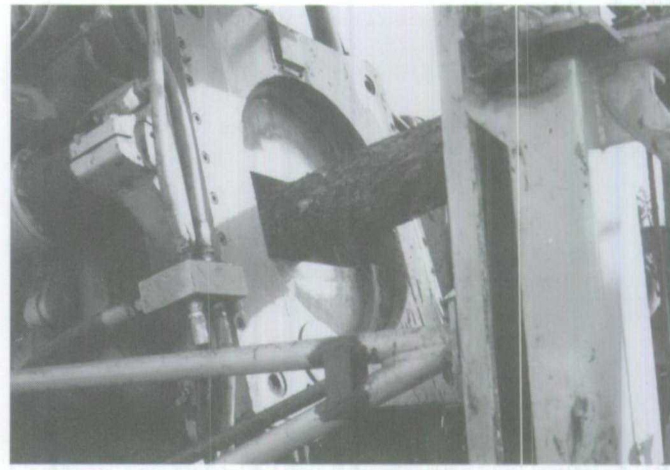


Figure 1.140 *The Arbomatik Processor's flying shear cuts bolts to accurate lengths.*

Figure 1.141 *The Arbomatik Processor with discharge conveyor for piling wood.*

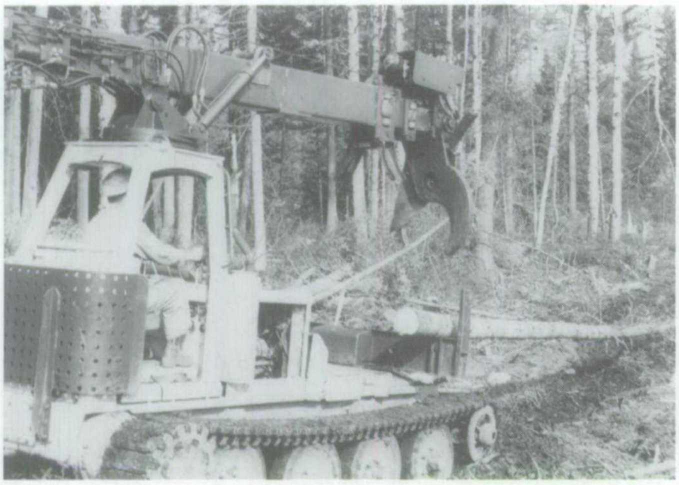


Figure 1.142 *The first felling head and grapple prototype (1965).*

was complete. A limit switch, actuated by the advancing tree, triggered flying shears. Operating at maximum feed speeds, the machine consistently processed two 40-foot trees per minute.

LRA chose to concentrate on the roadside processor because it was considered to be the heart of the system. It could be easily fed by conventional means and would perform the high-energy and time-consuming tasks of delimbing, bucking, piling and, in some cases barking, at roadside. Full-tree roadside operation allowed for two- and three-shift operations, which meant that the processor could meet its potential productive capacity (Rantzenhofer 1967). Because the processor was not designed for off-road operation, its undercarriage was greatly simplified.

Besides using the operations of the sponsoring companies, LRA had a field-test station on the Boulé River watershed near Saint-Jovite, Quebec, on the limits of the Canadian International Paper Company. Al Grimmer was seconded from Ste-Anne Power Company to be the project engineer at the Boulé. It was here, in 1965, that Paul Aird, Assistant Manager of the Woodlands Research Division, Canadian International Paper Company, initiated the first of four case histories to evaluate the effect of new logging systems on long-term forest productivity. In each case, the forest stand, reproduction and surface soil conditions were measured before any logging was done, immediately after the area was logged, and periodically thereafter. In 1966, these study areas became the base of a joint study by the Pulp and Paper Research Institute of Canada and the Canadian Forestry Service (Weetman, Grapes and Frisque 1973). The initial project was expanded to evaluate 12 logging systems in Ontario, Quebec, New Brunswick and Nova Scotia.

Although extensive surveys of forest reproduction had been conducted in eastern Canada (Candy 1951, Hosie 1953), this was the first extensive study in which the forest stand and reproduction were measured before and after logging. It was concluded that mechanical logging equipment effectively prepared the site sometimes, but not often, by removing most of the slash and churning up the ground. When used carelessly, mechanical logging equipment could destroy advance spruce and fir growth. After and area was logged, regeneration and surviving advance growth was often brush and hardwood species.

Figure 1.143 *The Mark II felling head. The telescopic boom is extended to full reach (28 feet) from centre of rotation.*

Figure 1.144 *The newly designed boom eliminates the winch box and gear reducer visible on earlier booms. Roller chains instead of cables are used to activate boom sections.*

By mid-1965, six prototype units of the LRA roadside processor, and six tracked, full-tree skidders with self-loading telescopic booms and grapples, were put on the operations of sponsors. By 1967, a new prototype of each machine was constructed, incorporating all the modifications that arose from one and one-half years of testing (Figure 1.141).

In 1967, a licensing agreement was completed with the Warner and Swasey Company of Cleveland, Ohio, and 15 processors were constructed, five for each of the LRA members.

Figure 1.145 The LRA LogAll Feller Buncher.

The original tracked self-loading skidder had been modified in 1965 to become a feller-skidder with a telescopic boom and a tree-felling and grappling device (Figures 1.42 to 1.144). It was a squat machine with a low centre of gravity, which made it very stable. By 1967, problems developed with the tracks and suspensions and this approach was dropped; a switch was made to rubber tires. A modified Clark Model 666 skidder was used as the basic chassis. When Warner and Swasey manufactured the LRA Arbomatik system, it produced the LogAll, a rubber-tired machine equipped with a hydraulically operated knuckleboom and felling head, with a claw-equipped bunk for firmly holding tree butts (Figures 1.145 to 1.146).

In 1971, LRA fielded a modified roadside processor with a high-speed processing assembly to produce eight-foot pulpwood logs. It incorporated a stripping or knife-type delimber with a top cutter, four independently powered feed rolls and a flying shear activated by a photo-cell system. The trials took place on the operations of Canadian International Paper Company.

The unit's productivity was so high (Table 1.8) that the disposition of the eight-foot wood produced was a problem. Integral receiving and off-loading devices, as well as separate independent wood-hauling equipment, were tried, but were not successful. This

Figure 1.146 The LRA LogAll Feller Skidder.

Table 1.8 Production of the Arbomatik Roughwood Processor (Anon. 1972a)

Number of Trees in Test (Average)	Tree Size (cubic feet)	Trees per Productive Machine Hour	Cunits per Productive Machine Hour	Machine Availability (%)
2 600	5.0	198	9.9	85
2 400	4.8	212	10.2	85

high rate of productivity conforms with a study on the limits of Rayonier Quebec Limited, Port Cartier, Quebec (Powell 1974c).

Self-Loading Skidder

Parallel to the early development of the Arbomatik processor, the Canadian International Paper Development Group at Trois Rivières, Quebec, produced a self-loading skidder equipped with boom and grapple, capable of loading pre-felled trees onto itself and skidding them out of the woods (Figures 1.147, 1.148). This unit was considered to be an interim step in the development of a feller skidder. It was a one-operator machine that could work independently between the forest area, where the tree was felled, and the roadside, where the tree was processed (at a rate of two cords per hour). No cable or chokers were used, and therefore no chokermen were required, which gave this unit an inherent advantage over other skidders. This self-loading skidder, which existed only in prototype form, was perhaps the forerunner of machines based on the principle of forwarding full trees or tree lengths rather than shortwood.

The original self-loading skidder depended upon trees being manually felled by chainsaw. Then the skidder loaded itself with its boom and grapple. The first prototypes were mounted on a Bombardier chassis equipped with a deck and specially designed

Figure 1.147 *The Canadian International Paper Co. self-loading skidder on a Bombardier chassis.*

Figure 1.148 *The Canadian International Paper Co. self-loading skidder in operation. A row of full trees is laid across the width of bunk and fastened, remainder of the load is simply piled on top.*

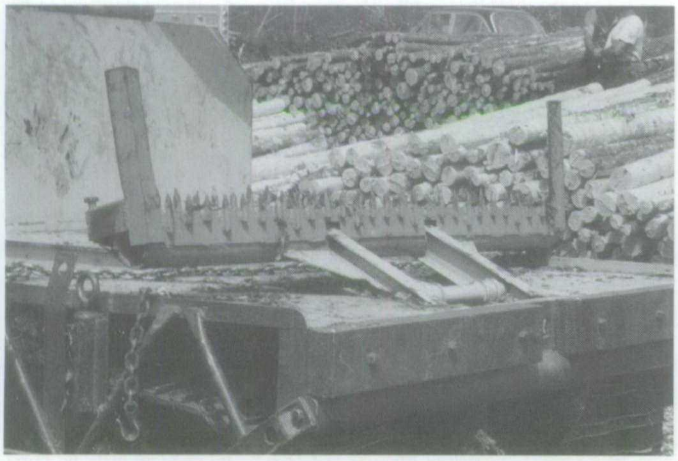


Figure 1.149 *Bunk of the Canadian International Paper Co. self-loading skidder. When the bunk is rotated 90°, the tree butts slide off as skidder moves ahead.*

Figure 1.150 *The LRA self-loading skidder on an LRA-designed chassis.*

bunk (Figure 1.149). Subsequent models were mounted on an LRA-designed heavy steel-track high-mobility chassis (Figure 1.150). To convert this unit from a self-loading skidder to a feller skidder, a felling head was mounted on the end of the boom. Development began in 1957 by Canadian International Paper Company finally resulted in production of the LRA LogAll in 1978.[43]

LRA actively continued its development work on behalf of the three companies until 1971, when the forest industry entered a severe recession. LRA activities were terminated and LDC assumed responsibility for all activities. When Canadian International Paper Company withdrew from the joint venture at the end of 1972, its interest was purchased by Forano Limited. LDC has generated over 250 patents worldwide (Skory 1976).

Dungarvon Carrier

In 1968, Domtar Limited approached the Dungarvon Company Ltd. of Almonte, Ontario, to develop the Dungarvon Carrier for long distance off and on-road transport.[44] This machine was expected to reduce the amount of branch road construction, and to reduce branch road specifications to just rock and stump removal with rough grading. The Dungarvon Carrier would eliminate truck traffic from poor branch roads, leaving them to operate only on better main roads. As a result, both forwarding and hauling costs could be optimized.

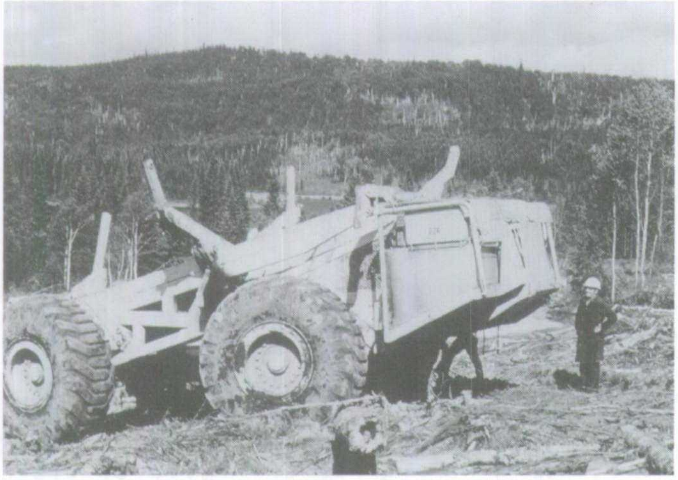


Figure 1.151 *The Dungarvon Carrier, advertised as the world's largest positive-drive cross-country 4 × 4, capable of carrying a 70 000-pound payload of logs or tree lengths on 38 × 35 logging tread tires with 36" ground clearance.*

The drive train of the Dungarvon Carrier was located within the framework of the machine and was completely independent of the main carrying axles and suspension. This eliminated the differential housing on the axles, permitting almost twice the usual ground clearance. The differentials were designed so that no wheel could slip until all four wheels slipped. The frame was not articulated, but front and rear sections (axles) could rotate 40°, which allowed the four wheels to remain on the ground at all times, even under extreme load conditions.

The Dungarvon Carrier was designed to carry tree lengths, and incorporated a tipping mechanism for easy off-loading (Figure 1.151). The prototype was tested on the operations of Abitibi Paper Company Ltd. at Iroquois Falls; Domtar Woodlands Ltd. at Lebel-sur-Quevillon, Quebec; and Northwestern Pulp and Power Ltd. at Hinton, Alberta. Although the concept seemed to be workable, problems of technical and financial support ultimately brought further development to an end.

The Nineteen Seventies

Harvesters, Delimbers and the Accufor

During the 1970s, the mechanization of logging in eastern Canada was in great confusion. There were a number of short-lived recessions, but the demand for forest products was up and prices increased steadily. Costs of production increased more rapidly than sales prices, though, and industry profits were badly squeezed. The high costs were attributed to a litany of items, well known to the industry:

> *Based upon available data, it does appear that pulpwood costs are higher for softwoods in eastern Canada than in other parts of North America. This is due to high labor costs in the woods, relatively low stocking per acre, fairly rugged terrain in some areas, and adverse winter-weather conditions all of which boost logging costs. The lower availability and use of chips compared with other areas and the resulting dependence on roundwood as a basic fibre source also increases the cost of wood at the mill. Other factors causing higher wood costs include the longer haul to the mill due to the need to log at great distances because of low density per acre, the longer growing cycle, and the high cost of building access roads (Gilligan 1973).*

The pulpwood logging industry was unhappy with the sharp increase in wood costs and the low rate of mechanization in eastern Canada. In 1969, the Logging Committee of the Woodlands Section, CPPA, was reorganized to become the Logging Operations Group (LOG), and given a broader mandate.

In both 1971 and 1975, LOG produced task force reports on logging equipment development (Rose et al. 1971, Mooney et al. 1975). Companies representing the total production of 20 million cunits of wood, both pulpwood and sawlogs, were asked for their opinions on the progress in logging equipment development, and for their needs. Under the promise of anonymity, they were frank, and in some cases, devastating. There was a long list of failures both on the part of the user and of the manufacturer.

Without trying to lay blame on either side, the results of these surveys provided a snapshot of the state of the art and conditions affecting logging mechanization in the mid-1970s. They clearly indicated that the industry was not developing the equipment necessary to remain competitive worldwide. Companies were resigned to being forced to mechanize, due to growing labour shortages, and many accepted higher wood costs as the price of mechanization.

Developments sometimes failed, but that was not always a result of poor design. Although there could be incompetence on the part of those involved in a development, there was often just a lack of persistence in introducing a new machine. Concepts could be inherently unsuitable, but sometimes just the timing of the introduction of a machine might be wrong. There were also times when failure was conceded prematurely.

There appeared to be widespread distrust of studies appraising new equipment and systems, particularly those using computer analyses. Mooney et al (1975) pointed out that "relatively poor attitudes towards the use of modern tools and procedures and of the scientific approach in general might be viewed with concern since it runs counter to the ever-widening use of computers and advanced science in most other industries." It was concluded that failure to develop a clear understanding of the current situation and to reach agreements for action led to the fragmentation and indecisiveness of the logging industry.

In 1977, Jack Boyd prepared a status report on new machines and systems for the Forest Engineering Research Institute of Canada. It painted a devastating picture of the logging industry in eastern Canada and of new developments in logging equipment. Between 1971 and 1975, the $12 million spent on new systems and machine development had yielded only $25 million in new product sales. A single machine produced by a single company (Koehring) was responsible for three quarters of the new product sales. Excluding this one company, manufacturers spent more on development than they earned in new sales, let alone profits.

Boyd characterized this dismal situation as it existed in the 1970s:

> *Tree harvesting has received the vast majority of development effort. While direct harvesting costs represent as little as one-third of wood procurement costs it has probably received more than three quarters of total effort, at the expense of off-road transportation, processing, landing-to-mill transportation, and overheads.*
>
> *Harvesting development has concentrated on single-stem concepts. Even the "collector" heads for single-stem machines have received surprisingly little attention. This situation has occurred despite the possibility that one-stem-at-a-time procedures may never*

produce low wood costs in small diameter eastern Canadian stands.

Development efforts in off-road transportation of wood have been modest, and research efforts minimal. There have been only limited attempts to find methods to increase road spacing and decrease off-road transport costs. In part, this may be due to the continuing lack of machines to fell and assemble bunches suitable for forwarding. Even machines that are apparently capable of particularly efficient off-road transport (e.g., the Tanguay Forwarder) have received little support, and experiments with high speed off-road travel (Dungarvon Forwarder) have been received with little enthusiasm.

Very few mechanization attempts have produced wood costs competitive to simpler systems.

Within the forest industries, loggers display a continuing lack of agreement on system development directions and a growing tendency to withdraw from active research and experimentation, as indicated by the low level of new equipment sales in 1976 and 1977. No important user-manufacturer joint ventures have been undertaken in the 1970s (Boyd 1977).

Jack Boyd also wrote, with co-author Wayne Novak of the Forest Engineering Research Institute of Canada, a paper entitled "A method of comparing logging system and machine concepts" (1977). It is one more description of a missed opportunity by the logging industry to come to grips with the struggle to control wood costs and to increase productivity. Their analysis of productivity, wood cost and required investment was made for 35 logging machines and 84 different logging systems. The method of analysis serves as an excellent example of how to assess new machine concepts and systems.

John Kurelek (1976) published a detailed analysis of logging concepts, comparing single-function to multifunction machines. He emphasized that the problems encountered did not only involve the mechanical reliability of the new machines being used, but that the industry had urgently needed to improve the efficiency with which these machines were being used.

In 1976, Conseillers en gestion des Forets (COGEF) of the Ministry of Forests and Energy of Quebec, produced a substantial report entitled "Méthods et matériel d'exploitation forestière" (Gagné 1976). The report described the different logging systems and their component machines. It illustrates schematically (Figure 1.152) the evolution of methods and machines for the period 1950 to the year 2000. From their analyses they predicted that between 1975 and 1980 the number of feller-forwarder, multi-stem delimbers and chippers would increase. Accompanying this increase, they predicted an almost complete

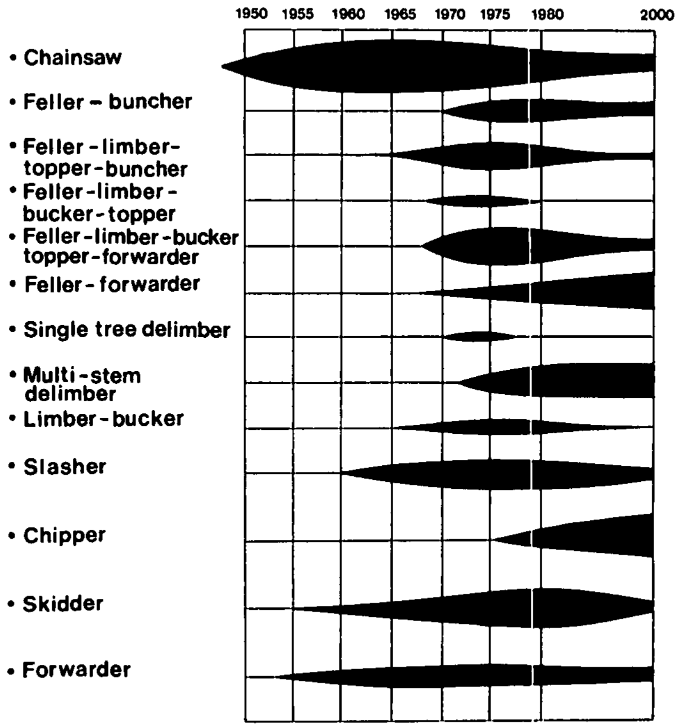


Figure 1.152 *Evolution of mechanization in the forest from 1950 to 2000.*

decline in single-tree delimbers, and feller-delimber-cross-cutter-topper machines. They believed, as indicated in Figure 1.152, that all the other machines would maintain their popularity to the year 2000. It is now possible to see the accuracy of some of these predictions. In general, the predicted trends appear to be valid, although the timing is at variance with experience gained by those who have developed shortwood harvesters.

NESCO Tree-Length Harvester

NESCO developed a tree-length harvester in 1971 (Figure 1.153), designed by Ed Maradyn, General Manager of Shop, in cooperation with personnel of Great Lakes Paper Company Limited. It had a number of design concepts that were different than existing harvesters, and showed promise of considerably increased productivity. First, the felling head on the end of a tree-gathering boom was state-of the-art, but it was the idea of transferring the tree to grapples on a vertical mast that was new. This meant that the felling operation could continue while the harvested tree was being processed automatically, that is, delimbed, topped and placed in a collector. Second, the delimbing head and the telescopic frame were mechanically operated, eliminating lengthy hydraulic systems. Third the transfer mast and delimbing frames were mounted to permit the articulation of the machine, to give it off-road mobility. This machine never got off the drawing board, though, in spite of active support from the forest industries at Thunder Bay.

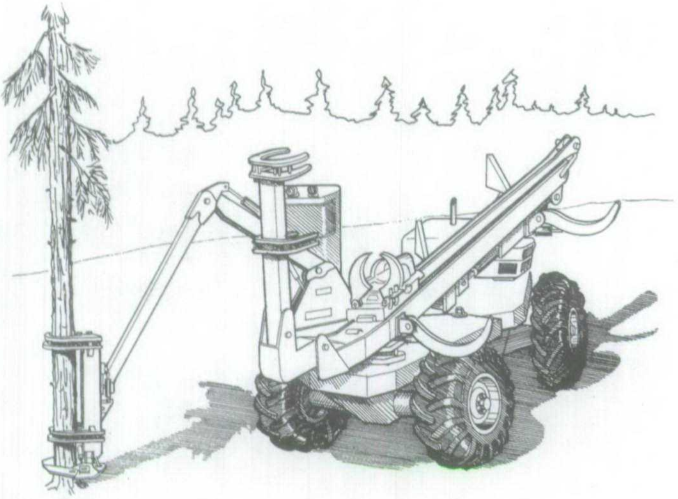


Figure 1.153 *The NESCO Tree-Length Harvester gathering trees.*

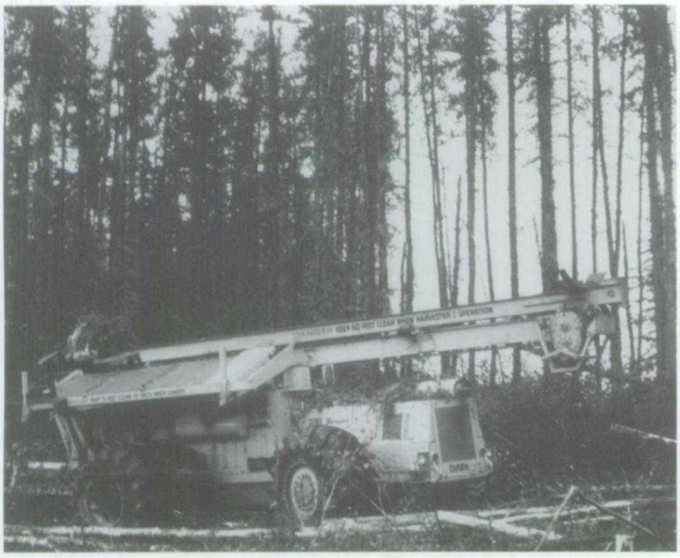


Figure 1.154 *The Clark Tree-Length Harvester.*

Clark Tree-Length Harvester

Clark Equipment of Canada Limited initiated a tree-length harvester project in 1970. Almost from the beginning, there was a close working relationship with the Forest Management Institute of the Canadian Forestry Service.

In 1973, field-testing began on the operations of Prince Albert Pulp Limited of Prince Albert, Saskatchewan, after which the machine was returned to the plant in St. Thomas for reworking. In 1974, it was tested on the limits of Eddy Forest Products Limited at Ramsay, Ontario. A second prototype, incorporating a complete redesign, was fielded in 1976 at Thunder Bay (Figure 1.154), and a third prototype was built in 1977, but it never left the factory.

Ian McKenzie, Vice-President of Engineering, believed he knew why most attempts to mechanize tree harvesting had failed:

> *I feel that the cost of wood through mechanization was never significantly less than the cost of wood by conventional methods. This in turn did not allow Woodlands Management to invest at the necessary level in a sophisticated organization to allow the newly introduced machine to reach its potential. If mechanization had been able to offer a quantum leap in cost reduction it would have got the backing and survived. Chainsaws, skidders and shears have made it because they are cost effective. (McKenzie, pers. comm.)*

Timberjack RW-30 Tree-Length Harvester

The Timberjack RW-30 Tree-Length Harvester felled, delimbed, topped and bunched tree lengths. The original concept is attributed to C.M. "Bill" Kerruish of the Forestry and Timber Bureau, Department of National Development, Canberra, Australia. The prototype of the machine was built by R.L. Windsor and Son Pty. Limited, Brisbane, Australia, for the Forestry and Timber Bureau in 1969, and was thoroughly tested under a variety of conditions during 1970–71 (Figures 1.155, 1.156). It was designed initially as a row harvester in Radiata pine plantations. After its success, there, it was tested in eucalyptus stands where it proved possible, with modified knives, to debark the hardwoods as well as delimb them (Anon. 1970a, Anon. 1971a).

R.L. Windsor and Son Pty. Limited was not a manufacturer of logging equipment but designed and manufactured paper and boxboard converting machines. Their approach to designing this harvester differed from the conventional. The machine was created as a small wooden model before any lines were put on paper. Various components, such as the felling head and grapple, and the delimbing mechanism, were all made to scale in wood in the pattern shop, and tested before even the shop drawings were made. The whole engineering development of the machine was carried out systematically with models and wooden mock-ups before any iron was cut. The design and construction of the prototype was carried out by the Windsors for a flat rate of $40 000 Australian (Silversides 1970). This is certainly one of the least costly machine developments in the history of logging mechanization.

In 1972, the Eaton Corporation of Woodstock, Ontario, entered into an agreement with Windsor to manufacture and market the RW-30 Tree-Length Harvester outside of Oceania. The first Canadian-built machines were introduced onto logging operations in eastern Canada in 1973 (Powell 1974d). By 1974 there were nine machines working in the forest

Figure 1.155 *A wooden model of the Timberjack RW-30 Harvester, constructed by R.W. Windsor of Brisbane, Australia.*

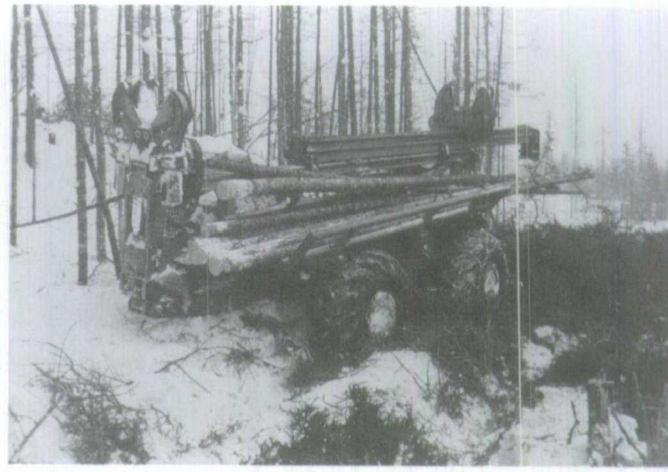


Figure 1.156 *The Timberjack RW-30 Harvester working in eastern Quebec.*

and by the end of February 1975, 45 machines had been built with more on order.

The harvester consisted of an articulated wheeled-chassis that had felling and delimbing attachments mounted on the front section. The operation of the machine was described by Powell (1974d).

> *In operation the machine moves into a position from which it can harvest a tree and the felling head is extended toward the tree. The felling head is positioned (often by manoeuvring the machine) and the tree is sheared at its base. The sheared tree is lifted clear of the ground, and the felling boom is aligned with the centre line of the machine, with the tree still held vertically. The felling boom is then raised into a vertical position, placing the tree horizontally in the limbing head. The limbing knives then close around the tree and the limbing head is drawn along the tree as the boom is extended. When the desired top diameter is reached, the top is sheared. The tree length, still held by the felling head is then released and falls into the collector. The felling head is then extended towards the next tree and at the same time, the limbing head returns to the ready position. When the tree collector is full the load of tree lengths is ejected to the side of the machine. The machine is able to harvest a swath 14 feet wide. It is able to harvest only one tree at a time as the felling head is used to hold the tree during delimbing.*

The felling head on the Windsor harvester differed from those of other manufacturers. Because, in dense stands, Radiata pine retains its limbs right to the ground (it is not self-pruning) Kerruish and Windsor designed a felling head that would slip in and grapple a tree at ground level to shear it. The shallow grapple was sufficient to hold the tree and control it as it was lifted up and back onto the machine.

In 1981, the Eaton Corporation brought out their TJ-30 harvesting system, which consisted of three distinct units. The Timberjack 30 feller-buncher was the basic harvester with the delimbing rails removed and the bunk enlarged. The bunk was side tipping so that loads of trees were dropped parallel to the work-face, always with butts forward and lined up for a fast pickup. The second unit was a grapple skidder and the third machine was the Timberjack 30 delimber. In this unit, the delimbing mechanism of the TJ-30 Harvester was mounted on wheels for mobility, and coupled to a heel-boom loader, powered by a hydraulic system. After the operator applied the topping lever, the delimbing shear moved on, free of the tree, the butt clamp opened and the stem dropped into the storage rack. During the delimbing operation, the loader operator could pick up the next tree and be ready to position it as soon as the delimbed stem dropped out of the way. As well as operating the delimber, the operator could load trucks with the heel boom.

Annand Shortwood Harvester

In 1971, the Annand Steel Company of Truro, Nova Scotia, in cooperation with Nova Scotia Pulp Limited, proposed a shortwood harvester; another concept that was stillborn. It had a Drott 40 feller-buncher for tree harvesting and motive power, and towed a trailer-mounted processing unit. The independently powered processing unit automatically fed one or two trees in a horizontal position, delimbed and bucked them into eight-foot or 16-foot lengths, and accumulated and off-loaded piles of 0.5–1.0 cord size for forwarding to roadside (Figure 1.157). The feed rolls designed by Charles Annand, had a "flexible" surface that enabled them to grip more than 25 to 30% of the tree's circumference, rather than the limited contact area of conventional feed rolls. Besides the

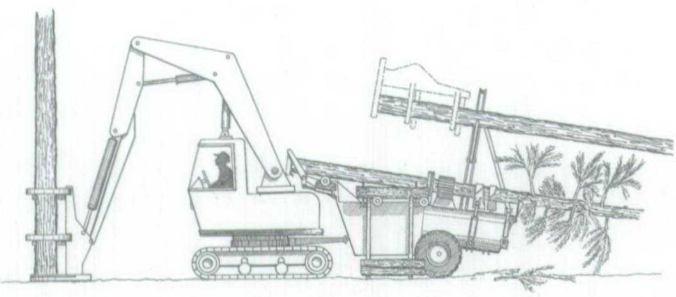


Figure 1.157 *The Annand Shortwood Harvester.*

greatly increased traction, two trees could be fed simultaneously through the rolls.

Detailed simulation studies were conducted by the Forest Management Institute of the Canadian Forestry Service, as well as by the Woodlands Department of Nova Scotia Pulp Limited. The Drott 40 feller buncher had ample productive capacity; it was the processor's productivity rate that was the limiting factor. The estimated productivity for three-bolt trees varied between 4.6 and 6.0 cords per hour. In Nova Scotia, the trees are shorter than in Quebec and Ontario, averaging 2.7 to 3.0 bolts per tree, 4.82 cubic feet in volume and 7 to 8 inches in diameter.

O and M Harvester

In 1974, the Woodlands Division of the Ontario-Minnesota Pulp and Paper Company, dissatisfied with the tree harvesters they had tried to date, decided to design and build one of their own. The project was headed by Merl Harp and Jim Ekland (Anon. 1974c) and the prototype was tested on the company's Kenora limits.

The undercarriage of the unit was a U.S. Army M59 personnel carrier. A Drott felling-head was mounted on a Barko boom that had a 34-foot reach, and a Tanguay delimber was mounted on the deck of the harvester. The whole package was powered by a 265 hp GM diesel, driving eight hydraulic pumps. The operator was only required to control the felling shear and the loader, although manual overrides were built in to allow the operator to take control of the automated functions if the need arose.

Tanguay Tree-Length Harvester and Forwarder

Tanguay Industries Limited built prototypes of a tree-length harvester and tree-length forwarder in 1971. These units underwent field-testing on the operation of the Consolidated-Bathurst Inc. on the Pierriche River in Quebec (Anon. 1972b) (Figures 1.158, 1.159).

The harvester had an overall length of 42 feet and a width of 13 feet. It was mounted on a six-wheel-drive articulated frame-steered chassis powered by a

Figure 1.158 *The Tanguay Tree-Length Harvester.*

Figure 1.159 *The Tanguay Tree-Length Forwarder with an eight-cunit load.*

Caterpillar D-333 turbo-charged engine. Engine power was transmitted to the wheels through a Clark torque converter, transmission and axles. The harvester engine was positioned at the rear of the machine over a single set of wheels (with 33.25-inch by 35-inch tires). At the front of the harvester, the felling boom, cab, and debranching mechanism were mounted over a single axle that drove a tandem bogie by means of a chain drive. The bogie tires were 29.5 inches by 25 inches.

The felling head was mounted on the end of a Tanguay 50-22 loader boom. It consisted of a two-blade scissor-like shear activated by two six-inch hydraulic cylinders, which could shear trees up to 20 inches in diameter. The delimber consisted of four hydraulically powered feed rolls that could pull the tree through a set of static delimbing knives.

Initially, the trees were pulled through the delimbing knives by two self-locking reciprocating arms, but this wasted too much time and the mechanism was replaced by feed rolls operating at a feed rate of 300 feet per minute. Tree lengths were topped automatically. When the delimbing knives closed to a preset diameter, a hydraulically operated topping knife was activated.

Delimbed tree-lengths were ejected by the rear conveyor to fall, butt first, diagonally to the ground. The operator determined which side of the machine the tree lengths would fall on, so loose bunches could be made.

The engine, torque converter, transmission, wheels and axles of the forwarder were all the same as the harvester's. On the forwarder, however, the cab and knuckleboom were located at the engine end of the chassis, and the load platform was positioned over the tandem bogie. The load capacity was approximately eight cunits but varied, depending on the length of the wood. Off-loading the forwarder was initially carried out by the same knuckleboom that did the loading, but this took too much time, so a system of drop stakes and powered chains was developed to speed up off-loading.

The harvester was evaluated by Les Powell of Pulp and Paper Research Institute of Canada (1973).

Koehring Feller Forwarder

Tree harvesting systems that extracted tree branches and foliage from the felling site were encouraged by Koroleff (1954) after a study tour to Russia. Acceptance of full-tree systems in Canada at about this time grew steadily with many developers involved.

The success of the feller-buncher-skidder operations led to the feller-forwarder concept by Koehring, which converted two machines into a one-machine operation.[45] The Koehring feller-forwarder was introduced in 1976 on the operations of Great Northern Paper Company, Millinocket, Maine and Ontario Paper Company, Manitouwadge, Ontario (Legault 1976, Folkema 1977, Heidersdorf 1978) (Figure 1.160). The increased use of these machines is shown in Figure 1.161. The machine operated well with hardwoods and softwoods, which was of considerable interest to the logging industry.

The Koehring feller-forwarder operation was compared to the conventional cut and skid method on the limits of the Ontario Paper Company (Meagher 1978). Major productivity increases and cost savings were realized with the full-tree logging system on relatively flat terrain. A Koehring feller-forwarder carried full trees to roadside where delimbing and topping were performed by a modified Timmins head (Figure 1.162). A productivity of 25.5 cunits per man-day (tree length at roadside) was achieved with this system over a one-year period; with conventional cut-and-skid crews, productivity was 6.9 cunits per man-day. One Koehring feller-forwarder and one delimber produced over 18 000 cunits of tree-length wood to roadside in 12 consecutive months (1979) on a double-shift basis.

Figure 1.160 *The Koehring Feller Forwarder.*

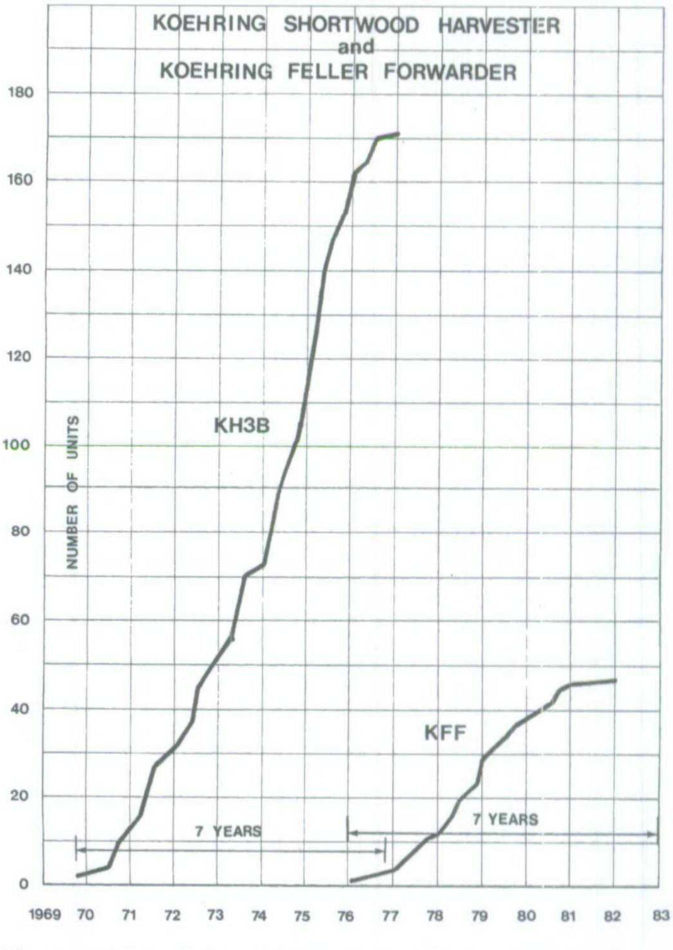


Figure 1.161 *Sales of the Koehring Shortwood Harvester and the Koehring Feller Forwarder 1969–1982.*

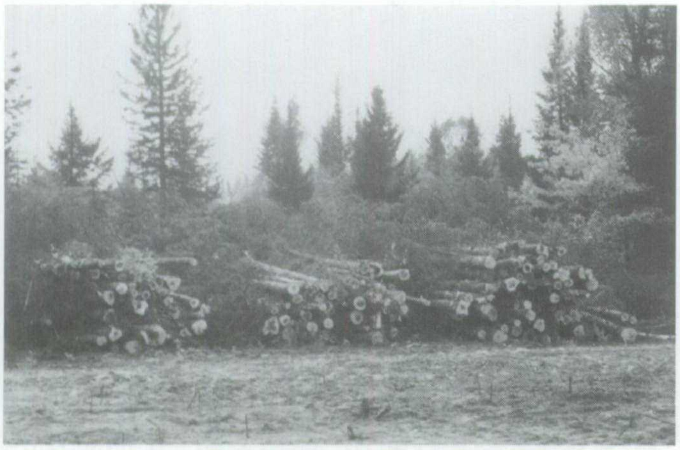


Figure 1.162 *Loads dumped at the landing by Koehring Feller Forwarder.*

In 1982, a smaller, more versatile machine, designated K2FF was produced. Both its weight and load-carrying capacity were considerably reduced. It was claimed that its productivity in dense spruce and fir stands was close to that of the larger machine, while in low density stands (6–13 cunits per acre) it averaged 4.8 cunits per operating hour. Of particular significance is the low level of productivity delay and therefore consistent high level of utilized time. The Koehring Feller Forwarder has been called a "Foreman's Delight — just point the operator."

Larson's Carousel

In 1975, Bob Larson of Larson Woodlands Research proposed a timber-harvesting machine which he called "The Carousel Mark I." In principle, it would shear, collect, delimb and pile tree-length wood. There were two felling shears mounted on two knuckle-type booms, 180° from each other. These booms revolved about a fixed axis; with the revolving shears and the forward movement of the carrier, an egg-shaped arc was cut into the stand (Figure 1.163).

The carrier was a variable-width hydraulic-drive vehicle. The front wheels were close-coupled at a 7.5-foot width while the width of the rear wheels could be adjusted from 8 to 14 feet.

As the shear is positioned at ground level and cuts the stem, the tree is raised back to the full up-and-retract position of all boom cylinders. While the loaded shear is swung over the frame of the vehicle and into the delimber mast grapple (with no loss of production), the other shear is entering the cutting path. The semi-vertical delimber mast simultaneously begins to revolve clockwise on its bearing. The delimbing grapple closes and removes the full tree from the carousel assembly. As rotation begins, the delimbing head starts up the 60-foot I-beam mast and 4 seconds later the tree is delimbed. A twin delimber head on the other side of the mast descends as the first goes up. On completing a half-revolution

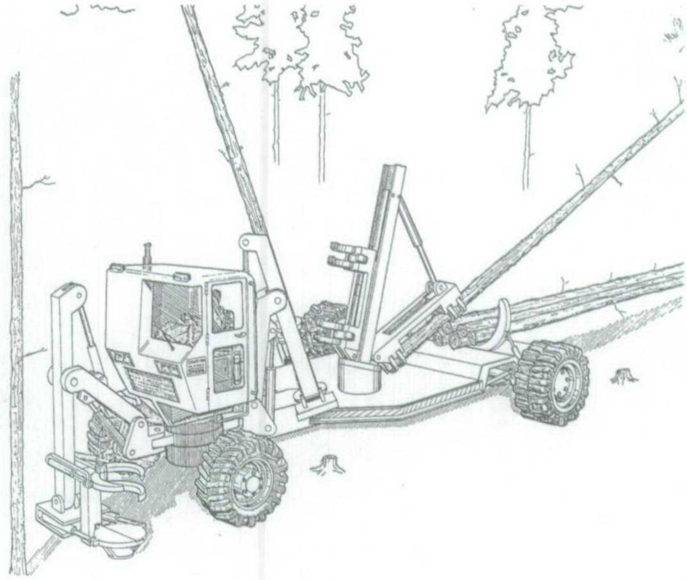


Figure 1.163 *The Carousel Mk I Harvester concept.*

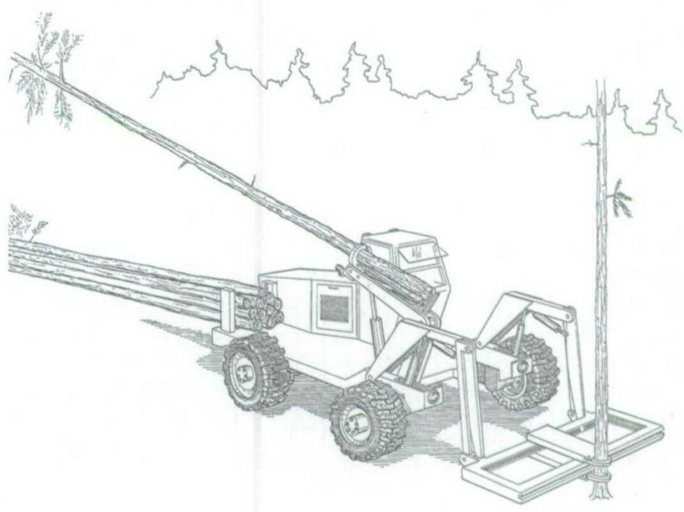


Figure 1.164 *The tree feller-delimber-buncher concept with sensing felling head.*

the mast indexes and stops, with the loaded grapple and delimber facing the rear of the vehicle. The delimber grapple is hinged from the top of the grapple to its base and then places the delimbed tree into the accumulator grapple. The cycle continues until 2 cords are in the grapple.

Larson calculated that in stands running 20 cords per acre and 15 trees per cord, with the harvester moving at 0.5 mph, it was theoretically possible to harvest trees at the rate of 12 trees per minute, or 48 cords per hour with this machine.

In his shortwood harvester, Larson had successfully developed a machine in which the felling and gathering operation was performed manually while the processing, that is delimbing, bucking, stowing and disposal of unmerchantable tops was automated. He

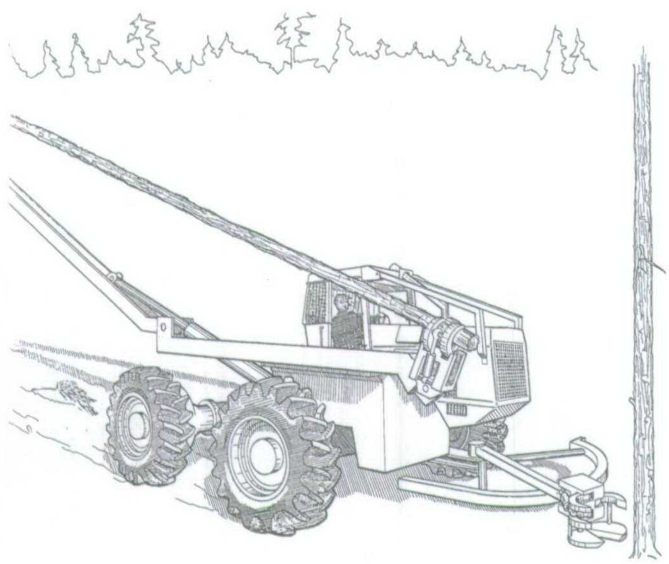


Figure 1.165 *The tree feller-delimber-buncher concept with curved sensing felling head.*

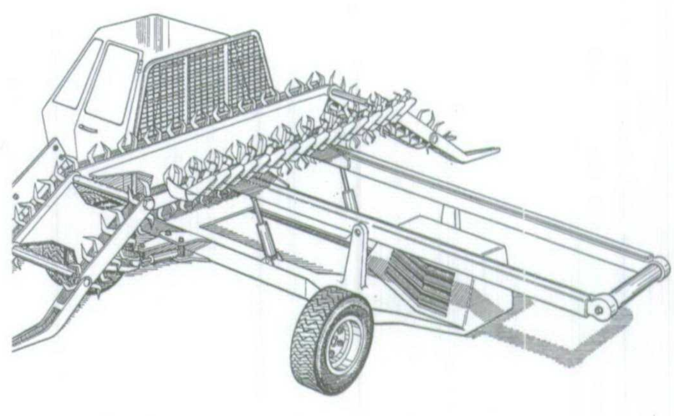


Figure 1.166 *The multi-stem delimber concept.*

envisioned the next step to be the automation of the felling and gathering operation so that the operator would concentrate solely on manoeuvring the harvester in the stand.

Several designs of this equipment were developed but none were produced. One of the first designs had a felling head on a track, positioned horizontally across the front of the harvester. When the front of the track contacted a tree, it triggered the felling head to move automatically into position to grapple and sever the tree from its stump. The tree was moved in an arc backwards to be placed in a delimber grapple. The delimber removed the limbs, cut off the unmerchantable top and placed the tree length onto a collecting bunk at the rear of the machine (Figure 1.164). Another design was also based on a semicircular contact bar, around which the felling head travelled to contact the tree, that activated the felling head (Figure 1.165).

Larson's Multi-Stem Delimber

The concept of swathing trees has always appealed to loggers in eastern Canada. Because of relatively small trees and low density, the upper limits of production for single-stem tree harvesters may have been reached. Multi-stem harvesting, which includes multi-stem delimbing and debarking, appears to be the next logical stage in development. Several different machines based on the swathing principle have appeared. These all employed circular saws that ran parallel to the ground to sever trees at stump height.

Larson developed another concept: a multi-stem delimbing machine for swathed trees, mounted upon a six-wheel drive chassis. The steering axis could be rotated at the wheel a full 90° (Figure 1.166). The machine would approach the pile of windrowed or bunched wood with the wheels parallel to the axis

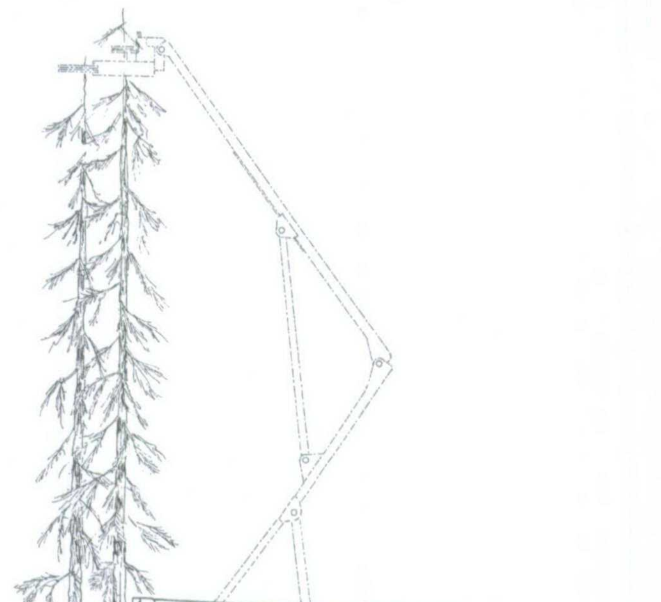


Figure 1.167 *The concept of a tree harvester to delimb, top and fell, without a mast, as in the Beloit Harvester.*

of the trees. The wheels would then be rotated 90°, and the machine would move into the pile with the tines and grappling arms extended and the tines would slide under the wood. The machine would then use a loading ramp to raise the butts off the ground approximately 18 inches. A pair of curved jaws, activated by a travelling feed chain, lifted and grabbed the butts. The trees moved up to the processing deck, at approximately 100 feet per minute, to maintain six trees in the delimbing position, separated and tightly clamped.

A cross-member assembly with six staggered delimber-heads closed on the prepositioned trees. The delimbing assembly moved down the frame, pulled by two cylinder-operated sheave separating units. At 3 inches diameter or 50 feet in length, whichever came first, a topping chisel operated by the delimber arms topped the tree. The momentum of the moving assembly tossed the tree tops beyond the machine. Deflectors behind the delimber head accumulated the limbs, and most of these were tossed off the end as well. Potential productivity for this unit was calculated at 60 cords per hour with a practical productivity estimated at about 24 cords per hour.

Figure 1.167 shows another Larson concept designed to supersede the Beloit Harvester.[46] Instead of a mast, as the Beloit had, a series of linked arms, activated mechanically by cables, propelled the delimbing and topping mechanism up and down the tree. This, however, was another concept that did not get past the drawing board.

Morard Delimber

A multi-stem delimber appeared briefly in the early 1970s. It was developed by Ben Morin, of Morard Pulpwood Company Limited in Hornepayne, Ontario, who was a contractor for the Ontario Paper Company Limited. A commercial version, know as the "Morard Delimber," was manufactured by NESCO for North Shore White Truck Sales Limited of Thunder Bay, Ontario (which owned the Canadian manufacturing and marketing rights) (Heidersdorf 1973, Pickard 1972b).

The delimber (Figure 1.168) consisted of two steel beams; the top one held a steel plate band with nine to eleven circular cutouts, each large enough to accommodate a tree with a 12-inch butt. The cutouts were lined with heavy, bevelled knife edges on a horizontal plane. The top beam was raised and lowered by means of a hydraulic cylinder. The bottom beam was stationary, with matching horizontal knife edges.

At the delimbing site, a skidder hauled its load of trees into position in front of, and at right angles to, the bundle delimber. As the delimber was backed into the load of trees, the bottom beam slid under the butt end of the load and the top beam, with its serrated steel plate, was lowered. The skidder then moved ahead, pulling the trees through to the point where they could be topped. A hydraulically operated circular saw was lowered on a boom, which cut off the tops. Depending upon the situation, the skidder could drop the load prior to delimbing, move ahead and then winch the load through the delimber.

The time to delimb a skidder-load of trees was 2.6 minutes and productivity, including waiting time, was 13.9 cunits per productive machine hour, with a

Figure 1.168 *The Morard Delimber.*

Table 1.9 Delimbing performance achieved by the Morard Delimber

Quality of delimbing	Description	% of loads
1	Virtually no branch stubs left on the load	20
2	A few branches and branch stubs left on the load, no additional delimbing required	29
3	About 50% of stems in load have some branches remaining. Additional manual delimbing may be necessary	29
4	Nearly all stems in load have some degree of branches remaining. Additional manual delimbing definitely necessary	22

calculated potential productivity of 24.9 cunits per productive machine hour. But Heidersdorf (1973) reported that the quality of the delimbing could limit the application of the machine (Table 1.9).

Flail and Stick Delimbers

One of the first approaches to multi-stem delimbing was Clark Horncastle's use of chain flails during the Ontario Paper Company full-tree logging trials at Heron Bay in 1956. In 1975, a variation of this technique was developed at The Pas, Manitoba, by Mike Stadnick, a contractor from Manitoba Forestry Resources Limited, and Gordon Franklin, the company's Equipment Manager. A flail was mounted on a mobile carrier and passed over bunched of felled trees lying on the ground (Skory 1975b).

The new flail delimber consisted of 30 short lengths of chain attached in staggered rows to a rotating drum mounted on a wheeled tractor (Figure 1.169 to 1.172). An operator drove the unit over bundles of tree lengths, usually in two passes. The drum and chains rotated at about 525 rpm. Because of the deflection of the chains and because the tree boles often rotated when the top branches were gone, the chain flail even removed limbs from the undersides of the tree boles. The tractor tires also tended to spread out the bunches, which broke off branches in the process (Evans 1976).

The development of the flail delimber became widely known when Bruce Hyde of Woodlands Enterprises Limited, Prince Albert, Saskatchewan, gave a presentation at the Woodlands Section, CPPA, annual meeting in 1975 entitled "Can one man in the woods industry delimb over 1 500 trees in one hour?" Hyde described the development by his organization of a flail-delimber mounted on a Hydro-Ax chassis. This unit could delimb 60 cords per hour, at approximately $0.75 per cord, while the rate of delimbing by power saw was 2 cords per hour (Hyde 1975).

The impact of his presentation was considerably enhanced by a parallel presentation by R. Pickering of Consolidated Bathurst Limited on tree-length delimbing with the Logma. The Logma was a Swedish delimber, designed to provide a replacement for the Beloit Harvesters that were being used in Swedish forest stands where ground roughness was severe and where trees were larger than in the Acadian and Boreal Forest Regions. It was known as a stick delimber, that picked up and held a tree by its top, closed its delimbing knives around the tree, and forced the

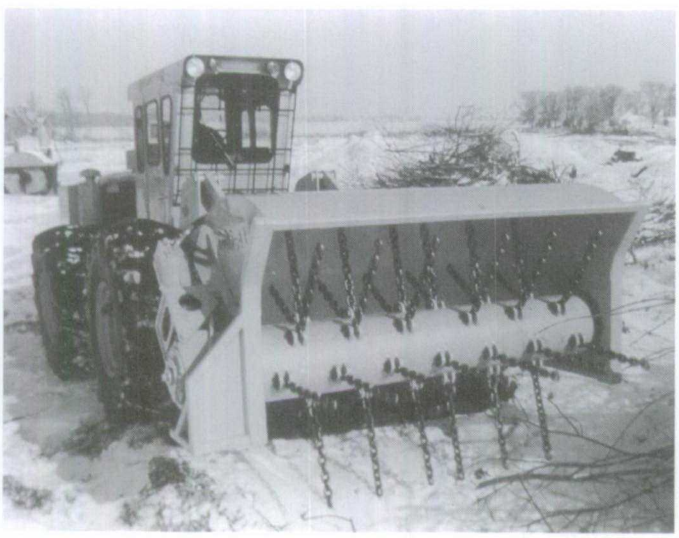


Figure 1.169 *The action of flail delimbers.*

Figure 1.170 *Flailing a pile of spruce trees, working from top to butt.*

Figure 1.171 *The flail delimber in action.*

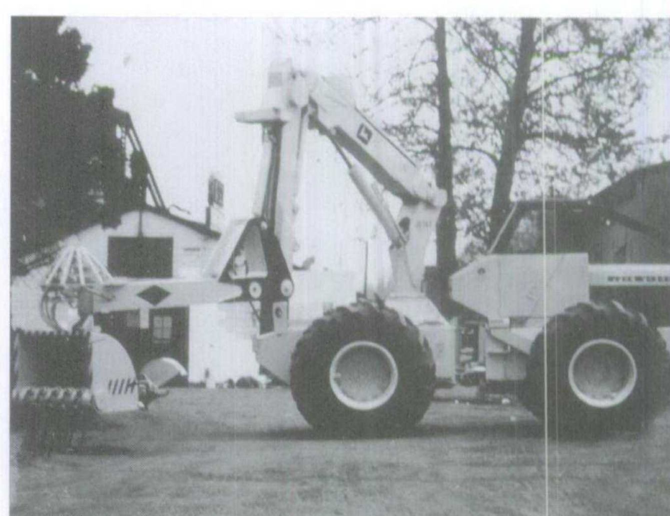


Figure 1.172 *A flail delimber mounted on the end of an articulated knuckleboom.*

Figure 1.173 *The Denis Stick Single-Stem Delimber.*

Figure 1.174 *The Tanguay Single-Stem Delimber.*

knives along its length with a telescopic boom. The reason for this reverse procedure (manipulating trees from the butt end was conventional practice) was that only that section of the tree with branches needed to be processed. Practically all other machines delimbed the entire merchantable length of the tree, including the butt section with no limbs.

The shock came when Pickering disclosed a delimbing cost of $7.00 per cunit, compared with Hyde's $0.88 per cunit. This set off flurry of interest in flail delimbers, and their principle of action was studied in some detail by the Forest Engineering Research Institute of Canada (Johnson 1976b, Heidersdorf 1980, Folkema and Giguère 1979). In winter, when limbs were brittle, the quality of delimbing was considered good. During the summer, when the limbs were more flexible, the quality of delimbing dropped drastically. To maintain production, some companies had men with chainsaws follow the delimber to finish the job.

The poor quality of limb removal had a considerable impact on the widespread acceptance of the flail delimber. Today, throughout most of eastern Canada where full-tree harvesting to roadside is going on, the stick delimber is in almost universal use (Figures 1.173 to 1.174).

The Swedish Logma machine was introduced into Canada as a complete unit. The delimber was mounted on a mobile rubber-tired chassis, capable of off-road travel. A number of Quebec and Ontario companies, notably Equipment Denis Inc., Equipment C. Bourbeau, Harricana, Roger, and Koehring began to produce stick delimbers as attachments to a wide range of chassis, from old trucks to new crane- or loader-tracked undercarriages. These attachments were much less expensive than the original Logma and they operated differently. They grappled the butts of trees and removed the limbs from butt to top, cutting off the top at a predetermined diameter. In some instances, the topping device was removed and the unmerchantable tops were left on, increasing delimbing productivity.

McColl's Accufor

Bruce McColl's contribution to mechanical logging is not yet fully appreciated by his peers in the industry. He has played a major role in the development of mechanical logging, first as a mechanical engineer employed by the CPPA and by the Pulp and Paper Research Institute of Canada, later in private industry, and finally as a consultant. His emphasis, from the beginning of his work in the industry, was on a systems approach to development and to the application of mechanical logging on operations.

Most of his contributions have been indirect and he has not profited from them. He developed the articulated frame-steered chassis for the Bonnard Prehauler and used by most manufacturers of wheeled skidders; the "Forwarder" concept, which helped the industry break away from the movement of packaged or bundled wood and the conventional method of cut and pile; the off-road tire that made the use of wheels in the woods practical; chip pipelining; and his chipped wood system concept.

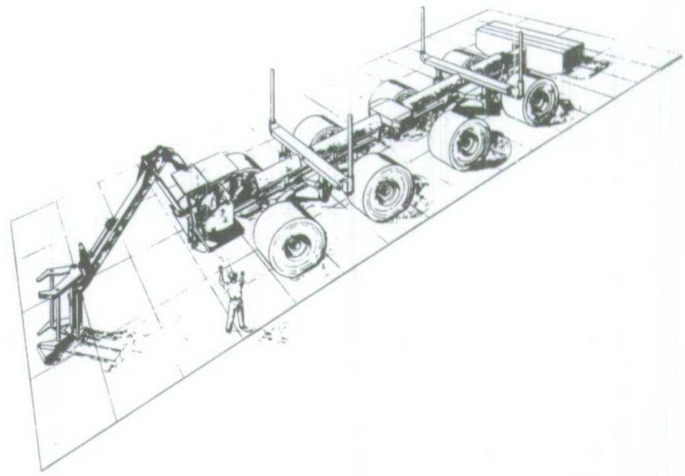


Figure 1.175 *The Accufor designed by Bruce McColl.*

In 1953, McColl co-authored a paper, with W.A.E. (Art) Pepler, Manager of the Woodlands Section, CPPA, entitled "The development of mechanical pulpwood logging methods for eastern Canada." It was an expansion of an earlier paper he had circulated in 1950 and was presented again in 1953, 1957 and 1963. The paper analyzed the shortwood, tree-length and full-tree logging systems, and indicated the areas in each that required greater development. It also contained a plea for a joint industry research and development program. It laid out a road map for the logging industry, indicating different paths that could be followed. But the logging industry, for whatever reason, preferred to develop units on a piece-meal basis, with little knowledge or interest in the savings and benefits of cooperative development.

In June 1958, after McColl joined the Pulp and Paper Research Institute of Canada as a consultant, his seminal report entitled "An appreciation of the problems of full tree logging" was issued on a restricted basis. This report contained a number of concepts, produced in model form, of harvesting and transporting machines, elements of which have been accepted and are still finding application in the forest today.

McColl often claimed that, because of the particular characteristics of Canada's Boreal forest — remoteness, small tree size and suitability for clear cutting — it lent itself to automated tree harvesting systems that were peculiar to the region and that would not be feasible in other areas, such as the forests in British Columbia or the southern United States. The components of such systems would be large machines with a very high productive capability, for both harvesting and transport. Such a system would be highly capital intensive.

In 1969, the CPPA Woodlands Section published McColl's major report entitled "A systems approach to some industry problems." In it he again outlined his engineering philosophy and pointed out that the factors impeding the progress of solutions to the technological and economic problems facing the logging industry were the same as they had been for the past twenty years: inappropriate attitudes and understanding of the innovative process. In 1979, in cooperation with the Forest Engineering Research Institute of Canada, McColl made a presentation to the pulp and paper industry of what he considered to be the second generation of articulated frame-steered machine. It was a machine he called the Accufor (from "accumulator forwarder") (Figure 1.175). It was an eight-wheeled machine with low-ground-pressure tires, a load-equalizing capability and a selection of steering modes which would permit a high level of mobility. All eight wheels were powered individually by electric wheel motors and steering was controlled by a microcomputer which permitted five different steering modes.

The eight wheels were divided into two quad-assemblies. The four walking-beam assemblies and a unique equalizer mechanism reduced the effect of an obstacle on any wheel to one quarter, and it was anticipated that this smoother ride would permit faster travel off-road, perhaps even double the speed of conventional machines. The unit would be powered by two 225-hp diesel engines that would generate the electric power for the wheel motors, but more conventional mechanical or hydrostatic power trains could be used.

It could well be that concepts proposed by others for improved felling-sites transfer to delivery loading terminals, as well as opportunities available from the Accufor, may provide solutions for Canada's forest industry. As yet, this has not happened.

The Nineteen Eighties and Beyond

During the 1980s, Canada plunged into a severe recession. By 1982 and early 1983, the forest industries were experiencing serious financial difficulties. What was considered initially to be a normal decline in the cyclical nature of the industry became deeper and lasted longer than any encountered in decades. In response, the pulp and paper industry retrenched its woods operations. Many small saw milling companies closed; some temporarily, some permanently. Logging equipment sales dried up, forcing a number of smaller machine manufacturers to declare bankruptcy, while others searched for new markets. Research and development in logging mechanization came to a near standstill.

At the same time, articles were appearing in various media about the anticipated increase in world demand for Canada's forest products and emphasizing the fact that the Canadian forest industries were rapidly losing their competition edge worldwide, and that wood costs were expected to quadruple by the year 2000 (Aird and Ottens 1980).

During this recession, company operations began contracting out timber harvesting, as it had before. There was a pronounced move away from paying labourers by time worked, and towards paying them by piecework. There was also a trend toward the worker owning his own logging machines. The impact these trends have had upon the development of harvesting machines is unknown. Currently, the most productive equipment in the woods is in the $150 000 to $300 000 range, far beyond the means of most forest workers. The development cost of new equipment will be beyond the scope of owner-operators.

As noted, in 1959, the St. Lawrence Corporation (now Domtar Limited) changed almost overnight from conventional four-foot jobber operations to eight-foot mechanized operations. Such a rapid and revolutionary change in operating procedures and equipment was uncommon in the logging industry. Yet in 1981, Domtar Limited decided to convert its logging operations at Lebel-sur-Quevillon from predominantly conventional to completely mechanized and owner-operated, in the shortest period possible (Huard 1983). In May, 1981, 15% of the company's logging was done mechanically, using company equipment charged on an hourly basis, while 85% was harvested by conventional methods (chainsaws and wheeled skidders) on a piecework basis. By March 1983, all production equipment was owner-operated (nine feller bunchers, seven delimbers and 24 skidders), the woodlands operations were completely mechanized, and all payments were based on piecework.

This radical changeover was conducted with few problems and with the full cooperation of the union. Considerable effort went into planning, consulting, training and evaluations. To assist them in their ventures, financial training courses were offered to new entrepreneurs and their spouses.

Domtar's experience demonstrates that woods labour and unions are amenable to change if they are part of the decision-making process from the beginning. But the trend towards contracting out to owner-operators is continuing, and it has been a major step backwards in the mechanization of logging.

As of the 1980s, logging mechanization in eastern Canada appeared to reach a plateau. Almost all of the major players have withdrawn from the development of new machines for timber harvesting; those that are left have become bigger. The development and refinement of the stick delimber in the late-1970s and '80s was the last substantial development in tree harvesting. Recent development efforts are focussing on improvements to existing machines rather than on bold new initiatives. The most revolutionary improvement with skidders was not in the mechanics of the units but in tire technology. The wide tires, up to five feet wide, and with a ground pressure of only three psi (less than half that of conventional skidder tires), have extended the operating range of skidders (Mellgren 1981). Skidders equipped with Rolligon tires, for example, use between 20 and 30% less fuel, cause no ground damage or rutting, cause less soil compaction and provide a more comfortable ride.

In 1982, after nearly two years of development, Les Industries Tanguay Ltée brought out a knuckleboom delimber to compete with the stick delimber. The concept featured a two-piece knuckleboom similar to those used in the company's line of loaders. A clamp to hold the butt of each tree was fixed to the machine itself. The delimbing head was mounted on a pivot or floating head at the end of the boom. The floating head closely followed the crook and sweep of trees. The operator picked up a tree using the delimbing head, and placed the butt in the holding clamp. Trees of up to 57 feet in length could be delimbed by this machine (Figures 1.173, 1.174).

The boom sections were powered by two hydraulic cylinders connected in series. Power from the upper cylinder was transferred to the lower cylinder automatically during the delimbing operation, which recovered a good part of the energy required. In field tests, the Tanguay delimber averaged between 180 and 190 trees per hour.

There have also been improvements in the ability of feller bunchers to accumulate trees. Shears, because of the damage they do to the butts of trees, have been largely replaced by hydraulically powered chainsaws, circular saws and circular cutting discs. Since the cutting discs rotate at about one-tenth the speed of circular saws and do not require a central mandrel, smaller diameter discs can be used.

Conclusion

Broadaxe to Flying Shear

During the evolution of mechanized logging east of the Rockies thousands of significant inventions were made. Chief among these are the light plant, which provided electricity to bush camps, the bulldozer for making roads, the chainsaw for felling, branching and bucking, the wheeled skidder for moving tree-lengths, and the full-tree processor. It is fascinating to reflect on the multitude of ways developed to do certain jobs. For example, trees can be felled using fire, a knife, an axe, a crosscut saw, a bucksaw, a circular saw, a bandsaw, a chainsaw, a shear, an auger, or a tensioned cable and cutting discs.

In the development of new machines and systems, a typical cycle became evident (Kock et al. 1960). The first logging machines were generally crude. Then they entered a period of refinement and elaboration, and often an increase in size and power. Well along in the development cycle, design became more sophisticated, and the machine was simplified and considerably reduced in size. An example was the wheeled skidder, which began with the Blue Ox, increased in size to the Timberskidder and was then reduced to the Timberjack.

One of the major problems faced by logging machine manufacturers was the small size of the market for their products. Since several logging systems were often under development at the same time, the result was further fragmentation of an already limited market. When hundreds or even thousands of machines were manufactured, research and development costs could be spread across them all and have minimal effect on the price. Conversely, when only a few units were manufactured, the research and development costs had a tremendous effect on the direct manufacturing costs. This was the case with the development of most specialized logging machines in eastern Canada. Relatively few machines had costs in the vicinity of $1.50 to $3.50 per pound, while more complex machines were mass-produced at costs of $1.10 to $1.25 per pound.

Manufacturers in the United States were once approached to mass-produce a special skidding tractor developed for the logging industry in 1944 by Tom Flynn of the U.S. Forest Service, Portland, Oregon (Koroleff 1952). The "Tom Cat" had the operator up front, a winch located behind and a sloping deck to the rear upon which the butts of logs or trees could rest. This unit was specifically designed for skidding logs and could not be used for other functions in the forest. The large tractor manufacturers all agreed that high quantity mass-produced general-purpose tractors could be easily adapted to accomplish the same job, with very little sacrifice in performance and for a much lower capital investment. And yet, none of the large manufacturers of conventional crawler tractors produced a special crawler tractor for skidding trees, principally because of the small market for such units, which was perhaps 3 to 5% of the demand for all-purpose tractors.

In the face of this reality, the high cost of research and development led to different approaches to encourage and support the design of new logging machines and systems. Five of these are discussed in more detail.

Industry Cooperation with Large Manufacturers

The large manufacturers of equipment were of little assistance to the logging industry in developing specialized logging machines. Generally speaking, improvements in trucks and tractors came from the efforts of the agricultural, transportation and construction industries. In the logging industry, the cost of modifications specifically for logging, in most instances, could not be justified. For example, the Mechanization Committee of the Woodlands Section, CPPA, after considerable consultation with its members, drew up specifications for the ideal logging truck — heavy square fenders, timber bumpers, tow hooks, elimination of all chrome — a real workhorse. To their surprise, after eliminating everything they considered to be extras and making the design as simple as possible, the truck cost much more than the standard units, because the desired specifications took it off the regular assembly line and made it custom-built. Still, a few large manufacturers did play a significant part in the logging mechanization program by taking over companies already marketing equipment, or by manufacturing logging equipment in volume under license from the original developer.

Industry Cooperation with Small Manufacturers

Manufacturers were considered small if the potential sales of the new logging equipment produced would significantly affect their volume and profit. These were the companies on which the industry depended for help in the research, development and manufacture of new logging machines. Normally, the engineering department of a small manufacturing concern existed, not as a separate profit centre, but as an auxiliary to the manufacturing shop. This meant that small firms generally specified the right of the manufacturer to follow through with part or all of the manufacturing operation. Initially, this applied only to prototypes, but later followed through the production stage.

Industrial Development Corporations or Partnerships

Logging Research Associates of Montreal is one example of this approach to logging equipment development. It was a separate research and development entity sponsored and financed by Canadian International Paper Company, Quebec North Shore Paper Company (an affiliate of Ontario Paper Company), and St. Anne Paper Company (a subsidiary of Abitibi Power and Paper Company, Limited) — all Quebec-based companies. The number of sponsors was intentionally kept small to enable rapid decision-making. All three companies had equal status and the rule of unanimity governed all major decisions.

A program of logging systems, general specifications of equipment and priorities was drawn up in considerable detail and agreed to in a letter of intent prior to formal documentation. This allowed work on the development of hardware to begin while legal counsel put the organization together. By investing considerable sums of money in this joint venture, equipment and systems could be designed and constructed specifically for the functions and in the manner that the investors considered essential. Such equipment could then be in the field as early as possible, which would help counteract the problem of mounting wood costs. This partnership also helped to reduce the fragmentation of effort and expenditures in the field of logging equipment development.

Organizations like LRA valued the potential cost savings that efficient equipment would provide far more than they valued the potential revenues from the sale of the equipment produced. They hoped that their efforts might inspire other companies to join in similar ventures to concentrate efforts in an attempt to reduce the cost of logging.

Industrial Associations

The development of the Bonnard Prehauler by the Mechanization Steering Committee, Woodlands Section, CPPA, was an example of development controlled by an industrial association. Once the initial design was complete, the committee turned the prototype of the prehauler over to a commercial equipment manufacturer. In doing so, however, they lost control over the final design and production; a situation that proved unsuccessful.

In fact, problems arose early in the development process. Machine design was a specialized field and the guiding committee members were not all fully supportive of the new ideas. A development team, by its very nature, tends to be ahead of the consensus view of a committee. Bruce McColl has ably put the CPPA's development of the Bonnard Prehauler into perspective:

> *In development proceedings, the first step taken to launch a hardware program usually determines its ultimate fate.... The fact that the Mechanization Steering Committee did not understand what was actually taking place demonstrated its ignorance in matters relating to technological advancement. The fact that the late Dan Bonnard — a man of business integrity — assumed the high financial risks to the end of 1953, but was to receive none of the benefits, was an indication of not doing the right things. The fact that a group of senior woodlands managers controlled the proceedings presented a series of questions concerning intuitive management practices.*
>
> *Two economic facts should be sufficient to illustrate the consequences of an intuitive approach to the management of technological innovation. First the myth 'Let the manufacturer do it, he makes all the money' has been around a long time. Myths are difficult to deal with even when suspect, but the insight comes eventually.... The fact of the matter is that a 'user' firm has 20 to 30 times the incentive of a 'manufacturer' firm in innovative endeavours of this kind. Systematic knowledge of many things is needed for an appropriate choice of policy in matters like this. In short, the choice is between the imitative-competitive route traditionally controlled by manufacturer firms as opposed to the innovative-cooperative route that can, and should, be controlled by User firms. While the imitative-competitive route makes economic sense for a Manufacturer firm, it can lead to economic disaster for User firms in some technical-economic situations.*
>
> *Second, consider the consequences of not understanding this choice. Would you believe that the imitative-competitive approach of the manufacturer — and there are some 30 to 40 Manufacturer firms now producing centre frame articulated vehicles for this application above — has taken more than a decade to provide this industry with that which we had control over in 1955.... Last year saw the first skidders produced that incorporated performance and life characteristics comparable to the Mark IV logger pre-production chassis. It is well known that the Manufacturers have made millions of dollars from the Logger concept. My arithmetic indicates that something in excess of a hundred million dollars has been lost by this sector of the industry as a consequence of a belief in a single myth (McColl 1969).*

Individual Industry Efforts

Most of the money and effort spent on the development of logging equipment came from individual industries. The initial ideas arose in the minds and from the efforts of practicing loggers who needed particular answers to problems they encountered in the forest. Sometimes a prototype was constructed in a small shop or using company facilities. If the item worked and proved to have wider application, it was taken on by an equipment manufacturer who redesigned it for production purposes.

In another form of solo development, equipment manufacturers produced a piece of equipment they perceived would serve a need in the industry. Willing companies then tested and critiqued the equipment, so the manufacturer could make improvements. This cooperative approach led to a number of machines being developed, and, often, equipment, originally designed for a different industry, being adapted.

Because this individual approach emphasized specific equipment items, often without regard for the system as a whole or the place of the equipment item within the system, there was little hope for significant gains, and the drop-out rate was high.

In retrospect, it seems clear that whatever the approach, the forest industry's initial "Show us first" attitude burdened the equipment manufacturers with all the risk. When it soon became obvious that loggers and logging equipment manufacturers were in business together, a symbiotic relationship developed. In fact, the user company often benefited more than the manufacturer from the successful introduction of a new machine. Fortunately, the spirit of active cooperation that has emerged in the last few decades, has helped to advance the mechanization of logging in Canada, east of the Rockies, and to keep the Canadian forest-products industry competitive in world markets.

Epilogue

The Harvester

In the twenty-three years since my two Estonian companions and I trudged out of the woods for the last time, there has been a revolution in the trade of the lumberjack.

Hugh mechanical marvels called tree harvesters have arrived. They resemble giant insects from another planet, and they are driven by bushmen wearing hard hats and sitting in air-conditioned cabs. They move relentlessly over all obstacles as they methodically snip trees off at the ground, strip them, cut them up and pile the logs into their racks. When these are filled, the machines move out to discharge their green gold onto huge trailer trucks. Neither night nor rain nor snow can stop them.

Ironically, it was my own brother John — the one who shared all those winters and summers with me and my sister Winnie on the prairies — who led the team of engineers that devised and perfected the tree harvester. John had always been the mechanically clever one in the family.

The harvester can cut forty cords of wood in eight hours and haul it out as well. The most I could cut in twelve hours was two-and-a-half cords. But modern timber companies also replant forests that have been cut out. I'm afraid we left Nature to handle our ravages as best she could.

Was our old way, for all its hardships, more romantic, more humane, more socially satisfying? I leave the answer to others. I only know I am glad to have been part of that good life before it passed into history.[47]

Armst William Kurelek (1974)

Notes

1. The vertical spool was later replaced by a horizontal reel, and then by a variety of reels, which eliminated the need for the horse (Shakespeare and Pain 1977).
2. In 1883 the first wire rope logging device was developed by Horace Butters, a pine lumberman. He constructed an overhead logging cableway in Ludington, Michigan. A special 7-inch by 10-inch double cylinder Lidgerwood hoist with boiler and three friction drums (weight 13 000 lbs.) to operate the cableway was purchased. Mr. Butters rigged his cableway to standing trees instead of towers, and actually hoisted and hauled logs from the woods and loaded them on railroad cars. In spite of the antiquity of wire rope, it may surprise one to learn that his earlier logging cableways employed manilla rope for the operating lines and guys, and for a short while even as a main cable.

   The zeal and determination of this enterprising lumberman put this overhead cableway skidder in practical operation, and while hardly a commercial success in pine loading, nevertheless it attracted the attention of cypress lumbermen in the swamps of North Carolina and Louisiana (Miller 1925).
3. In 1889, William Baptist of New Orleans developed a pull-boat system that could reach out 3 000 feet. This system required that canals be constructed to harvest the large swamp trees. In 1892, pull-boats were replaced on some operations by a railroad. The logs were skidded out of the swamps and loaded directly on railroad cars. This method of logging, because of its cheapness and efficiency, almost entirely replaced all other methods used under these difficult conditions (Anon. 1910a).
4. They had a combined cableway skidder and loader for handling their white pine timber up to 60 feet in length. This they were operating in very smooth country which is especially suitable for such work. They have been using machinery, in fact, for their logging during the past five years and report they have been well satisfied with the results.

   With one setting of the machine they can clean up an area of about 24 hectares (60 acres), or, in other words they can log a circle with a diameter of 2 200 feet (Anon. 1910a).
5. In 1916, Allis-Chalmers-Bullock advertised that theirs were the only skidders with inter-locking drums and a mechanical slackpuller. The company claimed that these two devices would provide highspeed outhaul, skid with the load in suspension, and reduce the strain on engines and cables.
6. The hectic pace of this expansion is described in *Canadian Chemical Processing* (1966):

   > *The prices of pulp and paper remained at their inflated level through 1919 and the industry output reached $236 million the next year (1920). This prompted the entry of more producers. Fraser at Edmundston and Dryden Paper were two to make their debut, and Great Lakes Paper was in the process of organization. In 1922 the recession brought the net value of output down to $156 million.*
   >
   > *As the 1920s wore on the temporary setback was forgotten. Great Lakes went ahead at Fort William, first with a groundwood mill and then with a newsprint machine. Kenora Paper Mills started up one machine in 1924 and added two more by 1927. Price Brothers built at Riverbend, Quebec.*
   >
   > *C.I.P., with a mill at Trois Rivières already in operation and Riordan in the fold, built a 600-ton/day mill at Gatineau and another installation at Dalhousie, N.B. More foreign money came into the picture and International Paper Company of Newfoundland, Anglo-Canadian (Quebec City) and Spruce Falls were established.*
   >
   > *Everybody was bullish. Port Alfred Pulp and Paper, which acquired a defunct sulfite mill built a four-machine newsprint operation, both Belgo and St. Maurice Paper, which merged in 1923, added to capacity, St. Lawrence Paper Mills (Trois-Rivières) doubled capacity and Brompton took advantage of the unprecedented demand for newsprint by installing a machine.*
   >
   > *Other ventures included those by Ste. Anne Paper (Beaupré) Lake St. John Paper (Dolbeau) and Manitoba Paper (Pine Falls). By 1929 industry output had reached $243 million, thus passing the 1920 high.*
   >
   > *This was also the period of consolidation. The Mead group in 1926 leased Murray Bay Paper from Donohue and in 1928 merged it with Abitibi, Spanish River, Fort William Power, Manitoba Paper and Ste. Anne Paper.*
   >
   > *Price acquired Donnacona in 1927 and Fraser set up Restigouche Co. (and built the Atholville, N.B. mill) as a result of the acquisition. But the other major coalescing of companies was performed by Canada Power and Paper, which brought together St. Maurice Valley, Laurentide, Wayagamack and Port Alfred Pulp.*
7. Prominent examples were the Lidgerwood cable skidding systems and the early use of motor trucks. In 1915, the Spanish River Lumber Company, Massey, Ontario, introduced a 3-ton Packard truck onto their operations for toting men and supplies, displacing nine teams of horses and wagons. The tote road was 60 miles (97 kilometres) long and cost $800 per mile ($1 287 per km) to construct (Anon. 1916). Hall Brothers Limited of Toronto, in their logging operations in Hastings County, Ontario, used a 5-ton truck to haul logs to the nearest railroad in 1917 (Anon. 1919). The truck was an Acason, manufactured by the Acason Motor Truck Co. of Detroit, Michigan.
8. In November, 1932, the Federal Minister of Labour stated in the House of Commons that there were 850 000 people on relief. By February 1935 the number had risen to 1 230 000. Standards for relief varied widely among provinces and municipalities, with a low of $10.00 monthly plus a 98-lb sack of flour for a family of five in Saskatchewan (Jamieson 1968). A pressing problem was the plight of single, homeless, unemployed men who, in 1931, numbered some 70 000.
9. In 1921, in the *Labour Gazette*, of the 132 causes listed for all the strikes and lockouts for which there were adequate records, no fewer than 87 occurred to resist wage reductions. Between 1933 and 1935 there were a number of strikes in the pulpwood camps in Northern Ontario. These were organized primarily to protest against living and working conditions in the camps (see Part II, p. 138).
10. The situation during the Depression is also exemplified by a statement made by the Honourable H. Mercier, Minister of Lands and Forests, Province of Quebec, in January 1936: "Pulpwood, which around 1920 sold readily at $30.00 per cord is now selling, with great difficulty, at less than $7.00 per cord, notwithstanding the fact that the pulpwood consumption is presently twice what it was then."

11. At this time, Abitibi Power and Paper Company, Limited was in receivership. G.T. Clarkson (of Clarkson Gordon) was Receiver and Manager, and each letter, internal or external, was signed under his authority, with a copy to the originator of the letter. The letters have been edited for clarity.

12. Few logging operators today remember the Cletrac, 27 to 100 hp, Cleveland Tractor Company, Cleveland, Ohio; Linn, 75 to 125 hp, Linn Manufacturing Corporation, Morris, New Jersey; Lombard 100 to 125 hp, Lombard Tractor and Truck Corporation, Waterville, Maine; Mead-Morrison, 45 hp, Mead-Morrison Manufacturing Co., East Boston, Massachusetts; Monarch, 60 hp, Monarch Tractor Company, Springfield, Illinois; DH Trackson McCormick Deering, 20 hp, International Harvester Company of Chicago, Illinois; Bates, 25 to 40 hp, Bates Manufacturing Co., Joliet, Illinois; JT, 30 to 40 hp, J.T. Tractor Company, Cleveland, Ohio (Koroleff 1928). In more recent times, the post-World War II Vickers tractors appeared briefly, but for just a few years.

13. The Austin and Nicholson Co. Limited of Chapleau, Ontario, operated two of these units on its logging operations in 1925, each hauling a train of 13 sleighs over both snow and ice roads (Anon. 1925a).

14. These two manufacturers merged in 1925 to form the Caterpillar Tractor Company, as it is known today (Anon. 1954b).

15. The performance of a vehicle with four wheels depends upon whether or not all four wheels are driven or only the rear two, upon the ratio of the wheel diameter to wheelbase, and upon the longitudinal location of the vehicle's centre of gravity. With equal-sized wheels front and rear, and with normal weight distribution, the performance of a 4 × 2 vehicle was less than one-third that of a 4 × 4 vehicle. It was found that the performance of a standard 4 × 4 vehicle with normal wheelbase and tire size could be improved by 25 to 50% by shifting the vehicles, centre of gravity forward. Front wheels performed best with a short wheelbase and weight to the rear, while rear wheels performed best with a long wheelbase and the weight forward.

16. A number of these sulkies were used: by The Anglo-Canadian Paper Mills Limited, now Reed Limited (McNally 1940); at Shelter Bay (now Port Cartier); by the Quebec North Shore Paper Company Limited (Fraser 1939, Godwin 1940); in New Brunswick by Fraser Companies Limited (Atkinson 1940); by the James MacLaren Company (Lathrop 1941); and by Singer Manufacturing of Thurso, Quebec (Seheult 1939, 1959).

17. The Woodlands Section was formed in 1917 in Montreal. Ellwood Wilson of the Laurentide Company, Grand-Mère, Quebec, was its first chairman. Subsequently, at a meeting in 1920 in Toronto, support and membership were enlisted from Ontario companies. In 1920, the membership was 20; in 1982 it was 1 800 corporate and individual members.

18. Bryant was the first recipient of a forestry degree on the North American continent, from Cornell University, in 1900.

19. The Canadian effort to design and manufacture chainsaws was primarily restricted to American branch plants. There was only one chainsaw manufacturer in North America in 1938, six in 1942 and thirty in 1949.

20. In 1911, a description of the "Endless" chainsaw appeared in the *Canada Lumberman and Woodworker*. It was manufactured by the Endless Chain Saw Company of New York City (Anon. 1911). Its description clearly links its ancestry to the present-day chainsaws:

    Before the invention and introduction of the endless chainsaw, the blade and teeth of saws were made in one integral part so the blade had to be reciprocated or revolved at the same speed as the teeth, with the disadvantage of requiring greater energy and less expedition in the work of felling trees or sawing up the logs.

    With the endless chainsaw the blade is stationary and the chain which forms the teeth moves. Thus the minimum weight is moved and the motion is continuous and uniform instead of back and forth as in the old forms of saw. The saw consists of a thin steel blade with a groove in its upper and lower edge, carrying a flanged sprocket wheel at each end, through which the endless chain runs. The chain consists of an endless bank of steel links with teeth of standard form on one side and the necessary projections or sprockets on the other side which fit into grooves in the blade and receive power from the driving sprocket wheel.

    Saws up to 20 feet in length are possible. The power required for the three-foot six-inch saw is seven horsepower and for the two-foot saw, four horsepower.

    The portable felling saw weighs complete about 150 pounds and can be carried by three men. The trees when felled may be crosscut into logs by turning the blade from horizontal to vertical position.

21. In the 1930s, these dragsaws weighed between 180 and 475 pounds. They were driven by single cylinder 2.5–4.5 hp gas engines, and could saw at a speed of 260 feet per minute. Usually they had a clamping attachment called a "dog", with which they were fastened to the felled tree or log, so that once the saw was started, it could continue unassisted.

22. These saws consisted of a belt- or chain-driven saw mounted on a post for support. The post was laid against a fallen tree or log lying on the ground, and the weight of the blade assembly allowed the reciprocating blade to advance.

23. The Beaver Chainsaw was manufactured by the Beaver Chainsaw Company, New Haven, Connecticut. This saw had a bow frame and required two to three men to operate it.

    The Rinco Motor Chainsaw was manufactured by Schles, Rincogesellschaft, Luben, Silesia. It was sold in Canada by Watson Jack and Company Limited (now Wajax Limited), Montreal. It had a $5^1/_2$ hp air-cooled engine and weighed 85 pounds. In 1927, it was considered one of the best saws available. By 1930, it was obsolete, having been superseded by a $6^1/_2$ hp model weighing 82 pounds.

    The Erco Motor Chainsaw was manufactured by E. Ring and Company Limited, Westerhausenerstrasse 16, Berlin, Germany. This saw was also sold by Watson Jack and Company Limited. It had an 8-hp, 2-stroke, 2-cylinder engine and weighed 94 pounds. Its cost in 1929 was $350 Canadian f.o.b. Hamburg, Germany.

    The Dolmar Motor Chainsaw was manufactured by E. Lerp and Company, Frankenstrasse 47, Hamburg 15, Germany. It was sold in Canada by J.P. Bourget, St. Alexander St., Montreal. This ssaw was available with either a gasoline-powered engine or electrical motor. The gas engine was one cylinder, air-cooled and produced 4 hp. It weighed 75 pounds and required two men to operate it. Its price in 1929 was $490 Canadian f.o.b. Hamburg.

    The Wolf Portable Link Sawing Machine was manufactured by Reed-Prentice Corporation of Worcester, Massachusetts, and sold in Canada by Canadian Ingersoll-Rand Company Limited, Montreal. This was powered electrically or by compressed air.

24. It was relatively inexpensive in relation to the earnings of the forest worker, and shortly after its introduction, payment for the use of the power saw was negotiated. In 1980, the rental Ontario companies paid to workers who used their own power saw on the job was $7.25 per day for falling and limbing trees. If the saw was used for crosscutting (bucking) trees on the landing or roadside, an additional $1.00 per day was paid. These rentals enabled the owners to fairly depreciate and maintain their power saws.

    The power saws increased the workers' earnings. Studies made after the advent of the power saw showed on overall increase in man-day productivity of approximately 20%. This increasing production accrued to the cutter, and after paying for the power saw, left him with an 8–10% increase in take-home pay.

25. All production functions affected by the new technology (power saw) fell under the span of control of the individual worker himself. This was an important factor in a situation where the worker was paid on the basis of his own productivity. The opposite situation existed with the introduction of the skidder and the resultant requirement that men work in crews. In this instance, a worker to a large degree was dependent upon other workers in his crew, upon their effort and output.
26. It was portable into other sectors of the workers' own economy. The power saw had wide use around a farm or rural dwelling in the production of fuelwood, fenceposts, etc. Having these alternative supplementary applications to the main function of logging made the ownership of a power saw attractive.
27. In the United States, McCulloch and Homelite each had 20% of the market, in Germany, Stihl had 17% of the market, and in Canada, Pioneer had 13% of the market. The remaining manufacturers individually supplied between 0.5 and 7.0% of the market.
28. The Radisson Tractor produced by Tracteur Radisson Inc. of Granby, Quebec (Keys 1958a) was a soft-track unit designed to tow a semi-trailer, mounted on either wheels or runners. It was equipped with a winch-operated swivel boom to load logs on the trailer. The running gear consisted of three solid rubber-tired wheels per side, each capable of oscillating approximately 12 inches, in the fashion of a military tank suspension. The tracks consisted of steel cable-reinforced rubber belts, joined by steel grousers. The front and rear wheels were notched to mate with the grousers. The drive wheels were-roller-chain driven, and the unit was steered by means of differential braking. The prototype underwent several thousand hours of operation but, evidently, the unit never went into production.
29. The sloop had nine-foot-long steel runners with 4-inch-wide shoes set at a 48-inch gauge. The loading arm was L-shaped and was swung on a 1$^1/_8$-inch axle fastened athwart the sloop at the midway point.
30. An earlier trial in 1949 had been made with a stripped-down Walters four-wheel-drive unit on the Canadian Army Proving Ground at Orleans outside Ottawa. This trial was carried out with the cooperation of the Vehicle Development Branch of the Department of National Defence and the Woodlands Section of the Canadian Pulp and Paper Association. The trials proved successful, but no further development took place (Irvin 1950).
31. The design of the undercarriage and of the track was alleged to be an extension of work initiated by Walter Siber and some of his designers when he was employed by Logging Research Associates. The appearance of this unit resulted in a lawsuit against Rolls Royce by Logging Research Associates, which was settled out of court.
32. The detail in the list of specifications that were established indicates the thought that went into the design of the harvester. The specifications established for the prototype of the Beloit Harvester highlighted the thought that went into the machine. It had a maximum opening of butt shear, 16 inches for ease in accommodating a 14-inch maximum butt; a minimum opening of top shear, 2 inches for maximum utilization; effective opening of delimber head, 14 inches down to 2 inches; a minimum effective mast height of 56 feet; a minimum effective boom reach of 18.5 feet; a minimum rotation (of boom, mast and tools) of 310°; a minimum lift at full extension of 16 000 pounds; a travel speed (forward and reverse) of 0.2 to 4.5 mph; a maximum ground-bearing pressure at designed depth of soil penetration of 3.5 pounds per square inch; a maximum working slope of 20%; and a minimum availability of 75%. A maximum time cycle of 74.4 seconds was established, broken down as follows: to swing and extend boom to tree — 15.2 seconds; to close delimber — 2.0 seconds; to move the delimber-head up — 14.7 seconds; to shear the tree top — 6.8 seconds; to move the delimber-head down — 14.7 seconds ; to shear the butt — 8.0 seconds; and to swing and drop the tree in a bunch — 13.0 seconds.
33. It is interesting to compare how the original specifications were modified to the point that the design concept was placed in jeopardy. The butt-shear opening increased from 16 to 24 inches; effective opening of the delimber head increased from 14 to 20 inches; mast height increased from 56 to 63 feet; boom reach decreased from 18.5 to 15 feet; and ground pressure increased from 3.5 to 8.8 pounds/square inch.
34. Described on page 38.
35. An interesting study was made of these slashers to show the effect of the machine modifications on wood cost (Desaulniers 1982). Slasher crew sizes were reduced and productivity was significantly increased over the period from 1950 to 1979. Desaulniers stated that the lowest costs realized during the NESCO slasher development occurred when the slasher's major operating functions were converted from direct mechanical power to hydraulic power.
36. Background on Bob Larson appears on page 38.
37. This concept was well known by designers of the Bonnard Logger at about the same time.
38. David Spanjer made a significant contribution to the industry, not only in terms of design concepts and specific hardware, but as a result of his attempts to systematize the analysis of machines and systems. His papers "The relative efficiencies of wheeled and tracked vehicles for skidding purposes" (1964); "Mechanization of harvesting operations in North America" (1967); "Consistency in the measurement of logging production and cost" (1968); "Why a harvesting system" (1970); all contributed significantly to the body of knowledge on equipment design and utilization.
39. Background on the Pope Tree Harvester can be found on page 36.
40. Described on page 33.
41. The Mark II unit sold in 1965 for $77 000. By the time the last harvester was sold in 1977, the cost had risen to approximately $450 000. The price change was due in part to inflation, but primarily to continuous upgrading of the machines.
42. For background on the LogAll, see page 53.
43. Described on page 53.
44. The Carrier was based on the Walters truck, a widely used heavy-duty truck manufactured in Almonte, Ontario. It was 27′5″ long and 150″ wide, and weighed 50 000 pounds, with a payload of another 70 000 pounds.

    This concept of off- and on-road transport was originally proposed and promoted by Tom Bjerkelund while he was employed by Domtar, and later when he was Professor of Forest Engineering at the University of New Brunswick (Bjerkelund 1977; 1978).
45. For background on this, see page 67.
46. Described on page 49.
47. From *Lumberjack* © 1974, Armst William Kurelek, quoted by permission of Tundra Books.

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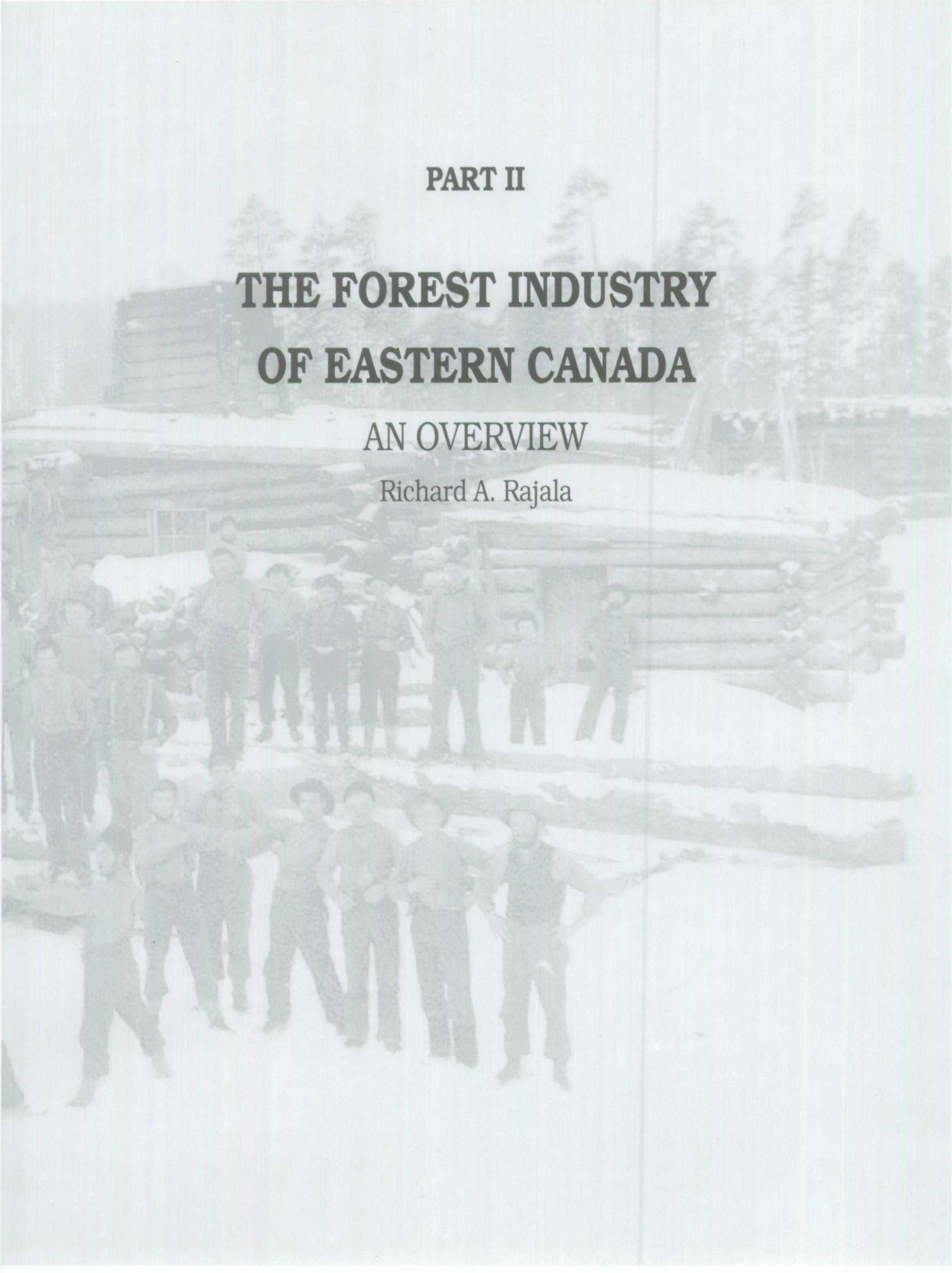

PART II

THE FOREST INDUSTRY OF EASTERN CANADA

AN OVERVIEW

Richard A. Rajala

Introduction

C. Ross Silversides' "Broadaxe to Flying Shear," is the product of a distinguished career both in the management of eastern Canadian forest operations and the development of mechanized logging techniques. However, Silversides drew on more than personal experience in documenting the eastern Canadian forest industry's transition from the era of manual labour, simple tools and animal power to today's technologically sophisticated work process; his account is also informed by considerable historical research. This essay is intended to serve as a companion piece, providing the reader with a brief outline of the economic, political and social changes that accompanied the technological transformation discussed by Silversides. Its objective is to shed light on the economic and geographic structures of development, resource policies, and the changing pattern of social relations between employers and woodsworkers.

In order to interpret these processes, the essay is organized into three chronological parts, corresponding to the industry's major periods of change: the nineteenth century; 1900 to 1945; and the postwar years. Discussion of the 1800–1900 period will focus on the timber trade in the Ottawa Valley and Maritime regions. Lumbering during these years was characterized by a seasonal round of activities. Woodsmen began entering the bush in late summer to construct shanties and fell timber. Between late October and December, teamsters took over, transporting logs to the skidways. When snow conditions permitted the sleigh haul to begin, crews moved the wood to waters' edge to prepare for the spring river drive to mills. Logging methods underwent few significant changes during the 1800s. For the most part, operators accepted long-established procedures that relied heavily on nature, simple hand tools, animal power and the wealth of skills that woodsmen accumulated from years of experience in the bush.

Historians have identified a close relationship between agriculture and lumbering in eastern Canada, referring to an "agri-forest" economic system that saw men leave marginal farms during the winter months for wage employment in the shanties. Such practices, essential for the survival of many farm families, also worked to the benefit of operators, who enjoyed an abundant seasonal labour force. Seasonality, a paternalistic employment relationship and ethnic divisions among workers prevented woodsmen from collectively demanding improved camp conditions and wages.

Early on, colonial governments recognized the revenue-generating potential of forestlands. Although Nova Scotia continued granting land outright to lumbering interests until the end of the century, by Confederation, the other colonies generally issued cutting rights in the form of leases. Toward the end of the 1800s, deforestation had reached sufficient proportions in the Ottawa Valley to generate industry calls for conservation measures to protect holdings from fire and settlers. Progressive lumbermen in that region prevailed upon the governments of Ontario and Quebec to introduce rudimentary fire protection and forest reserve programs.

The period between 1900 and 1945 blended elements of change and continuity. The rise of the pulp and paper industry transformed the wood-products economy. New corporate giants emerged to exploit the forests of northern Ontario, Quebec and the Maritimes, feeding the North American newsprint market. Provincial governments took an active role in the development of large-scale fibre enterprises, adopting policies that awarded secure tenure over vast stretches of forestland to pulp and paper firms. The need for rational management led to the establishment of forestry schools in Ontario, Quebec and New Brunswick. Graduates staffed provincial agencies responsible for the administration of protection and revenue-gathering activities on tenures, but governments had little use for the principles of forestry as an applied science that did not serve to promote economic growth.

During a period of massive technological and organizational change in other sectors of the economy, logging methods remained largely unchanged. Although the crawler tractor replaced the horse-drawn sleigh on some operations, company railroads came into use on others, and a few imported the high-lead yarding system from British Columbia, innovations leading to fully mechanized harvesting did not come until the postwar decades.

Throughout the period, workers protested poor camp conditions, tyrannical bosses and low wages by "jumping" from camp to camp, especially during World War I, when labour shortages upset the balance of power in the workplace. Militant leadership by the Industrial Workers of the World sparked collective action in the Ontario woods at this time. Organizers from the British Columbia-based Lumber Workers Industrial Union and One Big Union followed, but factional disputes and a deep recession curtailed union activity until the mid-1920s. Finnish radicals in northern Ontario continued the struggle during the Depression, leading strikes under the Lumber and Sawmill Workers Union banner.

World War II set the stage for sweeping changes in the eastern Canadian forest industry. Federal government intervention during the war encouraged companies to negotiate with union representatives, and a major 1946 strike led to the initial industry-wide agreement between the "Lumber and Saw" and Ontario's major pulp and paper companies. Newfoundland and Maritime bushworkers also made organizational gains in the postwar period. Labour shortages and the new power wielded by unions drove wages up, prompting industry research and development initiatives to mechanize logging operations. Although the path from drawing board to successful field application was far from smooth, during the 1960s wheeled skidders took the place of horses on many operations.

Mechanical harvesters, capable of felling, topping, delimbing, bucking and piling pulpwood followed, along with sophisticated slashers and trucks for log transportation. As new mechanical skills began to take precedence over the manual "know-how" of earlier methods, workers found themselves under closer supervision and labour requirements dropped dramatically. Year-round operation and truck transportation led to improved camp conditions for remaining workers, and on some operations employees commuted daily between home and logging sites.

Technologies engineered to advance a corporate concept of efficiency that viewed labour as a commodity made no accommodation for the ecological characteristics of eastern Canadian forests. The huge feller-buncher under the control of a single operator moved through the forest like a mobile factory, shattering any harmony between the processes of resource exploitation and renewal. Governments adopted an array of forestry policies during the postwar period, in an effort to maximize the flow of funds to provincial treasuries and sustain industrial activity. Recent scholarship suggests that they enjoyed more success in meeting the first objective than the second.

Nineteenth Century Lumbering

Lumbering became a major commercial activity in British North America during the nineteenth century; a period when an imperial mercantilist system prized colonies as sources of raw material and markets for finished products. As early as the 1660s, New France's intendant, Jean Talon, attempted to diversify the colony's economy by stimulating a range of industries, including timbering to produce ships, but the plan floundered because of high costs, lack of skills and France's proximity to Baltic timber supplies.[1] After the Conquest, a small trade developed from Lower Canada, amounting to as much as 20% of Quebec's exports, and in Upper Canada, the export of barrel staves and potash to Britain developed in the 1790s. Population growth in New Brunswick during the late eighteenth century generated a local market supplied by small sawmills. After 1784, the colony exported timber, staves and shingles to the mother country, along with masts for the British navy.[2]

Britain drew the bulk of its timber supplies from the Baltic region, which was much closer to its ports than the distant British North American colonies. But near the end of the eighteenth century, Britain's vulnerability in relying exclusively on this supply, coupled with the increasing difficulty of obtaining logs suitable for naval masts, prompted efforts to develop an alternative source of timber. In 1779, a Scot, William Davidson, accepted the first contract to cut masts in New Brunswick's pineries for the British navy. It was the mounting fear that Britain would lose access to Baltic wood if Napoleon erected a European blockade that led the trade to expand to include square timber as well as masts. Still, shipments remained small; between 1799 and 1805, British imports of squared pine from British North America never exceeded 6 000 loads annually.[3]

While traditional accounts may have overemphasized the importance of European events in structuring the development of the early Canadian timber trade, Napoleon's attempt to undermine British naval power by blockading Baltic ports after the defeat of his navy at Trafalgar played a decisive part in making forest exploitation a leading sector in the colonial economy, replacing fur as the major export staple.[4] Britain responded to Napoleon's blockade by adopting a sliding tariff that overcame the disadvantage of distance, giving British North American timber a protected market. Britain's huge Baltic timber fleet began plying the Atlantic, holds filled with the strong, light, easily worked white pine timbers abundant in the colonies. Although reduced in the 1820s, the preferential tariffs that enabled colonial producers to claim a secure market remained in place until the 1840s.

With access to a guaranteed export market, the Canadian timber trade flourished. Exports of timber from New Brunswick increased from 5 000 tons in 1805 to 417 000 tons in 1825. Trade figures reflect a similar pattern for the Canadas. By the 1820s, annual exports from Quebec reached 100 000 tons of squared pine, 20 000 tons of squared oak, and a vast quantity of deals (three-inch-thick planks subject to further processing into lumber) and staves. At this time, three quarters of England's timber originated in British North America, the bulk from the Miramichi and Saint John Rivers in New Brunswick, the St. Lawrence, and the Ottawa Valley, where the Ottawa River and its tributaries drained a huge pine-rich watershed.[5]

Throughout the colonies, merchant-wholesalers dominated the trade.[6] British naval contractors got in on the ground floor. The firm of Scott, Idles and Company established Quebec branches early in the century, and British timber merchants followed by shifting their activities from the Baltic. Very prominent in this category was the Glasgow firm of Pollack, Gilmour and Company, which in 1822 established Robert Rankin and Company in Saint John, and then located similar businesses in Quebec and Montreal. Typically, these merchants advanced credit to country storekeepers and timber brokers who in turn supplied lumberers engaged in the actual logging operations with provisions. The market underwent significant fluctuations even while the protective tarrifs were in place, and such a business system shifted the lion's share of risk to those at the bottom of the pyramid.[7]

By the end of Napoleonic Wars, the British North American trade was firmly entrenched, giving rise to a number of timber barons. American Philemon Wright sent the first raft down the Ottawa River and on to Quebec in 1806. For 20 years, Wright and his sons conducted the largest operation on the Ottawa, employing up to 250 men a year to raft timber to Quebec, where they sold to merchants. Irishman John Egan succeeded Wright as the chief timber baron on the Ottawa, by the 1840s employing up to 3 800 men on a seasonal basis.[8] One of their main competitors was William Hamilton of Hawkesbury on the lower Ottawa, who established sawmills and pioneered the trade in deals for the British market. William Price arrived from London in 1810 as an agent for Scott, Idles and Company and organized his own export enterprise in 1816. Like Hamilton, but unlike most of his competitors, Price quickly diversified into the manufacture of deals and planks. By 1840 he owned 40 sawmills, most secured from operators he had financed who failed to repay their loans. Eventually Price controlled over 20 000 km^2

(7 700 square miles) of timber, mostly on the Saguenay River.[9]

Mid-century, the British North American timber trade reached an important turning point. A mounting deficit in Britain prompted the government to move to free trade in an effort to balance the budget. The reduction of the preferential duties in 1842 that had sheltered the colonial trade in forest products caused great consternation among the timber merchants. Their worst fears were realized in 1843 when the lowered tariff on square timber produced a 25% decline in squared timber exports, but the next year, construction and railway building in Britain generated demand. Two explanations are offered for the survival of the square-timber trade until the 1860s, when exports began to decline. First, the preferential duties, although reduced, were not completely removed until 1866. Second, British construction and shipbuilding industries created sufficient activity to absorb increasing Baltic imports along with those from British North America.[10]

Another feature worthy of note during this period is the growing importance of timber processing. After 1850, the trade in deals to Britain surpassed that of squared timber. Planks and boards also became prominent exports to the United States. Small amounts of sawed timber from Canada began to penetrate the American market in the 1830s, and by mid-century about 20% of timber exports went to the emerging southern market. As Britain severed its mercantilist relationship with the colonies, Canadian timber interests grew increasingly anxious to develop links with the new market.

The idea of free trade with the US blossomed into a reciprocity movement devoted to removing tariff barriers that prevented the import of British North American products to the US. The Reciprocity Treaty of 1854 provided free entry into each country of a range of products, including timber. Conventional wisdom emphasizes the treaty's impact on colonial economic development, and the figures reflect an increased flow of goods across the border. But more recent thinking points to railway construction and population growth in the two countries as more critical factors than the treaty, which remained in place until 1866.[11]

By Confederation, the Canadian forest-products sector blended elements of the past with hints of the future. The trade in square timber continued to grow, but much less quickly than the more processed products that made up 70% of wood exports. The increasing importance of the North American market was also evident; wood destined for Britain had fallen from 80% of the 1850 total to about 50% in 1867.

In the Canadas, veterans of the square-timber trade constructed mills to exploit new opportunities. Gillies Brothers, Philemon Wright's sons, James MacLaren and John Booth became major figures in integrated lumbering enterprise, the latter building a railway from Ottawa south to the American border. Americans Levi Young, H.F. Bronson and E.B. Eddy brought American timber capital into the Canadian forest sector. In New Brunswick, where the British market remained dominant, Alexander "Boss" Gibson acquired extensive timber reserves and built a huge sawmilling business that included a railway linking the Nashwaak and Miramichi Valleys.[12]

Changes in industry structure accompanied the shift in products and markets. When the trade began in the early nineteenth century, access to the straight, tall pine required for square timber was relatively easy for farmers and labourers who spent winters in the woods. Such men might organize family units or small partnerships, selling their timber in the spring to the storekeeper or merchant who had advanced them credit and supplies the previous autumn. Alternatively, they might contract their labour out to a larger operation. Over time, however, as the most accessible stands of pine fell to the axe, opportunities for independent, part-time cutting declined.

In New Brunswick, the demand for sawlogs in the second quarter of the century extended the life of these family operations, permitting stands logged selectively for the square-timber trade to be cut over a second time.[13] But the expanding denuded area meant that operators required greater amounts of capital to outfit larger crews working in more remote locations. Sawmilling also contributed to the trend toward concentration. Mill construction involved substantial investment, and integrated operations might draw logs to plants from numerous camps. Increasingly, wage labour in crews structured along rigid functional lines supplanted the less formal patterns of work organization, characteristic of the family-based early nineteenth century shanty.[14]

Spurred on by increasing domestic and foreign demand, the industry engaged in an aggressive search for timber. As the Ottawa Valley began to experience shortages of easily accessible pine, railways linked Ontario timber to the American market. Rafts and schooners plied Lake Erie and Lake Ontario, completing the transportation of Canada's timber to the northern states. During the 1870s lumbermen such as Booth headed west, spurring industrial and urban development. But in a process that would replay itself in other regions, deforestation followed on the heels of economic growth. After cutting out several watersheds, the industry swept north to the Lakehead.[15]

In the Maritimes, the increasing difficulty of securing accessible pine caused the square-timber trade to go into a permanent decline after the 1870s. The sawmilling industry took up some of the slack, utilizing the spruce ignored in the first pass. But with depletion of the pine, New Brunswick's lumbering industry had passed its peak. Many of the province's lumberers departed for other regions. John Hendry went across the continent to British Columbia, becoming one of that province's leading timber capitalists. Others followed after logging their eastern Canadian holdings.[16]

The seasonal nature of the timber industry, the widespread desire of Canadian men to establish themselves on the land, and the difficulty of doing so without blending farm activities with some type of wage work created a strong relationship between lumbering and agriculture during the nineteenth century. The nature of this agri-forest economy has been the subject of intense debate, particularly among Quebec historians. One view stresses the way these activities complemented each other, with the contrasting seasonal demands of their work. Farm families needed the income winter jobs generated as well as the market for agricultural produce created by nearby shanties. A second, more cautionary interpretation suggests that the mutual benefits of this relationship vanished as the timberline retreated, and the distance between farm and shanty expanded.

Another interpretation casts agri-forestry in a negative light, emphasizing the destructive impact on rural society and regional development. It is argued that in Quebec's Saguenay region, the retreating forest frontier drew settlers into marginal agricultural areas where the long lumbering season shattered any harmony between the two endeavours. Moreover, families unable to achieve self-sufficiency might become ensnared in virtual serfdom to powerful timber barons who drew on an abundant supply of workers relying on wages to tide families over the winter. From this perspective, the agri-forestry system served as a "treadmill for reproducing rural poverty."[17]

Chad Gaffield's study of Prescott County in the Ottawa Valley illustrates the disruptive social consequences of deforestation upon a region dependent upon a mixed agri-forestry economy. Here, the land clearing that was undertaken to establish a farm produced wood products for sale. In addition, farmers and their sons took seasonal employment in shanties and sawmills, and marketed agricultural produce to camps during the winter.[18] Indeed, with the limited agricultural potential of the area, many families depended on the lumber industry. Initially, at least, this worked to their advantage.

But as the forest frontier moved northwest from Prescott County, the area's farmers found it more difficult to supply the shanties, and lacked alternative markets for their produce. The increasingly distant camps also provided less seasonal employment, severing the link between the two economies. By the 1870s, the lower Ottawa Valley was thoroughly denuded, and all of Prescott County's agricultural land had been taken up. Thus, land shortages compounded the problems created by the lumber industry's mobility, creating increasing numbers of landless proletarians.[19]

New Brunswick's educated elite decried the influence of lumbering on agriculture in the colony, a point of view shared by Arthur Lower. "The farmer timber maker was a prominent and sorry figure in New Brunswick life," Lower argues. "He tried to do two things and did neither of them well."[20] But more recent research points both to the need for, and benefits of, occupational flexibility in the Maritimes. "Lumbering," notes Graeme Wynn, "offered an opportunity for the ordinary man to improve his circumstances in New Brunswick." Seasonal participation in the industry enabled many to accumulate the capital necessary to establish themselves on the land.[21]

Throughout the Maritimes in the early nineteenth century, Rusty Bitterman explains, much of the rural population had no choice but to work for wages in order to make a go of agriculture. The cost of land, stock and equipment, coupled with the years of clearing required to make land productive, led to a widespread and prolonged reliance on wage work in the timber trade, shipbuilding and fishing to achieve self-sufficiency. In the Weymouth area of Nova Scotia's southern shore, at least three quarters of household heads engaged in more than one occupation to make ends meet.[22]

In the end, as Peter Baskerville notes in a recent history of Canadian business, it is difficult to generalize about the functioning of the agri-forest economy that prevailed in parts of nineteenth-century Canada. Nevertheless, it seems clear that the relationship between these endeavours, so essential to survival in many settings, often left families vulnerable as the forest frontier passed them by.[23]

The men who toiled in the shanties of the Ottawa Valley and Canadian Shield came from a variety of ethnic backgrounds. French Canadians, Irish, Scottish, German, Polish and Aboriginal labourers fell into two general categories according to a recent study by Ian Radforth. Specialists worked year-round in the industry's cycle of activities. Others, such as the farmer-lumberers discussed above, worked on a seasonal basis as circumstances dictated. Rafters tended to be specialists, working during the spring and summer driving logs, then joining the "occupational pluralists" drawn from farms, canal or railroad construction projects in the shanties.[24]

Ontario and Quebec companies drew men from settlements close to their operations, securing additional labour by recruiting French Canadian woodsmen from Ottawa. Typically, firms advanced the men from Ottawa transportation expenses, deducting the amount from their wages. Shantymen signed labour contracts setting out the wage rate and term of employment. Some of these arrangements specified fines for days not worked. Workers in Mossom Boyd's employ drew their wages at the end of the logging season, but in MacLaren's Lievre River operation, wives could draw their husband's wages at the mill office, and unmarried men could have their pay sent home to families.[25]

Some companies paid in script redeemable at the company store, a system with abundant opportunities for exploitation. At the shanties, employees could buy a range of goods from the "van," a facility managed by the camp clerk who charged purchases to the workers' accounts and deducted the amount from their pay. In an analysis of Boyd's shanties in the Kawarthas, Chris Curtis concludes that low wages, pay lost for days when illness, accident, or perhaps drink prevented a man from working, and deductions for van purchases left many with little to show for their labour. Some even left the shanty at season's end in debt to the operator.[26]

Nineteenth century lumbering in eastern Canada was defined by its seasonal round of activities, primitive technologies, and a heavy reliance on nature to move wood from the forest to ship or mill. Skills learned on the farm were easily adapted to many occupations. The annual cycle of logging began in late summer when a small crew arrived at the site chosen by the foreman or "shanty boss" for the camp. They erected the shanty near the middle of the area to be cut that year, close to a water supply. Operators agreed that timber more than a four-kilometre (two-and-one-half-mile) radius from the camp could not be logged profitably because of the time consumed walking to and from the cutting site. This advance crew also built the animals' shelters, cut hay and built the hauling roads.[27]

With the arrival of the main crew in late autumn, gangs of five or six men began cutting (Figure 2.1).[28] The leader or "head chopper" selected each tree and put in the undercut with his single- or double-bitted axe, determining the direction of fall. As he moved on, a pair of choppers made the back cut, dropping the tree. During the 1870s, the development of the raker tooth permitted the two-man crosscut saw to replace the axe in this phase of the felling operation. While the axe continued to be used in undercutting, by 1900 the crosscut had spread throughout the industry, accelerating felling procedures. The two-man bucking crew then delimbed, topped and cut the tree into appropriate lengths.[29]

Figure 2.1 *Choppers felling trees in Nova Scotia. (Bear River Historical Society)*

This completed the cutting stage in sawlog operations, but only set the stage for more extensive woods processing in camps logging for the square-timber trade. First the rosser, wielding a short hoe-like tool, scraped two narrow strips of bark from the trunk's length. The liner then coated a piece of twine with chalk, fixed it to each end of the log and snapped it against the trunk, marking a straight chalk line along the path etched by the rosser. Next came the scorer, who notched each side of the log at four-foot intervals, chopping them out and making way for the master craftsman of the trade — the hewer.

This highly skilled worker used a broad axe to hew the two sides to a perfectly smooth surface (Figure 2.2). "The deftness and skill with which the makers of timber can smooth the side of a log...so as to equal the work of the best plane," wrote one observer, "is beyond conception to one who has not seen the operation." The end result, when all four sides had been treated, was a timber at least twelve inches square, forty to sixty feet long. Processing pine in this manner maximized the capacity of ships carrying timbers to England for sawing into lumber.

Behind the cutting gang came the skidding crew, responsible for moving wood from the stump to the dump site at river or lake side. Until mid-century, oxen provided the motive power (Figure 2.3). Teams of four or six might be required to haul a single large timber, with the lead end raised on a sled to ease its passage. Although able to live on coarser food and

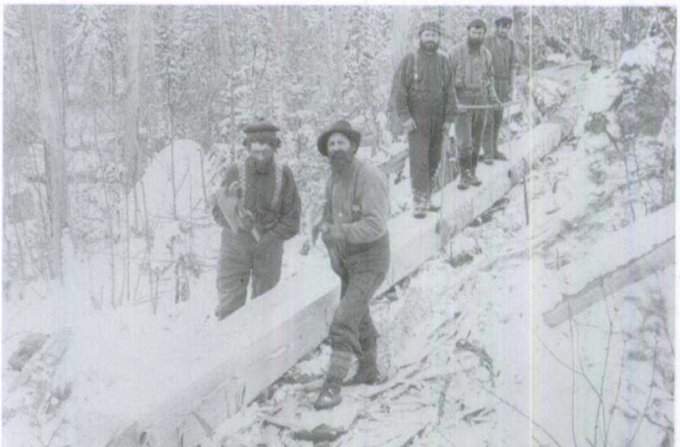

Figure 2.2 *Hewers in the Ottawa Valley with scoring crew behind. (Courtesy Public Archives of Canada C75265)*

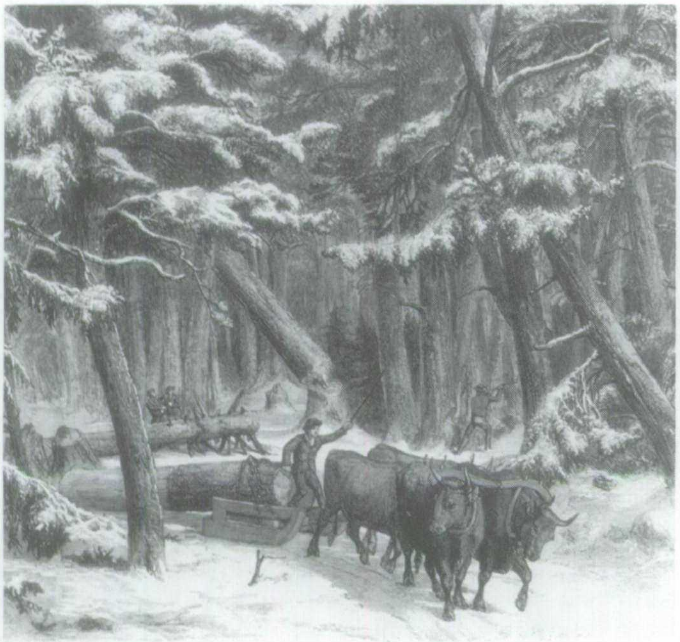

Figure 2.3 *Oertel (British School). Lumbering in New Brunswick — Lumbermen at work in the forest (oxen skidding logs). Hand-coloured wood engraving (from illustrated* London News, *28 August 1858). (Courtesy Webster Canadian Pictorial Collection, New Brunswick Museum)*

Figure 2.4 *Loading logs on sleigh. (Courtesy* Fonds Campagnie Price Ltée., *Archives nationales du Quebec)*

demanding less care than horses, the plodding oxen increasingly gave way to the Percherons and Clydesdales that worked at a greater speed. This phase of transportation grew more elaborate on sawlog operations as hauling distances increased over the course of the century. Between late October and January, teamsters skidded logs along trails leading from the stump to skidways where they were piled. Such trails might be cleared by the teamsters themselves, or by less-skilled workers hired at a low wage for the task. Increasingly, operators assigned men in a similar skill category to pile wood at skidways, freeing teamsters from this back-breaking work.

From these points, the sleigh haul completed the movement of wood to water's edge (Figure 2.4). This phase of log transportation began after the new year when freezing temperatures and abundant snow provided suitable hauling conditions. The key figure in loading a sleigh was the top loader or "decker." Standing atop the load with a peavey or cant hook, he oversaw the activities of the two rollers who shifted logs from the skidway to the senders. These workers looped a decking line around each log, which ran through a block attached to a nearby pole or tree and then to a team under the guidance of a teamster. When the animal pulled the line, the logs rolled up two inclined poles to the top loader, who positioned each stick to create a balanced load. "There is considerable danger if he is not quick and sure in his actions," noted two observers of the procedure.[30]

With the completion of a load, the teamster, standing at its apex, drove the team that hauled it to the dump site. Sleigh road construction and maintenance was a critical part of a profitable lumbering operation. Each December, after the accumulation of an adequate snow pack, a horse-drawn plow went over the roadway. Tank cars followed nightly, flooding the road with water to create a frozen surface with parallel ruts for the sleigh runners. During the day, boys known as "chickadees" kept the road free of manure. "Sandpipers" were stationed at the crest of steep slopes, pouring hot sand down the road to slow the speed of sleighs that might otherwise go out of control. "A high state of efficiency of the roads demands ceaseless attention," reported an early twentieth-century forestry student.[31]

Crews at the dumpsite unloaded the sleighs and piled them in rollways situated on the banks of a stream or on the surface of a frozen lake. By mid-March, barring unexpected thaws or other impediments to efficient logging, the entire product of a winter's work would have reached the terminal point of land transportation. A brief hiatus followed while operators awaited the spring breakup, which generated sufficient water to permit the river drive to commence. During the early part of May, crews gathered in anticipation of the drive. Carefully engineered splash dams restrained the water; when opened, the river's pent-up energy was released, sending the season's cut on its way.

The drivers moved along the river banks, using pike poles to free logs that threatened to hang up or create jams. After Maine's Joseph Peavey invented the tool bearing his name in 1858, workers possessed a more efficient implement for manipulating floating logs. John Cochrane made a distinctly Canadian contribution to the technology of river driving during the same decade, building the first pointer boat for J.R. Booth. The family continued producing these nimble, shallow-draft boats that proved so valuable in clearing logs from rapids. When jams developed the rivermen faced their most dangerous task, applying peavey or pike pole to pry logs off the accumulation

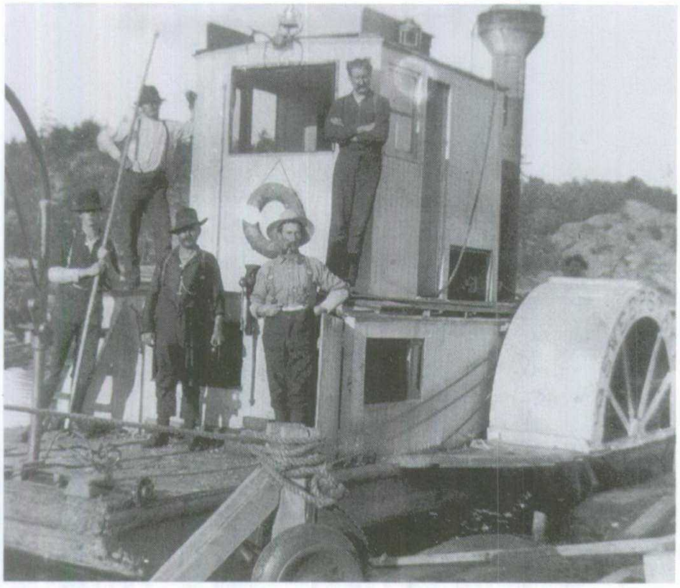

Figure 2.5 *Alligator tug. (Courtesy Archives of Ontario 153770)*

until the "key" log was released and the mass freed. The most severe jams demanded the expertise and dynamite of the "powder monkey" to blast them loose. Although no comprehensive accident statistics exist, anecdotal evidence leaves little doubt that the romantic river drive was hazardous for even the most agile and expert rivermen.[32]

When drives encountered lakes, crews boomed the logs, which were then towed by a steam vessel, or moved by the more primitive "headworks," which consisted of a raft-mounted wooden capstan. This procedure involved dropping an anchor ahead of the vessel, attaching a rope to the boom and winding the capstan, drawing both raft and boom across the lake. More sophisticated technology came into use after 1889, when John West of Simcoe, Ontario invented the "alligator steam warping tug" (Figure 2.5). These amphibious craft were capable of hauling a boom across a pond, then skidding themselves over a portage to the next lake. Once logs were flumed between the two water bodies and boomed, the alligator winched them across the second lake. Crews repeated the process until the logs reached a river suitable for driving.[33]

Scholars should resist the temptation to equate strenuous manual labour with an absence of skill. Felling, for example, required enormous judgement to avoid hang ups and place logs in the desired position for skidding. Teamsters had to understand the tendencies of the animals they drove, and care for their well-being. Crews who constructed cribs and rafts for driving square timber down rivers consisted of highly skilled specialists. Lacking any technological control of work, operators had to rely on the experience and 'working knowledge' of those they employed at every stage of the lumbering operation.[34]

The material conditions of shanty life underwent relatively little change during the nineteenth century. Operators kept investments in these temporary all-male settlements to a minimum, utilizing materials at hand whenever possible (Figure 2.6). The original New Brunswick shanties were extremely primitive affairs, sometimes only two logs high with spruce poles projected upward in the form of rafters from two sides to meet 4.5 to 6 metres (15 to 20 feet) above the ground. Poles laid across these rafters were covered by a network of spruce or hemlock boughs, which provided a small measure of insulation.[35] Over time the log portion of the structure rose to accommodate a man standing erect. Roofs were constructed of layered hollowed out logs, called scoops, or shingles. A hole in the centre allowed smoke from the fire to escape.

Shanty life centered around the camboose, a large square enclosure surrounded by logs and filled with sand where a fire burned continuously to provide heat. Here the all-important cook plied his trade, serving up a rough diet consisting of bread, salt pork, potatoes, pea soup and tea. In addition to these staples, the men might contribute the results of Sunday hunting and fishing expeditions. By the 1850s, Ottawa Valley camps also served beef, biscuits, rice, barley and peas. No operator underestimated the value of a proficient camp cook. "Men may grumble at early hours, hard work, unpleasant tasks and heartily curse the boss," stressed one account, "but when it comes to poor grub they don't kick very much; they quit."[36]

Men bedded down on the floor in the earliest Maine shanties, then wooden bunks were raised to run two tiers high around three walls of the building. These "muzzle loading" bunks featured hay or balsam boughs as a mattress, and the men slept side by side with their feet toward the fire. At the foot of the bunks, running the length of the building, was the "deacon seat" where the workers sat for meals and enjoyed their few leisure hours. With the exception of Saturday night, when fiddling, stories and songs kept them up later, all were in bed by 9:00 p.m. and rose by 5:00 a.m.[37]

During the 1890s, eastern Canadian camps became more functional. Large operations featured a bunkhouse, barn, blacksmith's shop, clerk's cabin, and separate cookery where meals were prepared and the cook served the men. Bunkhouses provided few additional creature comforts, although wood-burning stoves replaced the open fire. Camp diet may also have improved to include more fresh meat and vegetables toward the end of the nineteenth century.[38]

Historians have uncovered little evidence of collective resistance by shantymen to these employment conditions. Occasional protests against the quality of meals or an employer's attempt to alter the terms of contracts might erupt, but generally workers expressed

Figure 2.6 *Shanty at the Booth Lumber Camp, Aylen Lake, Ontario c. 1895. (Courtesy Public Archives of Canada C75264)*

resistance individually, by quitting. Ethnic clashes among workmen were far more common than class-based challenges to the power of bosses. The most frequently cited incident came in the Ottawa Valley between 1835 and 1837, when Irish and French Canadian raftsmen battled over control of the labour market. Lumberman Peter Aylen led Irish workers in the Shiners' War, a violent campaign designed to drive French Canadians from the camps. Class conflict on a significant scale did not begin until after World War I.[39]

Half a century after the Shiners' War, some Ottawa Valley lumbermen began to demonstrate an awareness of the benefits to be derived from state intervention to conserve their dwindling stocks of pine. Government interest in forest enterprise was certainly not new; as far back as 1728 the British had reserved the best of Nova Scotia's pine for naval use.[40] After 1816, colonial officials took over the administration of New Brunswick's forests from imperial authorities. They began issuing licences that identified the area to be cut, levying a duty on the timber taken. Thus were established two important features of Canada's forest history: Crown ownership of the resource and government dependence on revenue from its exploitation.[41]

Thomas Baillie, appointed New Brunswick's Commissioner of Crown Lands and Forests in 1824, set a course followed by subsequent generations of provincial administrators by encouraging investment in the forest sector, increasing government control, and maximizing the flow of revenues. By the 1840s, his policy of land sales and timber berth auctions had contributed greatly to the process of concentration that saw large companies monopolize the forest of New Brunswick.[42]

The economies of Upper and Lower Canada were more diversified than the "timber colony" of New Brunswick, but the lumbermen of the Ottawa Valley accumulated political power commensurate with their wealth. Figures such as George Hamilton wielded influence in the colonial administrations of the Canadas, and here too regulations tended to favour the interests of well-capitalized operators who sought to stabilize the timber economy by depriving others of access to the forest. By the 1860s harmonious relations prevailed between timber capitalists and colonial administrators throughout British North America. The licencing system regulated cutting rights, and governments came to rely on the revenues generated by ground rents and royalties. After Confederation, provincial Crown land departments concentrated largely on revenue collection.[43]

Nova Scotia represents something of an exception to this pattern. Here, most Crown lands were sold or granted prior to the twentieth century, and lumbermen accumulated much of the productive timberland before Confederation. Over the next 30 years the province granted over 800 000 hectares (two million acres) of the remaining forest to operators at a cost of $0.40 per acre ($0.16 per hectare). In 1899 Nova Scotia stopped granting Crown lands outright, and adopted a lease system that maintained industry's access to the public forest.[44]

By the late nineteenth century, timber interests were demanding more from governments. The most enlightened operators on either side of the Ottawa River, contemplating the depletion of their holdings, called for protection against both the encroachment of settlers and the ravages of fire. They provided leadership for a broadly based conservation movement, directing it along a path consistent with their goals of economic stability and industrial expansion. Conservation, in effect, came to mean efficient resource exploitation by large-scale enterprise in partnership with a more activist state.[45]

The Ottawa Valley lumbermen established a public forum for their views in 1882 when the American Forestry Congress gathered in Montreal. Their presentation captured the interest of provincial politicians and civil servants, and in the meeting's aftermath both Quebec and Ontario acted in accordance with the operators' conception of forest conservation. The Quebec legislature moved first with an 1883 measure that provided for the appointment of forest rangers, at limit-holders' expense, to patrol their holdings under the supervision of a special superintendent. The province's lumbermen also applauded the establishment of a forest reserve east of the Ottawa River that barred settlers from the designated territory. In 1886, however, the new Parti National government heeded the demands of Quebec's colonization movement and opened the area to settlement.[46]

Ontario advanced along the same path, but with a more lasting effect. In 1883 the province established the position of Clerk of Forestry in the Department of Agriculture to educate farmers on woodlot management, and two years later appointed rangers to patrol limits on a shared-cost basis with operators. Depressed market conditions in the late 1880s and early 1890s undermined industry's interest in conservation. But the 1893 creation of Algonquin National Park barred settlement from a huge area where operators' limits remained valid. Thomas Southworth pressed for additional reserves after becoming Clerk of Forestry in 1896, and two years later Ontario's *Forest Reserves Act* authorized the setting aside of additional areas to ensure future timber supplies. Quebec, in spite of having repealed its reserve legislation, established Laurentides and Mont Tremblant parks in 1894, but did not bar lumbermen from cutting timber already under licence.[47]

Over the course of the nineteenth century, then, the eastern Canadian forest industry swung increasingly into a North American economic orbit. The technology and methods of logging underwent little significant change, falling behind the pace of innovation in the mills, which now featured steam-powered gang saws. But lumbering had taken an undeniable toll on the forests in New Brunswick and the Ottawa Valley, and observers noted the absence of pine regeneration in these areas. Tenure policies had been developed to serve the interests of larger concerns, and lumbermen with a sophisticated conception of business-government relations were calling on provincial administrations to take a more active role in conserving forest resources for industrial use.

The Early Twentieth Century: Fibre, Unions and Forestry

The early twentieth century witnessed the rise of a new forest-products economy in eastern Canada, led by the pulp and paper sector. The new fibre economy emerged against a backdrop of change in the more traditional staples. In 1908 the last square-timber raft came down the Ottawa River, signalling the end of that trade. The lumber industry boomed during the first decade of the new century; the number of Ontario sawmills increased from 847 to 1 079. But the depletion of pine and heavy competition from British Columbia and the US caused lumber production to level off after World War I. By this time, much of New Brunswick's accessible pine appropriate for sawing had been cut out. Lumber production in that province peaked in 1915, and then began to decline.[48]

Government efforts to protect the lumber industry played at least some part in the rise of eastern Canada's fibre economy. Ontario confronted the problem of log exports during the 1890s as operators began rafting logs across the Great Lakes for processing in Michigan mills. American trade policy permitted the import of raw logs, but the 1897 Dingley Tariff placed duties on lumber imports. Moreover, the measure provided for higher duties if Canada responded with an export tax on logs. Anxious to maintain access to the American market, Ontario lumbermen approached Prime Minister Wilfrid Laurier for assistance. Denied in Ottawa, they pressed their case successfully to the provincial government. In 1898 the Hardy administration amended the *Crown Timber Act* to include a "manufacturing condition," stipulating that all pine timber cut on Crown land be sawed in Canada. American limit-holders challenged the measure, but public opinion supported the adoption of policies that fostered domestic processing of natural resources. The legislation slowed log exports, and spurred mill construction along Lake Huron and Georgian Bay.[49]

The logic of extending the manufacturing condition to spruce pulpwood became obvious as the pulp and paper industry became more prominent. Canada had a small paper sector before Confederation, but it was based on inputs of rags, grasses and straw. The development of processes to convert wood into fibre by mechanical or chemical means established the basis for mass production, and eastern Canada possessed huge reserves of spruce suitable for conversion into newsprint. Abundant opportunities for the generation of hydro-electric power provided an equally important endowment.[50]

The availability of new paper-making techniques coincided with a huge expansion of the American demand for newsprint. Newspaper circulation increased by more than 80% between 1870 and 1909 in that country. Papermakers in the United States exerted sufficient political pressure to have pulp and paper placed on the dutiable list in the 1880s, allowing pulpwood free entry. But by the early 1900s American newspaper publishers, facing rising costs as a consequence of forest depletion, launched their own lobbying efforts to have wood pulp and newsprint placed on the free list. Canadian producers agreed with this position, and asked their provincial governments to place an embargo on pulpwood exports. Ontario, hoping to stimulate mill construction, extended its manufacturing condition to include pulpwood logs cut on Crown land in 1900, Quebec followed in 1910 and New Brunswick in 1911. When the American barriers to entry of newsprint came down in 1913, the stage was set for massive development of the Canadian pulp and paper industry.[51]

Investment capital poured into Ontario. Pulp mills went up at Sturgeon Falls in 1901, and Espanola in 1905. Iroquois Falls, Fort Francis, Smooth Rock Falls and Port Arthur became newsprint manufacturing centres between 1912 and 1918, and several additional mills entered the field during the early 1920s. Quebec's pulp and paper production increased in value from $5 million in 1900 to $14 million in 1910, then reached $75 million in 1922. Cutting shifted from the Ottawa Valley to the spruce forests of the St. Maurice and Saguenay regions in order to meet the fibre demand. New Brunswick also pursued pulp mill development, and the Bathurst Lumber Company and Fraser Company established plants during the 1910s. In Newfoundland, the Anglo-Newfoundland Development Company inaugurated large-scale exploitation of the colony's timber for pulp in 1909 at Grand Falls. Bishops Falls became the site of the A.E. Reed Company's mill, and in 1925 the Newfoundland Power and Paper Company initiated a large development in Corner Brook.[52]

Newsprint destined for the American market led Canada's pulp economy, rising from a value of $1.2 million in 1910 to over $100 million per year by 1930. There is some debate about the degree to which this expansion can be attributed to the government policies described above. While historians have generally considered tariffs and embargoes important in stimulating newsprint development, economist Trevor Dick argues that they pale in comparison to the market forces that created a strong American demand for the spruce and hydro-electric power available in the eastern provinces.[53]

Given the determination of American interests to secure access to Canadian timber reserves, it should come as no surprise that capital flowed north in significant amounts. In 1919, direct American investment in the Canadian pulp and paper industry reached $74 million. The presence of American subsidiaries reflected the continental integration of the two economies. Particularly prominent in this category was the Canadian International Paper Company, a creation of International Pulp and Paper, which established its first Canadian mill in 1921 at Trois-Rivières.[54]

The 1920s brought further expansion in production as new mills went up and existing plants increased capacity. Investment in newsprint mills rose from $157 million in 1918 to $580 million in 1928. One year later production reached 2 725 000 tons; about 80% of that total went to the American market. But by 1926 capacity had outstripped demand, and newsprint prices fell sharply in the closing years of the decade. The larger firms organized cartel agreements to arrest the drop, but price-cutting continued as firms fought for sales. A wave of mergers swept through the industry in the late 1920s. One of the most significant examples of concentration saw five Quebec firms — St. Maurice Paper, Wayagamack Pulp and Paper, Belgo Paper, Laurentide, and Port Alfred Pulp and Paper — merge into the Canada Power and Paper Company. By the end of the decade this firm, along with the Canadian International Paper Company and Abitibi Power and Paper, dominated Canadian output.[55]

The giants of the industry financed their acquisitions by accumulating massive debt loads that left them vulnerable when the Depression hit. Newsprint prices fell further during the early 1930s, producing a flurry of bankruptcies as debt-ridden firms defaulted on loans. By 1932 four of the six largest producers were in receivership, including Abitibi and Canada Power and Paper. The newsprint market recovered somewhat thereafter, but in the end it required intervention by the Ontario and Quebec governments to restore a measure of stability. After 1937, the industry adopted a legalized price-fixing arrangement, in which the Newsprint Association of Canada oversaw the selling practices of cartel members.[56]

World War II brought the Canadian economy out of the Depression; this recovery was shared by the pulp and paper industry. Under C.D. Howe's firm hand, the federal Department of Munitions and Supply gained enormous power over the economy. By 1948, newsprint prices had returned to their mid-1920s level. Between 1900 and 1945, then, pulp and paper became the dominant sector of the eastern Canadian forest-products economy. Never an industry of small operators, by the end of the period it had reached a high degree of concentration. In the woods, however, traditional methods showed a resiliency that disturbed some observers.

Logging remained a seasonal, labour-intensive enterprise during the first half of the twentieth century. The emerging pulp and paper sector introduced some distinctive innovations after World War I, but on the whole managers preferred to invest in the manufacturing end of the business. Nature continued to provide the conditions essential to log transportation in the vast majority of operations. Why, wondered the editor of the *Canada Lumberman* in 1902, had the problem of wood supply not "aroused the spirit of inventive genius to the same extent as other branches of lumbering." The raw material flow could still be interrupted at any stage in the process if nature failed to cooperate: "If there is too much snow in the woods cutting is interferred with; if the snow leaves too early in the spring the logs cannot be hauled to the streams; if they reach the streams and the snow goes away too rapidly, they are likely to be hung up; if the snow leaves too gradually and there are no heavy rains, the moisture sinks into the soil and the streams do not swell sufficiently for driving operations."[57]

Frequent calls for a greater commitment to innovation failed to generate much in the way of systematic research and development. Pulp and paper firms initially accepted the felling methods developed in the lumbering trade during the previous century. Then as the pressure to reduce costs mounted in the 1920s, they rationalized their cutting procedures by replacing three-man felling crews with individual fellers in the "short wood" system. This saw the camp foreman assign each cutter his own strip where he worked in isolation, felling the timber, cutting it into lengths of four or eight feet, and piling these at the end of the strip. Finns in northern Ontario are credited with introducing the buck saw in the 1920s, a light cutting blade set in a wooden frame. By the 1930s, factory-made steel frames became standard. Because fellers cut the spruce and balsam fir used in pulping as close to the ground as possible, felling was back-breaking, strenuous work.[58]

Skidding also exhibited continuity with nineteenth century procedures, although pulp and paper companies slashed their labour costs further by adopting one- or two-man crews to skid logs to roadside in tree-length operations. After World War I, the jammer, a sled-mounted crane capable of being moved between skidways, replaced the decking line in loading. Logs were raised by a horse pulling on a cable that ran through a block stationed at the top of the jammer. In short-wood operations, workers loaded sleighs by hand, an arduous task. In the majority of camps, horse teams continued hauling loads to the dump site. Unlike many other North American lumbering regions where railways figured prominently in log transportation, in eastern Canada the cost efficiency of river driving ensured its dominance.[59]

Not all operators were content to carry on with traditional labour-intensive methods. A number of Ontario companies introduced more factory-like skidding operations by adopting the Lidgerwood skidder, a steam-powered system of logging. By 1915

Cleveland-Sarnia Lumber Mills, Eddy Brothers Company, and Serpent River Lumber Company in Ontario had experimented with steam, in some cases employing the Lidgerwood overhead system that was in widespread use among large Pacific Coast firms by World War I. Cargill Ltd. of Bruce County, Ontario did so in conjunction with its railroad, mounting the Lidgerwood engine and 40-foot spar on a rail car to yard logs to the track.[60]

Commentators attributed the appeal of mechanized skidding to a declining standard of woods labour, but even enthusiasts had to admit that for small, scattered timber, horses were more efficient. Acute labour shortages immediately after the war appear to have stimulated greater interest in overhead logging. In 1919, one booster predicted that the high-lead system would soon be common in eastern Canada "by reason of the increasing cost of labour and supplies, and the generally poor quality of labour now available." Equipment designed for West Coast conditions was, alas, too heavy. A Belleville engineering company apparently built some smaller models for eastern operators, but steam-powered skidding failed to catch on as it did in the west because smaller timber and lower stand density did not justify the investment.[61]

Woods managers had greater success in mechanizing their hauling operations. Railways, so fundamental to log transportation in the United States and British Columbia, were built by some eastern Canadian firms who held extensive limits on relatively flat terrain. Quebec's Fassett Lumber Company operated a 40-kilometre (25-mile) line between its mills and its 27 500-hectare (68 000-acre) holdings on the north side of the Ottawa River. Abitibi constructed an extensive rail system through their Iroquois Falls limits, but a 1916 *Canada Lumberman* survey of firms concluded that river driving remained the most efficient method. Logging by rail was "the court of last resort in the East."[62]

The tread and ski-mounted steam-powered traction engine provided operators with a much less expensive alternative to rail transportation. The Lombard Log Hauler became the most popular after its 1901 introduction (Figure 2.7). An unknown number of firms, including at least one New Brunswick operator, used these 15-ton behemoths to haul sleigh trains over long distances. "It is not a panacea for all the troubles of the logging business," commented one user, "but simply a substitute of a machine and a few men for a larger number of men and a number of horses." High cost, frequent breakdowns, and the inability to cope with anything but the easiest grades prohibited widespread use of the steam hauler.[63]

The smaller, faster tractors powered by the internal combustion engine proved to be a superior technology, and by the 1930s trucks were hauling wood on iced roads. By the late 1930s, Ian Radforth reports, northern Ontario operators used tractors and diesel trucks on the sleigh haul as frequently as horses. By World

Figure 2.7 *Lombard Log Hauler. (Courtesy Saskatchewan Archives Board S-B7415)*

War II, then, eastern Canadian operators had made greater progress in mechanizing the sleigh haul than any other phase of their operations. But even in hauling, the horse and teamster continued to have a prominent place.[64]

What explains the industry's limited innovation in eastern Canada, especially when compared with other lumbering regions, which exhibited a higher degree of technological sophistication? Some informed observers chastized the operators for failing to devote sufficient resources to the improvement of methods. "Dependence is still placed on the physical strength of men and horses and the uncertain transportation of the streams and rivers," noted Roland D. Craig in 1920. He urged eastern operators to follow the example set by those in the far west, whose Pacific Logging Congress provided an annual forum for discussion of technological and managerial issues.[65]

The Canadian Pulp and Paper Association (CPPA) had organized a Woodlands Section in 1917 to investigate and disseminate information on more efficient techniques, and in 1921 the association established a committee to cooperate with the American association in a study of logging methods. One of its members, Abitibi's G.H. Anson, suggested that the association establish an experimental division headed by an efficiency expert. In 1927 the CPPA appointed Alexander Koroleff as the section's secretary to coordinate research on woodlands issues (Figure 2.8). But the faltering pulp economy of the ensuing years provided little encouragement to those who considered mechanization the solution to efficiency problems. "Human physical energy is a cheap commodity, particularly at present," Koroleff observed in 1929.[66]

As the forest industry began to recover from the worst of the Depression in 1936, J.D. Gilmour offered another perspective, attributing the pulp sector's traditionalism to the jobber system. The small, seasonal operators who logged for the pulp and paper companies lacked both the capital and incentive to mechanize their operations. After attending the Pacific Logging Congress in late 1936, Koroleff chided eastern Canadian executives for investing less than one tenth of the energy and funds in logging than their more progressive western counterparts had.[67]

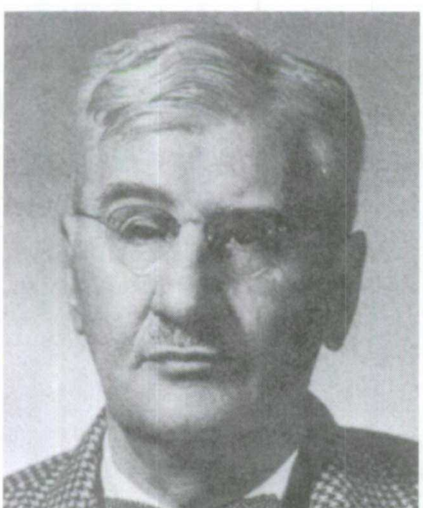

Figure 2.8 *Alexander Koroleff (Courtesy Canadian Institute of Forestry)*

Ian Radforth, the Ontario industry's foremost student, has seconded Gilmour's analysis, and noted that executives preferred to devote research funding to the mills where they had received their training. But he argues that labour abundance was primarily responsible for undermining the industry's incentive to allocate capital to mechanization as long as mills received an adequate wood supply each year. Turning to the workplace implications of those machines that did make their way into the eastern woods, Radforth concludes that they had relatively little impact on the organization of work. In essence, vehicles such as tractors and trucks took the place of horses, and drivers supplanted some teamsters, but the cutting, skidding, piling and loading activities that occupied most workers changed little.[68]

Logging, then, continued to demand a wide range of physical and conceptual skills. Unlike the stable setting of the sawmill or pulp mill, where more sophisticated technologies enabled capital to achieve a higher level of control over production, the variable and ever-changing woods environment left the worker in control of his own labour. "The old thought that logging is a repetitive, routine job requiring a strong back and a weak mind is quite incorrect," noted an Abitibi official in the 1950s. "Due to the changing combination of the many variables in logging operations, it requires considerable intelligence on the part of woods employees in order to carry out their jobs efficiently."[69]

With limited success in mechanizing the workplace, pulp and paper firms pursued efficiency by adopting piecework payment schemes in the aftermath of World War I. Incentive payment offered several advantages over the daily or monthly wage. First, dispersed cutting operations precluded close supervision. Lacking machinery to set the pace for employees, observed one operator, "the only chance of getting more work done would be in getting the men working by piecework." Second, the system bred a competitiveness among the men that undermined solidarity. Workers themselves seemed to prefer remuneration on a basis that promised the potential for higher earnings and freedom from supervision. On the other hand, rates drove men to more strenuous effort, contributing to fatigue and injury.[70]

Despite pressure from workers and reformers, camp conditions improved little over the first half of the twentieth century. Unsanitary and crowded, bunkhouses were a breeding ground for infectious disease. The Ontario Board of Health received complaints in 1897 when the town of Sault St. Marie reported a number of typhoid fever cases brought in from neighbouring camps. When the agency inquired into the precautions taken to prevent the spread of disease to the general populace, the *Canada Lumberman* declared that operators "are interested in the health of the community...and realize the benefits to be derived from proper sanitary arrangements."[71]

Three years later a smallpox epidemic spread from Ontario camps, prompting legislative reforms. The 1901 Act respecting Sanitary Conditions in Unorganized Territories required operators to arrange for medical care for bushworkers and to improve sanitary conditions. Hospitals were to be constructed at every camp, and owners were to contract local doctors to make regular visits financed by payroll deductions. The regulations set standards requiring stables to be more than 38 metres (125 feet) from kitchens or bunkhouses. The bunkhouses were to have 8.5 m^3 (300 ft^3) of air space per man and bunks were to run parallel to sidewalls, doing away with the muzzle loaders.[72]

Unfortunately, lack of enforcement and political pressure by lumbermen made the legislation a dead issue. When Ontario's Labour Minister criticized conditions in 1915, the *Lumberman* responded that campworkers were "well treated, carefully looked after, and well paid," thanks to "the paternal interest of a large company whose interests are the interests of their employees." But Quebec's chief medical officer returned from an inspection of pulpwood camps in 1921 to declare them "not fit for human beings." The *Lumberman* blamed the men for refusing to care for their habitations. The Quebec government issued regulations under the province's *Health Act* in 1924, stipulating minimum standards for ventilation and sanitation. New Brunswick adopted similar legislation later that year, but the impact of these measures has not been evaluated.[73]

Labour shortages and a surge of unionization in the immediate postwar years prompted some improvement in the larger Ontario camps during the 1920s. Inspection and enforcement also improved, but the Depression curtailed any meaningful improvement in living standards. In Newfoundland, Dufferin Sutherland observed, "already crude camp conditions deteriorated as contractors tried to make a living on lower and lower prices for wood." Just as the labour performed by bushworkers changed little during the early twentieth century, Radforth's conclusion that living conditions in Ontario went largely unaltered likely holds true for the whole of eastern Canada.[74]

Pressure for more humane treatment of campworkers also came from reformers infused with the spirit of the Social Gospel during the early twentieth century. As early as 1869, Presbyterians in Ottawa founded the Lumber Mission and dispatched missionaries to the Ottawa Valley camps. The organization sent Alfred Fitzpatrick into the camps in 1892. Appalled by what he saw, Fitzpatrick established the Reading Camp Association in 1899 to "provide workers with wholesome reading materials as an alternative to the vices of camp life." The next year he founded Frontier College, an organization that dispatched university students to work alongside the lumberjacks during the day and conduct classes in the evening.[75]

The Home Mission Boards of the Methodist and Presbyterian churches also tried to maintain a presence in the bush, placing camps under the care of local Ministers. In 1908, the Church of England Missionary Society sponsored Church Camp Missions, which employed a number of missionaries nationally to bring Christianity to campworkers. William Henderson's Shantymen's Christian Association also ministered to frontier labourers across Canada. Together, Norman Knowles argues, these groups sought to "instill ideals of true Christian manliness" in their subjects. But appeals for support from operators emphasized more practical considerations. The field secretary of the Shantymen's Association advertised their work as having a "very salutary effect upon tendencies toward labour agitation." Lumbermen who provided funding for these organizations did not heed the reformers' pleas for material improvements.[76]

Workers who greeted the message of Christianity with apathy or hostility began to place their faith in one of class solidarity after World War I, when radical Finnish immigrants led a union drive in the Ontario woods. Those who sought to mobilize bushworkers into a cohesive force faced numerous obstacles. Labour abundance, the isolated location of camps, the seasonal nature of logging, ethnic diversity, and the tendency of men to view themselves as temporary wage-earners or farmers made the organizer's task a challenging one. Turnover in the camps may have made it more difficult for workers to confront bosses, but geographic mobility also gave them a broad, social perspective on industry conditions that transcended particular operations.[77]

Finnish woodsworkers, radicalized in their homeland before immigrating, provided leadership for unionization in northern Ontario. Their initial attempt at organization came at Port Arthur in 1911, through the short-lived Lumber and Railroad Workers Ring. The Industrial Workers of the World (IWW, or the "Wobblies") attracted some Finns in Ontario at the same time as the union drew large numbers of miners, railroad workers and loggers together in British Columbia, the western states and midwest. During World War I, Finnish Wobblies made organizational efforts around the Lakehead district. They and other socialists came under the scrutiny of the Royal Canadian Mounted Police, and in 1918 the federal government banned the IWW as a threat to the war effort. Still, operators didn't have everything their way during the war. Enlistments and the munitions industry reduced the labour supply. As wage costs rose, efficiency in the camps declined because of the abundance of employment opportunities. Managers fumed as workers exerted their independence. "Logging camps last year were manned by the most promiscuous, incapable, and uncertain crews that ever went into the Canadian bush," lamented the *Lumberman* in 1917.[78]

The end of the war brought new opportunities as workers across Canada sought to advance their interests. In 1919 western unionists, dissatisfied with the Trades and Labour Congress, established a more militant organization modelled on industrial rather than craft lines — the One Big Union (OBU). That year also saw loggers in the most western province establish the B.C. Loggers Union, which joined the OBU as the Lumber Workers Industrial Union (LWIU). Both bodies sent organizers to Ontario. OBU organizer Joe Knight addressed a gathering of 500 woodsmen in Pembroke in 1920, gaining a number of members.[79]

It is difficult to judge the extent of the OBU's strength in the Ontario woods during its peak in 1919–1920. Radforth estimates that as many as 4 000 loggers joined, although only a fraction of these paid regular dues. Nevertheless, the union's call for an eight-hour day, a $5 minimum daily wage and better conditions addressed the harsh realities of bushwork, and it probably had some influence on the minor postwar reforms in camp facilities. There can be no doubt that operators were anxious to rid themselves of the militants. "The Bolsheviks, the One Big Union, the Reds, and other cults appear to be quietly but efficiently getting in their nefarious work," reported the *Lumberman* in March 1920. Finns had engineered a number of strikes in Northern Ontario during the previous months, and workers were prone to "demand concessions of a fantastic character." The lumbermen's organ could only express its relief that Quebec loggers seemed largely unaffected by socialist appeals.[80]

Conflict among industrial unionists and a brief but severe recession after 1920 blocked labour's postwar surge. In 1921 the LWIU and the OBU split, dividing the nascent woodworkers movement in Ontario. As membership in both organizations fell, unemployment gave operators the whip hand in workplace relations. Companies slashed wages throughout eastern Canada in 1921. When 50 New Brunswick workers quit to protest a wage cut at one camp, others eagerly filled their places. J.A. Mathieu of the Shevlin-Clarke Company in Fort Frances, Ontario reported in late 1921 that "men were willing and anxious to work for anything they could obtain." The loggers were also working harder, Mathieu explained, "because they realized that unless they did so others would take their place."[81]

After 1920, the OBU gradually lost out to a resurgent IWW in a struggle over the allegiance of northern Ontario workers. Then in 1924 another organization emerged, the Communist-led Lumber Workers Industrial Union of Canada (LWIUC). Although the multiplicity of unions hardly fostered solidarity, during the late 1920s woodsworkers staged a number of strikes for higher pay, the eight-hour day, and better conditions. About 700 pulp cutters walked off the job at Port Arthur in September 1926 and got a wage increase after a month-long strike. Conflict between the IWW and LWIUC may have undermined strikes in the Cochrane and Kapuskasing areas later that decade, but according to one report, these ended on terms favourable to strikers.[82]

Over the next three years, unemployment and internal tensions sapped the movement's strength. A dispute involving 200 tie cutters for higher piece rates at Onion Lake, Ontario in January 1929 ended in a compromise after provincial police intervened to stop picketers from interfering with non-strikers. Employers broke another strike of 800 northern Ontario pulpwood cutters later in 1929, replacing strikers with men brought in from Winnipeg. Wages and camp conditions deteriorated during the first three years of the Depression. New Brunswick operators slashed wages by half between 1930 and 1932. In Newfoundland piece rates dropped so low that only the most experienced men could hope to make a living.[83]

By 1933, the LWIUC had regrouped sufficiently in northern Ontario to stage a number of large strikes over the next two years. In July 1933, 1 300 loggers were on strike in the Onion Lake and Nipigon districts, demanding higher piece rates, a reduction in board charges, and recognition of camp committees. Eventually the Minister of Lands and Forests and local civic officials brought the parties together in a compromise settlement.[84]

By the end of the year over 2 000 Ontario woodsworkers had walked off the job. Pulpwood cutters in the Rouyn and Saguenay districts of Quebec also withdrew their labour in a violent but unsuccessful effort to achieve wage increases and improved conditions. The Ontario disputes also featured numerous incidents of picket-line violence, ending with gains for workers and their union. In addition to wage increases, an agreement between the Lakehead Timbermen's Association and employees provided for the election of camp committees and open meetings. Operators refused to grant recognition to the union, however.[85]

The strike wave also extended east to the Atlantic region. Newfoundland and Labrador woodsworkers staged mass walkouts over low wages. But in New Brunswick the pattern of small jobber camps coupled with the absence of radical immigrants made organization difficult, and the province witnessed none of the militancy demonstrated in other parts of eastern Canada or British Columbia. West Coast loggers achieved a $0.40 per hour minimum wage in

1934 with a massive strike that tied up production throughout Vancouver Island.[86]

The strikes and violence of 1933–34 prompted provincial governments across eastern Canada to establish minimum employment standards in the camps. The Ministers of Lands and Forests for Quebec and Ontario met in early 1934 to discuss the creation of uniform labour conditions in the forest industry. Hoping to prevent a recurrence of the disorder, Ontario passed the *Woodsmen's Employment Act* in 1934, empowering the Minister of Lands and Forests to appoint an inspector to inquire into employment conditions on Crown land operations. The legislation allowed the Minister to make binding recommendations on wage, hours and board issues, but produced no rigorous standards. Quebec's 1934 *Forest Operations Commission Act* established similar mechanisms, requiring operators on Crown land to submit relevant information to the government. The government repealed the Act in 1936, and implemented legislation that set minimum wages and piece rates the next year.[87]

New Brunswick moved along the same path with its 1934 *Forest Operations Commission Act*, which created a board to set a minimum wage and handle disputes. Parenteau concludes that the mechanism functioned well initially, altering the balance of power in the camps and increasing wages somewhat. In the long run, however, administrative shortcomings undermined the legislation's power to improve standards uniformly.[88]

Anxious to stem a tide of complaints concerning wages and conditions in Newfoundland, that colony's Commission Government appointed F. Gordon Bradley to conduct an inquiry into the forest industry in 1934. Bradley's report, penned after a thorough investigation, revealed the extent of the exploitation endured by loggers at the hands of the Anglo-Newfoundland Development Company and the International Power and Paper Company. Needing at least $50 per month to provide a reasonable level of family subsistence, the average cutter took home only $25.20 a month. In response, the government negotiated a $25 per month minimum net wage with the companies in exchange for withholding the document.[89]

Ontario's woodsworkers' movement remained the most aggressive during the mid-1930s, taking a new direction in 1935 when Communist International directed its members to pursue alliances with mainstream unions and other progressive organizations in the fight against fascism. LWIUC leaders in British Columbia and Ontario merged with the United Brotherhood of Carpenters and Joiners (UBCJ), a conservative craft union affiliated with the American Federation of Labor and the Trades and Labour Congress in Canada. By early 1936, LWIUC members had ratified the creation of the Lumber and Sawmill Workers Union (LSWU). Conflict between Communist militants and traditional craft union officials quickly led British Columbia and Pacific Northwest loggers to reject the UBCJ and create the International Woodworkers of America (IWA), in affiliation with John L. Lewis's Congress of Industrial Organizations. Despite tensions, LSWU officials in Ontario maintained the union's link with the UBCJ.[90]

The passage of Ontario's *Industrial Standards Act* (ISA) in 1935 gave union officials an opportunity to bargain with employers in regional meetings convened by the Minister of Labour. If the parties agreed on wage standards, the Minister could make the settlement binding on all companies and employees in the region for the coming year. According to Radforth, the LSWU used the ISA to attain "a kind of quasi-collective bargaining relationship with operators throughout the north." Over the next few years, agreements were signed governing wages and hours in the Port Arthur, Massey, Timmins and Rainy River forestry districts.[91]

World War II created conditions favourable to the expansion of union power in many sectors of the Canadian economy. The war brought the unemployment of Depression to an end, led to a sharp increase in industrial activity, and ultimately prompted the federal government to take an active role in the administration of workplace relations. Government's primary goal in wartime was full production, placing a premium on labour-management cooperation. But Mackenzie King's effort to control inflation involved wage freezes and an initial refusal to introduce compulsory collective bargaining, policies that antagonized workers and union leaders.

Labour shortages in Ontario's logging industry during the early war years brought immediate benefits to workers in the form of increased wages. The LSWU followed the Communist Party's line of opposition to the war until June 1941, when Nazi Germany's attack on Russia shattered the Hitler-Stalin non-aggression pact. Although no evidence existed to support employers' claims that the union sought to obstruct the war effort, in 1940 the RCMP confined LSWU official Bruce Magnusson at the government's Petawawa internment camp. Magnusson was released in 1942, but in the interim the LSWU made few gains.[92]

Operators confronted problems of their own during this period. Competing with one another for the diminishing supply of available labour, they consistently violated the terms of federal wage freezes. Workers moved from camp to camp, capitalizing on wartime labour market conditions. Regional War Labour Board conferences, held to stabilize the situation, gave the LSWU an increasing legitimacy with government officials. As the war dragged on, Canadian workers grew increasingly militant, frustrated with policies that seemed more attuned to business than working-class interests. Finally, lengthy strikes by Ontario miners and steelworkers, coupled with growing support for the Commonwealth Cooperative

Federation forced King to act. In 1944, the Liberals adopted PC1003, an order in council guaranteeing workers the right to organize and bargain collectively. Woodsworkers in Ontario would wait until 1946 to stage the strike that won them collective bargaining rights and union recognition, but wartime conditions had set the stage for their success.[93]

Newfoundland unions also entered into closer relations with the state during World War II. By 1940, four organizations — the Newfoundland Loggers Association, Newfoundland Labourers Union, the Workers' Central Protective Union and Fishermen's Protective Union — represented loggers, reflecting the industry's geographic dispersal and the disparate nature of the labour force. In 1940, the Commission Government established a mechanism to stabilize labour relations in the industry. The Woods Labour Board drew the Anglo-Newfoundland Development Company, Bowaters, which had purchased International Paper's holdings, along with the four unions into a body designed to negotiate contracts, hear grievances, and minimize inter-union rivalry. The arrangement persisted until 1957, with not a single strike or lockout during that period.[94]

Provincial control of forest resources dictated that the federal government would play a much less vigorous role in forest policy development during the first half of the twentieth century. Throughout this period, the provinces concentrated on the revenue-producing aspects of forest administration, subordinating conservation to a promotional ethic that valued the forest as an engine of economic growth. Although the conservation movement provided an ideological basis for the establishment of forest services under professional leadership, scientific management in the form of cutting regulations and reforestation initiatives stood a distant second to the concept of forestry as a revenue generator in the minds of provincial politicians.

Ontario appeared to have laid the groundwork for effective forest administration by 1905, but the speculative mania associated with the emerging fibre economy of the province's north overcame any interest in the science of forestry. Anxious to attract pulp and paper mills, Ontario granted corporations long-term leases to huge pulpwood limits, a policy that encouraged the entrance of speculators interested in quick profits rather than long-term business development. The Liberals did hire Judson Clark, the province's first professional forester, as Thomas Southworth's assistant in 1903 but the position had little influence.[95]

When the Conservatives took power in 1905, they cancelled a number of concessions that had failed to produce any mill construction, and initiated an auction system for acquiring timber rights. Clark had recommended reforms that would have given the state a strong regulatory role to ensure corporations acted in the public interest, but the Whitney government's commitment to attracting American capital prevented their implementation. Soon after, Clark resigned and began a prominent career as a consulting forester.[96]

General public and industry support for the establishment of a forestry school led to Bernhard Fernow's appointment as Dean of the new University of Toronto School of Forestry in 1907, the most meaningful contribution recorded by the administration. The Department of Lands, Forests and Mines also adopted several "inconsequential" regulations designed to protect young growth, granted pulpwood concessions in the Temagami forest reserve, and reduced its size to permit mining. Fernow grew increasingly critical of policies that pursued economic development at the expense of sound forestry.[97]

By World War I, Ontario's conservation movement had lost its momentum. The state regulated neither the declining lumber industry nor the new pulp and paper giants in a manner acceptable to Fernow. The United Farmers administration of 1919–23 established a commission to investigate Crown forest management, but proved unwilling to adopt significant reforms. The subsequent Conservative government passed a new *Forestry Act* in 1927, restricting agricultural settlement on marginal lands and creating a new board to oversee research. It followed two years later with legislation that created three new reserves, now called provincial forests. In 1929, the province's *Pulpwood Conservation Act* required Crown land operators to provide government with inventories and adopt sustained-yield principles, but the financial constraints that accompanied the Depression prevented these measures from being implemented. Government cut its forestry staff by half. By 1934, Gillis and Roach conclude, "the forestry and conservation movement in Ontario had to all intents and purposes, died so far as its influence in official circles was concerned."[98]

Tension between the forest industry and Quebec's colonization movement generated a mere dynamic approach to forest management in that province. Between 1904 and 1908, the Liberal administrations of S.N. Parent and Lomer Gouin placed 427 600 km^2 (165 109 m^2) of timberland in reserve for future pulp and paper production. Recognizing the need for professional management expertise, Gouin sent Gustave C. Piche and Avila Bedard to attend Yale's forestry school in 1905. The two then studied forestry techniques in Europe before taking positions in Quebec's Department of Lands, Mines and Fisheries. By 1910, Gouin had founded a school of forestry at Laval University and the Quebec Forestry Service, with Piche and Bedard in leadership positions.[99]

Initially the agency conducted surveys, supervised fire protection and made efforts to enforce diameter-limit cutting regulations. By the 1920s, the Forestry

Service was asking large firms to provide inventories of their holdings and annual operating plans, which were to include reference to silvicultural techniques (the planting, growing and tending of trees). These policies encouraged corporations to use airplanes in survey work and to establish private nurseries. In 1921, the province was the first in Canada to adopt legislation requiring annual Forestry Service approval of working plans. It would be an error, however, to interpret the Liberal relationship with big business as anything but cooperative.[100]

Quebec's encouragement of the rapidly expanding pulp and paper industry drew opposition from French-Canadian nationalists concerned with foreign control of the province's natural resources. Replacement of the reserves with a more flexible system of land classification failed to quiet critics, who called for tighter regulation of corporate logging practices and greater business opportunities for French Canadians. During the 1920s, Gouin's successor, Louis-Alexandre Taschereau, continued to pursue American investment in the province's natural resources, awarding timber limits as a way to promote industrial expansion.[101]

As the pulp and paper industry faltered during the late 1920s, appropriations to Quebec's Forestry Service fell short of requirements, and then plummeted further during the Depression. Corporations abandoned any pretense at forestry practice. Although the province tightened its working plan regulations in 1939, by the end of the period Quebec's promising start had fallen victim to market imperatives.[102]

New Brunswick had done little more in forest management by 1900 than follow Ontario in adopting a cost-sharing plan with operators for fire protection. After the turn of the century, expansion of the paper industry prompted the province to introduce a Crown land survey as a basis for classification. In 1908, a permanent corps of fire rangers was set up, and the Conservative administration of Douglas Hazen established a forestry department at the University of New Brunswick in 1910. Despite these advances, the province's premiers shared with their Ontario and Quebec colleagues a preoccupation with industrial development that precluded meaningful regulation.[103]

In 1913, pressure from industry produced legislation that extended the life of pulp and sawmill leases and provided funds for land classification in New Brunswick, but evidence of corruption led to a Liberal election victory in 1917. They modernized the province's administrative apparatus, passing a 1918 *Forest Act*, which created a Forest Service within the Department of Lands and Mines, and a forest protection fund supported by taxes on leased land.[104]

Fires, spruce budworm infestations and the lumber industry's permanent decline created problems for the new agency, which limped along with reduced support during the Depression. A 1937 amendment to the *Crown Lands Act* required that operators cutting under-sized trees on Crown land submit operating plans signed by a professional forester, but the Forest Service's K.B. Brown conceded in 1941 that cutting methods in the province left "much to be desired from a silvicultural standpoint."[105]

Brown's statement had equal relevance to all of the eastern provinces. Governments had taken steps to protect stands from fire and made varying commitments to management standards, but lacked both the knowledge and will to regulate cutting practices that would foster forest regeneration. Like timber capital on the West Coast, large eastern Canadian firms had developed a need for the engineering expertise, although not the silvicultural knowledge, held by forestry school graduates. Foresters hired by pulp and paper companies during the early twentieth century found themselves confined to inventory, mapping and road layout work. The profession's preoccupation with engineering duties was reflected in the title of their organization founded in 1908, the Canadian Society of Forest Engineers. Corporate policy, noted F.W. Avery in 1921, "does not include the principles which permit the forester to practice the fundamentals of continuous yield."[106]

The horse logging practiced during the first half of the twentieth century provided much better opportunities for natural regeneration than the mechanized systems that followed, but it was apparent early on that the pine forests were being converted to spruce and balsam stands or non-commercial species. "The white pine as a timber tree has almost disappeared from our forests," wrote New Brunswick's G.V. Hay in 1907. When the Dominion Royal Commission on Pulpwood investigated forest management in 1924 it found a "very grave" situation in the Maritimes, where operators consumed pulpwood at three times the annual growth rate. The more extensive forested area of Ontario and Quebec made for less alarming conditions, although neither province regulated cutting or invested sufficient revenue in their forests.[107]

Governments devoted limited scientific and financial resources to artificial reforestation during the first half of the twentieth century. Quebec established a nursery at Berthierville in 1908, selling some stock to pulp and paper companies. Ontario passed reforestation legislation in 1921, but its nursery production went largely to farmers' woodlots and municipal forests in the south. New Brunswick's first small nursery opened in Fredericton in 1923, and in 1926, a provincial nursery opened in Lawrencetown, Nova Scotia. Corporations such as Riordan Pulp and Paper, Donnacona Paper, Abitibi, and Laurentide conducted small planting programs with seedlings grown at private facilities. In general, however, business and government were content to let nature do the job. Unfortunately, as Ellwood Wilson noted in 1929, "everyone is dissatisfied with the natural reproduction we are getting."[108]

With artificial reforestation considered too costly to undertake on a widespread scale, it was up to woods managers to devise cutting practices that promoted natural seeding of cutovers. But as the pulp and paper industry turned to extensive clearcutting of spruce and balsam stands, natural reproduction suffered. Profitable logging rather than silviculture influenced cutting practices. Techniques such as group, strip, or selective harvesting never made the transition from the forestry textbook to the field.[109]

Between 1900 and 1945 the eastern Canadian forest industry witnessed significant changes in its relations with employees, the state and the environment. Thanks to government intervention, and prompted by their own willingness to collectively resist corporate power, workers had advanced their class interests, especially in Ontario. Provincial forest policies represented a mixed bag of regulations that went little beyond fire protection and revenue collection, unified only by a common desire to promote economic growth. Sustained yield remained a concept with no relevance to the concerns of the pulp and paper companies that dominated the region's forest economy. Even under the constraints of its primitive technological regime, the industry's expansion of the logging frontier raised questions about the sustainability of forest economies.

The Postwar Years: Mechanization, Work and Forest Ecology

The postwar period brought further concentration and expansion of the eastern Canadian forest industry. But a fundamental transformation of logging methods, culminating in modern harvester technology, ensured that manpower requirements declined as the rate of cut increased. Membership in woods unions also grew throughout the region, as the postwar compromise between capital and labour spread to the forest industry. Greater state regulation of corporate forest practices appeared to herald a new era of scientific management. The new technologies of logging, however, were applied with little regard for the ecological characteristics of commercial species. Despite achievements in artificial reforestation, harvesting has far exceeded the pace of forest renewal.

Consumer demand for all types of forest products increased at the end of World War II. American demand for newsprint grew as newspaper advertising increased. By 1950, the United States purchased six million tons of newsprint annually, nearly double the 1945 amount. Between 1945 and 1955, the Canadian pulp and paper industry increased its capacity by 71%. American capital financed much of this expansion, and the Cold War strengthened links between the two North American economies. In the early 1950s, the US government placed newsprint on its "strategic materials" list, making it a key component of foreign policy initiatives in the fight against Communism.[110]

As pulp and paper production expanded in the American south during the postwar decades, Canada's reliance on its traditional market decreased. In 1960, 78% of the newsprint Canada produced still went to the US, but has since fallen to about 70%. At the same time, the US increased its consumption of domestic newsprint from 27 to 48% of the total. With Canadian newsprint becoming less important to the US market, firms here have diversified their product lines to include a wide variety of paper products.[111]

The postwar period brought a series of mergers and takeovers that increased the degree of industrial concentration. In 1961, the St. Lawrence Corporation and the Howard Smith Paper Company joined to form Domtar. The same year, Price Company merged with the Anglo-Newfoundland Development Company. The 1970s saw Abitibi absorb Price, creating Abitibi-Price. Early in the 1980s, Noranda, which controlled Fraser Inc. of New Brunswick, and the MacLaren Company acquired MacMillan Bloedel shortly before being taken over by the Bronfmans' Brascan. The ink had barely dried on these deals when Canadian Pacific Enterprises acquired the Canadian International Paper Company, having already taken control of Great Lakes Forest Products. By 1989, Canadian Pacific Forest Products operated 28 manufacturing plants across Canada, controlling over 10 million hectares (24.7 million acres) of forestland. Critics charge that the industry's monopolistic structure has worked to the detriment of the independent farmer-pulpwood producer.[112]

During the postwar decades, the structures that had supported industry's reliance on traditional logging methods came under pressure. Rising labour costs, due to labour shortages and unionization, the scarcity of horses and skilled teamsters, and booming but competitive product markets combined to generate an interest in mechanization among managers. Although the process was marked by frustration and frequent disappointment, by the 1980s the industry had attained a level of technological sophistication that transformed the nature of woods work.

A decline in the number of seasonal workers was the most significant spur to mechanization. Rural depopulation in Ontario and Quebec, the availability of unemployment insurance, and the prospect of steady, well-paying work in less arduous urban industries reduced the number of workers willing to spend their winters in the camps. A diminishing labour supply generated upward pressure on wages and exacerbated the problem of labour turnover, permitting workers to move freely from camp to camp in search of better conditions and piecework opportunities.[113]

Industry had some success in pressuring the federal government to increase the labour supply through immigration, but not enough to alter the situation fundamentally. This left companies with the option of increasing the efficiency and stability of workers by introducing training programs and improving camp facilities. But the real key to attracting a more permanent workforce was to establish logging on a year-round basis, which required mechanization to end the industry's reliance on winter conditions.

By the 1950s, then, mechanization had become a pressing matter for pulp and paper corporations. In 1948, the CPPA's Woodlands Section established committees to promote mechanization, and went further by initiating a research and development project funded by member companies. But it was the workers themselves who introduced the first significant postwar innovation — the chainsaw. Pulpwood cutters purchased these relatively inexpensive machines to increase their earnings, and by the mid-1950s in Ontario, the bucksaw had been rendered obsolete. Newfoundland cutters proved equally willing to adopt the new technology; by 1958 chainsaws cut 87% of the province's pulpwood.[114]

Increased productivity in cutting provided an incentive to mechanize the skidding phase, as horses and teamsters could no longer keep up with the cutters. The initial wheeled skidders produced by equipment manufacturers in the mid-1950s, including the popular Blue Ox, were simply modified four-wheel drive trucks. Although subject to frequent breakdowns and far less manoeuverable than the horse, early models did enjoy some popularity because of the growing shortage of horses and competent teamsters. The Woodlands Section's attempt to develop an articulated frame vehicle capable of bending in the middle, ultimately resulted in the introduction of several production models in the 1960s. By 1965, there were over 3 500 skidders in use in eastern Canada, greatly increasing the productivity. Kimberly-Clark, for example, doubled their man-day productivity by replacing horses with skidders.[115]

Mechanized skidding also had implications for the organization of work, as firms abandoned shortwood logging for tree-length or full-tree systems. This permitted bucking, piling and scaling to take place at roadside landings, a more stable setting. Concentrating these functions, in turn, encouraged the development of sophisticated processing units such as slashers. From this point, firms increasingly relied on trucks to transport wood to the mill. As with power saws, many of the early vehicles were owner-operated. Trucking, in conjunction with the wheeled skidder, eventually freed the industry from its "seasonal straightjacket."[116]

The most dramatic postwar changes in logging technology involved the emergence of multi-purpose tree-processing equipment. In 1965, *Canadian Forest Industries* noted that high wages underlined the "vital necessity of developing logging systems with minimum labour requirements." The Vit Feller-Buncher, Beloit Harvester, Arbomatik Processor and others discussed by Silversides represented various approaches to the problem of developing a mobile harvesting unit capable of operating under a range of conditions. The most impressive is the Koehring Shortwood Harvester, which Radforth terms "an entire production line on wheels." They met with varying degrees of success because, as one engineer puts it, the "forest milieu was not technologically ready."[117]

There is no doubt that the sophisticated machines achieved significant productivity gains. But, as Silversides contended in 1964, no one system could be universally employed because of the range of conditions encountered in the eastern Canadian woods. By 1970, many expressed disappointment with industry's efforts to achieve fully mechanized logging. To some, the power saw and wheeled skidder remained the major innovations. Others, however, continued to call for research to develop a "super harvesting system" capable of cutting, processing and transporting wood at fantastic rates.[118]

How did the new postwar technologies change the nature of woods work? The power saw had little impact, merely substituting a power tool for the bucksaw. Mechanized cutting, did however, have negative consequences for the health and safety of cutters, who suffered hearing damage, loss of feeling in hands and arms due to constant vibration, and severe cuts. But pulpwood cutters remained independent workers, paid on a piecework basis.

The wheeled skidder proved much more disruptive to traditional patterns of work organization. Most important, skidders integrated formerly independent operations into a coordinated labour process. In making year-round skidding of tree lengths or full trees possible, the machines fostered cooperation between cutters and skidders, linking the two procedures into a "specialized assembly line process." As Curran explains, a tree might be cut in the morning, skidded to a roadside landing, bucked, and trucked to the mill by the end of the day.[119]

Moreover, mechanized skidding produced a change in the division of labour. Rather than have fellers buck the trees at the stump, buckers performed this task at the landing. They, or other workers, then piled the wood onto truck pallets. In essence, the skidder set the pace for a number of cutters. Although cutters still organized their own work, they now had to gear their rate of production to that of the skidders, which travelled faster than horses and required no rest. Pressured to keep up with skidders, fellers and buckers had less control over their work, which was a source of some discontent.[120] The introduction of harvesters and processors also had consequences for woods work. Operators sitting in enclosed cabs were no longer exposed to weather extremes, and their working environment, although not comfortable, was less hazardous.

Dexterity in operating sophisticated equipment replaced strength as the prime attribute of mechanized logging. Presenting mechanization in the most favourable light, industry consistently claimed to need more skilled labour. Equipment manufacturers, on the other hand, emphasized ease of operation. According to Radforth, the variable nature of the forest environment prevented management from seizing complete control of the labour process. He detects no uniform process of de-skilling, but a "complex process of job redesign that involved trade-offs in terms of autonomy, technical skill, and status, and a considerable amount of reskilling." Optimum skidder and harvester performance depended on the operator's "skill, perception, and reflexes."[121]

Management achieved its primary objective through mechanization; a reduction in the number of workers required to produce an equivalent amount of pulpwood. In Quebec the number of bushworkers fell from 32 000 to 12 000 between 1952 and 1972; the decline was attributable to the longer operating season and the productivity increases were made possible by technological innovation. Ontario's woods labour force went from 25 000 seasonal jobs to about 7 000 in roughly the same time period.[122] Price Newfoundland cut its woods payroll from 3 590 to 1 647 in the 1962–68 period, thanks in large part to the introduction of the wheeled skidder. Woodsworkers and their unions accepted these technological changes, albeit with some initial reservations. Although conflict over piece-rates and bonuses occurred when companies introduced skidders, harvesters and processors, scholars have discovered surprisingly little resistance to these technologies.[123] Radforth contends that the key to acceptance lay in increased earnings, as companies passed on a portion of the savings generated by mechanization to employees. Moreover, year-round logging provided the opportunity for greater employment security, and the reduction of physical labour enabled loggers to extend their working lives. Unions would have resisted such drastic manpower reductions if they had been triggered by sweeping lay-offs, but high turnover and quit rates made these unnecessary. Like the International Woodworkers of America on the West Coast, eastern Canadian unions put up no obstructions to technological change.[124]

Even as mechanization slashed the workforce, year-round logging provided a basis for unions to solidify their position in the woods of eastern Canada. The LSWU expanded rapidly in Ontario during the 1950s, increasing its membership to about 16 000 in 1957. The Union Catholique des Cultivateurs signed what is reported to be the first agreement for Quebec bushworkers in 1951 with Price Company. A year later, the Confederation of National Trade Unions negotiated another with Consolidated Paper Company. By 1964, the UBCJ represented 65% of Quebec's 30 000 woodsworkers, and four years later almost 80% of the province's forest employees were unionized.[125]

By the mid-1950s both the IWA and UBCJ were anxious to sign up loggers in Newfoundland, where the four provincial unions still held sway under the Woods Labour Board. In 1956, representatives of both internationals appeared at the convention of the Newfoundland Lumbermen's Association (NLA), where a vote on affiliation with the IWA was narrowly rejected. The IWA then began an organizing campaign among Anglo Newfoundland Development Company (AND) workers, winning a 1958 vote 5 197 to 498. The NLA took its members into the UBCJ.[126]

When the AND Company refused to accept a conciliation board's recommendations for higher wages, a shorter work week, and the union shop, the IWA struck the company in January 1959. Lembke and Tattam argue that the union was unprepared for the conflict, which drew Premier Joseph Smallwood's intervention. Smallwood attacked the IWA, founded the Newfoundland Brotherhood of Wood Workers (NBWW), and promised loggers a settlement if they supported his creation. He then pushed bills through the legislature decertifying the IWA locals and giving the government the power to dissolve any union whose officers "had been convicted of such heinous crimes as white slavery, dope-peddling, manslaughter, embezzlement, such notorious crimes as these."[127]

When picket-line violence between police and strikers at Badger led to the death of a police officer, Smallwood used the incident to turn public opinion against the IWA. Two days later the AND Company and NBWW signed an agreement. The IWA never recovered, and the NBWW represented loggers until 1962, when the UBCJ replaced Smallwood's union as their bargaining agent.[128]

Labour shortages, turnover, a longer logging season, and union pressure contributed to improvements in camp conditions after World War II. Operators began to replace log structures with smaller portable buildings constructed of lumber during the war, so that entire camps could be moved from site to site. Another solution was to construct semi-permanent, centrally heated buildings; expanding road networks and truck transportation enabled some companies to establish large, central camps. Men could be bussed longer distances to and from work, increasing the longevity of these settlements, which included recreation halls, maintenance shops, water systems and lighting plants.[129]

The most dramatic contrast with the old shanty came in the form of the company village (Figures 2.9 and 2.10). Seeking to stabilize their crews during the 1950s, some firms built family homes to rent to employees. The Anglo-Canadian Pulp and Paper Mills' village at Forestville, Quebec included dwellings, schools, churches, stores and an infirmary. Marthon Corporation and Longlac Pulp and Paper established similar sites in northern Ontario. Even the enhanced services offered by the company village ran a poor second to life in more established communities, however, and where possible many workers chose to commute from their own homes. The Dryden Paper Company and Kimberly-Clark were among the firms to set up commuter operations for employees during the 1960s.[130]

A second path to improved workplace efficiency involved industry training programs. First tried during World War II, worker training grew more systematic in the decades that followed, as firms offered instruction in cutting techniques and machine operation. By 1950, the CPPA's Woodlands Section had formed a committee on the training of woods labour, and firms such as Price Company and the Quebec North Shore Paper Company offered instruction for pulpwood cutters. In 1965, the Marathon Corporation and Consolidated Paper had schools for skidder operators. Industry took advantage of federal and provincial funding of approved courses. The Bathurst Paper Company, for example, shared the cost of training

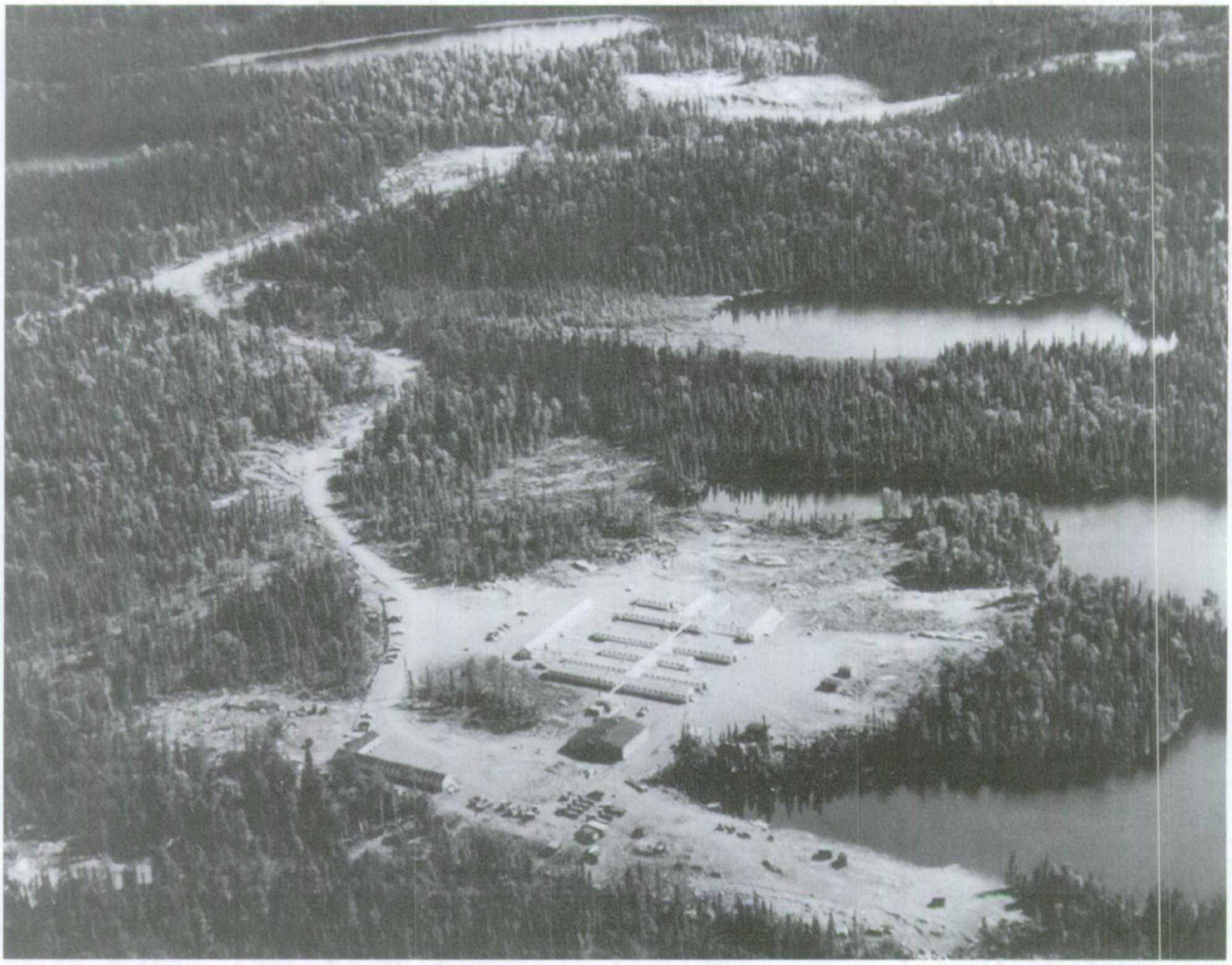

Figure 2.9 *An aerial view of an Abitibi Power and Paper Company woods operation, circa 1950. Photo by Gilbert Milne. (Courtesy Abitibi-Price archives)*

with Quebec's Ministry of Education and the National Employment Service during the 1960s. In 1972, specific programs for truck drivers, mechanics, and loader, skidder, power saw and slasher operators were established in the province, although Quebec lagged behind Ontario in this area. Safety concerns led Ontario to make training of cutters and skidder operators mandatory in 1989.[131]

Just as mechanization altered relations between corporations and workers, it had consequences for industry's relationship with the forest environment. Postwar forestry in Canada saw most provinces adopt long-term tenure systems that awarded large firms exclusive control over huge areas of forestland. Industry favoured such arrangements because of assured access to timber, while governments retained some regulatory power through working-plan approval and inspection. Unfortunately, such policies have failed to provide a sound integration of silviculture with logging practices, a need that became more pressing as mechanized harvesting systems increased the rate of cut and inhibited natural regeneration.

Ontario prepared for the adoption of new policies in 1945, appointing Howard Kennedy to head a royal commission into the province's forest situation. In addition to calling for the introduction of a sustained-yield policy and immediate reforestation after cutting, Kennedy recommended that all licences be revoked for ten years to permit development of a new timber-allocation system. Kennedy's proposal would have seen a number of new companies under joint government-industry management take over logging, each responsible for balancing economic and silvicultural objectives. Government rejected this radical plan, passing a new *Forest Management Act* in 1947, which required companies to submit cutting plans and to practice a minimal level of forest management on leased lands.[132]

Ontario amended its *Crown Timber Act* in the early 1950s, making the licencee responsible for regenerating Crown land, but with few exceptions, industry continued to place the reforestation burden on natural seeding. Unhappy with the results of this legislation, government again took over responsibility for forest renewal in 1962. This measure gave legal

Figure 2.10 *Dinner is served at an Abitibi Power and Paper Company logging camp, circa 1950. Malek photo. (Courtesy Abitibi-Price archives)*

sanction to the separation of logging from silvicultural priorities, placing a greater burden on artificial reforestation. The province reversed its position again in 1979, amending the *Crown Timber Act* to transfer responsibility for sustained-yield management back to industry in the form of Forest Management Agreements. Twenty-two of these 24 tenures had been negotiated by 1984, which provided for government approval of working plans and public funding of reforestation carried out by holders.[133]

The 1970s also witnessed change in New Brunswick's forest administration. Early in the decade, an inquiry into the province's pulp and paper industry raised questions about the rate of cut, and submitted a range of policy recommendations dealing with land-use planning and forest management. At the same time, the negotiation of a federal-provincial agreement committed $46 million in federal funding to foster development of the resource over five years. Then in 1981 a new *Crown Lands and Forests Act* adopted the Ontario model of Forest Management Agreements. The ten corporate holders were responsible for maintaining the productivity of their 25-year tenures under government guidelines and supervision.[134]

Quebec introduced significant reforms in its tenure system during the 1970s. In 1973 the province's Liberal government assumed control over silviculture on Crown timberlands, leaving companies responsible only for harvesting and protection. Pleased to leave forest management to the state, companies conducted their logging operations with regard only for the balance sheet. This policy proved unsuccessful, and in 1986 a new *Forest Act* implemented a system of forest-management permits that awarded timber rights for 25-year periods on the condition that holders carried out silvicultural obligations at their own expense.[135]

Perhaps the most compelling problem foresters confronted during the postwar period concerned the impact of mechanized harvesting systems on silviculture. Having helped open up vast expanses of the boreal forest to timber capital, foresters had little choice but to hope that natural regeneration would follow logging. The effect of mechanized harvesting equipment on forest conditions had not been widely studied, Silversides noted in 1964. "There is no doubt that harvesting forest crops with machines causes more damage to the residual stand and advance growth than was the case with animal power. No machine has yet been produced to equal the horse for its ability to snake logs out of the forest with a minimum of disturbance or damage," he admitted. But Silversides was hopeful that light skidders with articulated steering and high clearance would hold such damage to a minimum.[136]

K.W. Horton of the federal Department of Forestry offered a more pessimistic appraisal the following year, arguing that artificial reforestation was the only adequate method of reforestation for sites cut over by mechanical methods. Foresters were particularly concerned about the deep ruts and the compacting of soil that accompanied skidder logging, leaving some sites with poor conditions for either approach to restocking. They also debated the wisdom of progressive clearcutting in the boreal forest, a practice necessary to justify growing investments in machinery, but one that left little hope for natural regeneration on many sites.[137]

Industry argued that clearcutting produced abundant spruce growth, but studies showed that balsam fir dominated the new forest. More alarming were investigations that revealed low rates of regeneration, findings that prompted calls for government regulations to minimize the extent of clearcuts and to foster strip-cutting techniques. Higher logging costs and blowdown in residual stands have prevented widespread adoption of this harvesting method. Finally, full-tree logging has raised questions about the long-term impact of nutrient removal on forest productivity.[138]

Postscript

Probably no figure had a more intimate connection to the process of mechanization in the eastern Canadian forest industry than Ross Silversides. His career with the industry spanned the postwar period, placing him in the unique position of being able to evaluate the record of technological change. "Broadaxe to Flying Shear" reveals both a faith in the benefits of modern technology and an awareness of some of its social consequences.

Near the end of his career Silversides questioned whether research on mechanized logging had not devoted too much attention to the "individual tree and not enough to the forest as a whole." The latest generation of "wondrous machines" were perhaps too large, too complex and too expensive. The time had arrived, he suggested, to develop a "softer technology" capable of balancing social and ecological considerations.[139] Can the "bottom-line" preoccupation of industrial capitalism accommodate such a departure from the traditional concept of efficiency that has taken reduction of labour cost as its primary objective? Perhaps, but there is little in the historical record to inspire optimism.

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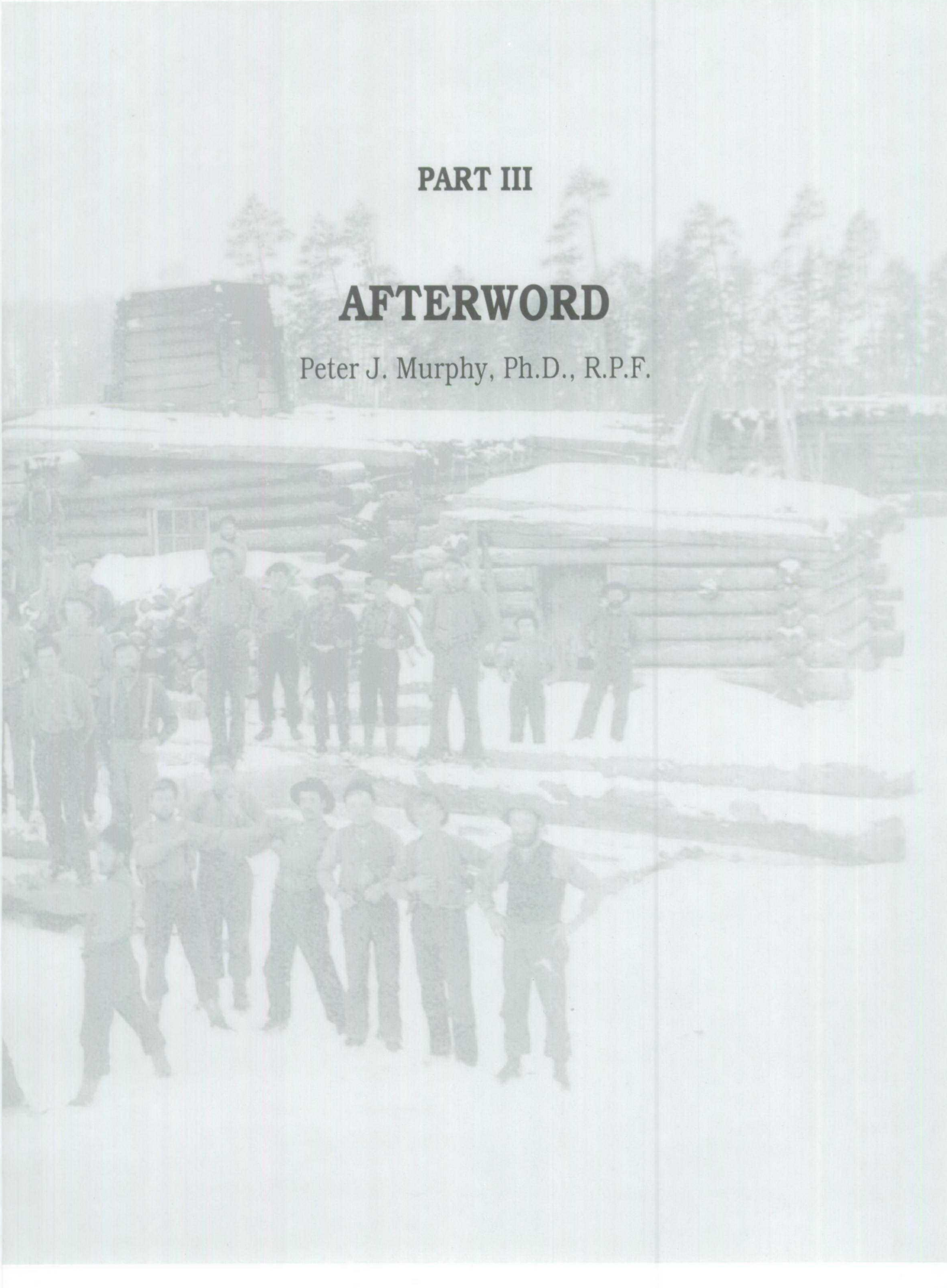
PART III

AFTERWORD

Peter J. Murphy, Ph.D., R.P.F.



"Broadaxe to Flying Shear," and the accompanying essay by Dr. Rajala, effectively conclude their respective narratives by describing developments in the early 1980s. Since more than ten years have passed since Ross Silversides chronicled the history of forest harvesting mechanization in eastern Canada, it seems appropriate to consider briefly some of the salient issues and events of the intervening period. In particular, two themes deserve consideration.

The first theme is a historical one that includes the story of the Canadian Forest Service and the development of forestry practices and policies, which have led to sustained-yield forest management — the balancing of growth with harvest. The second theme extends the story of the impressive and positive policy and technological improvements that have evolved from 1984 to 1997 — ones that are taking us from sustained yield of forest crops to sustainable forest management that takes the entire forest ecosystem into account. The purpose of this Afterword is to address both themes.

Canada is a forest nation, with forests extending over 4.2 million hectares, covering half of the country's land mass. The forests have been, and remain, important to Canadians for their environmental, economic, social and cultural values. The forests are largely under public ownership, managed by the province in which they lie. Provinces set their own forest policies, as described by Rajala. The federal government is now largely responsible for science and technology, regional development and trade, international relations, and forest environmental matters. However, the federal government has also assisted in bringing together the provinces, industry, labour, academics, and public interest groups to discuss common and national interests.

The *British North America Act* of 1867 clearly assigned exclusive responsibility to the provinces for public lands owned by the provinces and "of the Timber and Wood thereon." The intention for the Dominion of Canada at Confederation was that Canada would become a nation from sea to sea. To achieve this meant bringing British Columbia into Confederation, and acquiring Rupert's Land (Royal Charter lands draining into Hudson Bay) from the Hudson's Bay Company. Both were accomplished in 1870. The federal government thus became a major forest land owner in the prairie, west and north, for 60 years. These lands were designated the North West Territories, referred to as Dominion Lands and, from 1873, administered by the Department of the Interior. Until 1899 the forests were controlled by Crown Timber Agents, and were viewed primarily as sources of revenue from timber-harvesting dues. The main national focus at that time was on settlement and development, and during these early years, land clearing for farming and timber had a great impact on the forests.

An early reference to forest conservation was penned by Prime Minister Sir John A. Macdonald in his 1871 letter:

> *The sight of the immense masses of timber passing my windows every morning constantly suggests to my mind the absolute necessity there is for looking into the future of this great trade. We are recklessly destroying the timber of Canada, and there is scarcely a possibility of replacing it. The quantity of timber reaching Quebec is annually decreasing, and the fires in the woods are periodically destroying millions of money (Public Archives of Canada, Sir John A. Macdonald Papers, MG26A, vol. 518, pt. 4, L.B. 15, p 963; Macdonald to John Sandfield Macdonald, 23 June 1871).*

It has been argued that governments of the day were more interested in collecting revenues than in spending money on forest protection and management, but several events soon caused at least a partial change in attitudes.

Concerns about the destruction of forests by fire were widespread across Canada. In the west, on the Dominion Lands, there were two additional concerns — trees had to be provided to settlers on the prairies for windbreaks and to enhance wood supplies; and the mountain and foothills watersheds had to be protected from fire and uncontrolled logging to preserve water flow for irrigation. These led to the formation, in 1899, of what became the Canadian Forest Service (CFS). Until 1930, it grew to be the largest and most influential forest service in Canada. The year 1899 also marked the beginning of serious efforts by the federal and provincial governments to protect and manage their forests.

One of the major turning points took place in 1906. With the support of the CFS, the Canadian Forestry Association (CFA) organized the first National Forest Congress, held in Ottawa and presided over by Prime Minister Wilfrid Laurier. This was also the first time the public was involved in national forestry discussions, and influential voices from newly established conservation movements were heard. The outcome was positive. The congress was followed by the establishment of provincial forest services, improved fire control, recognition of the need for planning for forest management and logging, and the development of university forestry programs — led by the University of Toronto in 1907 and the University of New Brunswick in 1908. The congress also established a federal role in forestry research, and leadership in cooperation with national associations, the provinces, the public and the forestry sector.

On Dominion Lands, a number of surveys led to designated forest reserves and fire ranging districts. As well, the CFS established a tree nursery with a strong program to provide trees to settlers for windbreaks and shelterbelts and as future sources of fuel and building materials. Programs of the CFS were typical of those being developed concurrently by the provinces. Once the forested areas were defined, an administrative structure was put into place. Foresters and other technical staff were hired, headquarters were established, and facilities such as roads and trails, patrol cabins, lookouts and phone lines constructed. Patrols and forest-fire fighting capabilities were put into place. Prototype programs for forest regeneration and silviculture followed. In 1913, research into wood products was started in cooperation with McGill University and the forest industry, and in 1917 research began on a new forest experimental area at Petawawa, near Chalk River. During the 1920s, research programs expanded to support the field operations of the CFS in forest-fire behaviour, growth and yield of forests, reforestation and silviculture, and the use of aerial photography for mapping and planning forest management. The results of these studies were of great value to all forest managers, and the CFS thereby created a new and vital role for itself.

In 1930, the federal government transferred control of its lands and natural resources, including its forests, to the western provinces in which they lay. This ended the federal government's role as a major forest land manager, but left it responsible for science and technology and for continuing to foster collaboration in the national interest. Its research activities grew to meet the national needs in forest management. In the meantime, the Depression years of the 1930s saw sharply reduced expenditures on forestry by all agencies, and during the wartime and postwar years of the 1940s, the forests were exploited heavily without regard to sustained-yield management. It became clear that the forests needed concerted attention.

Another pivotal role for the CFS arose in 1949 with passage of the *Canada Forestry Act*. This Act redefined the role of the CFS for the first time since resources had been transferred to the western provinces. In addition to confirming the CFS's role in forest research and areas of federal responsibility, it enabled the CFS to make cost-sharing agreements with provincial governments and others for forestry-related projects. By this time it was evident that forest management required a proper forest inventory so that estimates of volume, species and growth, and maps showing the extent and location of forest stands could be made. There was no Canada-wide inventory, and provincial inventories had either recently begun or were being considered. The 1949 Act provided the incentive to conduct the first comprehensive forest inventory; all provinces took advantage of the opportunity, and results became available by the mid-1950s.

The forest inventory data provided a rational basis for extensive forest-management planning for the first time. It was timely in guiding the great expansion of the forest industry during the decades ahead. The data also showed the inadequacies in forest regeneration after fires and much of the logging that took place during the previous decades. The so-called regeneration backlog was a concern to foresters, but it was difficult to get governments to share those concerns in their budgets. Two developments helped resolve this problem — innovative agreements enlisted industry support for ongoing forest renewal, and sectoral support for shared-cost agreements tackled the backlog.

For example, a new agreement for a forest-management area in western Alberta was negotiated in 1954 to supply timber to Alberta's first pulp mill. The area was selected using data from the new forest inventory. For the first time in Canada, planning for forestry operations could be done for an entire area, and the mill could be located central to the wood supply. Among the innovative features of the agreement were a commitment by the company to maintain its own forest inventory, do its own forest management planning, build its own roads and bridges, and ensure adequate forest regeneration at its own cost — in addition to paying dues, land rentals and protection charges. Plans were subject to approval by the provincial government foresters. The success of this approach quickly became evident, since the company could plan comprehensively for management, harvesting and renewal as a system. Variations of this shared-responsibility approach evolved in most provinces, and the regeneration of logged areas now largely follows as a matter of course.

To tackle the backlog required a national effort. The 60 very tumultuous years from 1906 to 1966 passed without another major national forestry convention. After early progress in the 1910s, energies were diverted by World War I, then the 'dirty 30s', then World War II. Attention to forestry practices had to wait. During the postwar period of growth, concerns again emerged about what was perceived to be happening to the forests in Canada, whether or not we could compete economically, and what were the best ways to build our economic capabilities. This led to a 1966 Forestry Congress, held in Montebello, Quebec, organized by the federal Department of Forestry in its role as facilitator. It was well-intentioned, but there was little public participation and no follow-through. As a result, virtually nothing changed.

The problem of inadequate forest renewal persisted. Timber-cutting policies typically ignored forest regeneration and regeneration needs. The pervading view was that forests were a provincial responsibility, and provincial governments largely relied on natural regeneration processes. Supplemental programs for seeding or planting were a low priority in government budgeting processes. The problem was highlighted at the 1977 Forest Regeneration Conference held in Quebec City. It was organized by the CFA, in cooperation with the CFS, provinces, industry, labour and the forestry profession. This was probably the most significant forest conference since 1906. It marked the beginning of a series of congresses and national forums on forestry concerns that eventually led to federal-provincial cost-sharing agreements for forest-renewal programs to reduce the backlog and strengthen other forestry programs. During this time, most timber-harvesting policies were changed to require industry commitment to adequate regeneration after harvesting and to be more actively involved in forest-management planning.

In 1985, on the national scene, the federal and provincial ministers responsible for forestry formed the Canadian Council of Forest Ministers (CCFM). One of their first projects was to develop a Forest Sector Strategy for Canada. They attempted to identify the major issues through multi-interest discussions, which culminated in their 1987 National Forest Sector Strategy. This document was a well-defined strategy that recommended 34 detailed policy directions. Its significance lay in the collaborative approach to problem identification and resolution. Its weaknesses were the too-narrow base of consultation, the call for action through recommendations, and the lack of follow-up mechanisms.

These deficiencies were addressed in the National Forest Strategy that began in 1990 and was completed in March 1992. Also sponsored by CCFM, it featured a Secretariat to provide continuity, and a national coalition of interest groups serving as a board of directors. One of the leading concepts that had emerged in the meantime was sustainable development, introduced by the Brundtland Report (Brundtland, G. 1987. *Our Common Future*. New York: Oxford University Press). It had become clear that sustainable forest management had to include consideration of the full-forest ecosystem with its inherent ecological, economic, social and cultural values, and that public participation in developing a strategy was essential.

The strategy was developed through widespread discussions — starting with a discussion paper, broadly representative public consultations at five regional forums, two regional forums for Aboriginal people, questionnaire workbooks and ongoing consultations to review the strategy as it was written. It included nine Strategic Directions, and 94 commitments, not recommendations, some of which were applicable to all participants. The Canada Forest Accord, based on these commitments, was endorsed by participants at a national congress in March 1992. The CCFM assumed responsibility for implementing and monitoring the commitments, including third-party independent reviews at mid-term and at the end of the term. The mid-term review indicated that significant progress was taking place. The goal and headings of the Strategic Directions emphasize the comprehensive nature of the commitments.

Sustainable Forests: A Canadian Commitment

Goal

Our goal is to maintain and enhance the long-term health of our forest ecosystems, for the benefit of all living things both nationally and globally, while providing environmental, economic, social and cultural opportunities for the benefit of present and future generations.

Strategic Directions

1. *Forest Stewardship: The Forest Environment*
   To conserve the diversity of our forests, and maintain healthy ecosystems.
2. *Forest Stewardship: Forest Management Practices*
   To plan for a range of forest values and uses, practice sustainable forest management, apply best practices, and ensure accountability.
3. *Public Participation: Expanding the Dialogue*
   To increase opportunities for public involvement, provide better information for the public, and expand public education.
4. *Economic Opportunities: A Changing Framework*
   To improve our competitive position, improve our resource supply, contribute more to communities and the economy, meet environmental standards, and encourage diversification and value-added.
5. *Forest Research: A Team Approach*
   To cooperatively generate knowledge for sustainable development, provide technology to improve industry competitiveness, expand input from clients and stakeholders, and broaden networks to encourage multidisciplinary research.
6. *The Workforce: The Demands are Growing*
   To encourage development of a more highly skilled and adaptable workforce, and training for new skills needed.
7. *Aboriginal People: A Unique Perspective*
   To increase involvement of Aboriginal people, and expand economic, cultural and spiritual benefits.
8. *Private Forests: A Growing Opportunity*
   To increase benefits from private forests, and expand the stewardship ethic.
9. *Our Forests: The Global View*
   To enhance our contribution to the global environment, and encourage wise use and conservation world-wide.

Following the United Nations Conference on Environment and Development (UNCED) Rio Summit in June 1992, the Canadian delegation remained active, attempting to encourage a global approach to sustainable forest management. Through the so-called Montreal Process, starting in 1993, the CCFM established a steering committee to develop Canadian criteria and indicators. This consultation group consisted of about 30 representatives from governments, academia, industry, Aboriginal groups, the forestry profession, conservation associations and other interest groups. The resulting set of criteria and indicators, Defining Sustainable Forest Management — A Canadian Approach to Criteria and Indicators, was approved as a national policy by the CCFM in October 1995. The criteria were described in six categories:

1. *Conservation of biological diversity.*
2. *Maintenance and enhancement of forest ecosystem condition and productivity.*
3. *Conservation of soil and water resources.*
4. *Forest ecosystem contributions to global ecological cycles.*
5. *Multiple benefits to society.*
6. *Accepting society's responsibility for sustainable development.*

Working projects to develop and demonstrate principles and practices of sustainable forest management were set up across Canada by the CFS on a cooperative basis through a network of model forests. Canada's Model Forest program was initiated in 1991 to accelerate adoption of new approaches to sustainable-forest management based on shared decision making. The ten model forests were strategically selected to represent the ecological diversity of Canada's major forest regions. Each model forest is managed by a partnership of organizations and individuals with an interest in the forest; each partnership decides on the particular objectives for its model.

In 1994, the Canadian forest-products industry asked the Canadian Standards Association (CSA) to develop a sustainable forest management (SFM) standard that could be applied in Canada. Under such a standard, companies demonstrating their commitment to sustainable forest management by becoming registered could claim that wood products from the Defined Forest Area (DFA) came from a sustainably managed forest. The CSA SFM System is consistent with the ISO 14001 and ISO 14001 Standards of the Environmental Management System developed by the International Standards Association. This process includes commitment, public participation, preparation, planning, measuring and assessing performance, and reviewing and improving the SFM System. Registration results from a successful independent third-party audit confirming that all aspects of the SFM standards are met.

The SFM standards were developed by a multi-interest Technical Committee, made up of 32 voting members. To try to effect an equitable representation, members were drawn from four defined interest groups — producers, environmental and general interest, professionals-academics-practitioners, and government-regulatory — on an approximately equally basis. As well, 15 to 20 non-voting observers participated.

The Standard for Sustainable Forest Management was unanimously approved by Technical Committee members in July 1996, and the CSA issued the Standard in the fall of 1996. In the CSA philosophy of "continual improvement," standards must be reviewed at least every five years. The Standard is therefore intended to be a "living" document.

Forestry practices have improved immensely as a result of these and other policy developments. The national commitment through the Canada Forest Accord to work towards sustainable-forest management is resulting in even more profound changes. The last decade has been both exciting and heartening in forestry.

In a similar vein, developments in the mechanization of forest harvesting have also set the stage for profound improvements. The trend toward increasing sophistication that Dr. Silversides noted has been evident in changes since 1984. New harvesting equipment is much more environmentally friendly. This is especially reflected in the "cut-to-length" system that is both softer on the land and lends itself well to partial cutting scenarios such as thinning and individual crop-tree removal. Equipment is smaller and more manoeuverable, wider tracks and low-pressure tires minimize soil disturbance, and longer-reaching arms reduce the number of extraction trails and protect advanced regeneration. About 30% of harvesting is now done with this system, the use of which is expected to increase. These improvements followed logically, building on the early lessons of mechanization of which Dr. Silversides was a part. Further, principles of mechanization are now being applied to silviculture — the planting, growing and tending of trees — to enhance its feasibility. These changes are reflected in the present FERIC Mission Statement: "*to provide its members with knowledge and technology to conduct cost-competitive, quality operations that respect the forest environment.*" Ross Silversides would have approved.

GLOSSARY

This glossary was prepared from standard sources found in the Library of the Faculty of Forestry, University of Toronto. Words in *italics* or their variants are defined elsewhere in the Glossary.

Alligator — a boat used to handle floating logs. It was moved overland from one body of water to another by its own power, usually applied with a winch drum and cable.

Articulated knuckleboom — a hinged boom that permits arm-like movements during use.

Articulated skidder — a tree *skidder* with the main frame separated into forward and rear parts, united by a joint.

Board foot — the amount of timber in a piece 1 foot × 1 foot and 1 inch thick, used as a unit of lumber measurement.

Bogie — a vehicle, generally a trailer, for carrying logs. It has a pair of wheels and a tongue or pole, the load is supported above the axle and generally trails on the ground behind.

Buck — to cut felled trees into logs.

Bundling — binding together bunches of logs, pulpwood or small-dimension stock with steel strapping, wire or cable for ease of handling and transport.

Cable yarding — transporting timber from the stump to a yard, or *landing*, along a skyline cable, for which the motive power is supplied by a yarder (a yarding donkey).

Choker — a noose of steel cable or a loop of chain that is tightened around a log and ends in a hook (the choker hook) or other fastening device for attaching to a butt hook, to enable the log(s) to be gripped firmly for *skidding*.

Clear cut — strictly, the removal of the entire standing crop of trees.

Cord — a unit of gross volume measurement for stacked wood. A standard cord contains 128 stacked cubic feet and generally implies a stack with a vertical cross section 4 feet × 4 feet and a length of 8 feet with a small percent extra in height to allow for settlement.

Cunit — a unit of stacked wood containing 100 cubic feet of wood, not including bark or air space. (Note: in 1924, "Pulp and Paper Magazine of Canada" awarded a prize for the best word to describe this standard measure of pulpwood to C.W. Halligan of the Newsprint Service Bureau — Anon. 1974a).

Delimb — cutting a standing or felled stem clear of its branches, more or less flush with its surface, without leaving "stubs."

Dog — a short, heavy piece of steel, bent and pointed at one end with an eye or ring at the other (to take a rope, cable or chain), used to hold or hoist logs.

Feller-buncher — a wheeled or tracked machine capable of felling trees and piling them in bunches.

Feet board measure (fbm) — a method of timber measurement in which the unit is the *board foot.*

Forwarding — carrying wood from stump to *landing* rather than dragging or *skidding* it. Machines specially adapted for this purpose are called forwarders or forwarding machines.

Grapple — a hinged, hand-like mechanism used to grip pulpwood or logs for loading or unloading.

Landing — a cleared area where wood is accumulated for later transportation.

Machine availability — that portion of *scheduled machine hours* when a machine is working, or could be working, if it were not waiting for parts or mechanics.

Outrigger — a projecting frame that provides support to a stationary wheeled or tracked vehicle, such as a machine for loading logs.

Overtime — the hours of productive work and/or service and repair carried on outside usual shift hours.

Peeled cord — a cord of wood from which the bark has been removed.

Pike pole — a pole 3 to 6 metres (10 to 20 feet) long, ending in a steel point (the pike) and a hook or spur (called a gaff), which is used in handling floating timber.

Productive machine hours — that part of *total machine hours* during which a machine is performing its primary function (e.g. for a tree skidder, it is the time during which it is used to skid wood).

Scale — to measure wood to determine its cubic contents. The scaler may estimate how many *board feet* a log will "saw out." Pulpwood can be measured two ways: in *cords* of 128 cubic feet of piled material; or in cubic feet, in which each piece is measured separately.

Scheduled machine hours — a nominal statement of intent for regular machine activity (i.e., 8-hour shift, 9-hour shift). It usually corresponds to the operator's paid on-job time.

Skidding — a loose term for hauling loads of wood by dragging them from stump to roadside, deck, skidway or other landing. The timber may slide more or less wholly along the ground (ground skidding, dragging, snaking, snigging) or with its forward end supported on a tractor (a tree skidder), on a cable (a high-lead skidding) or even entirely off the ground by sliding along a cable during its main transit (aerial skidding).

Skid road — a road or trail leading from stump to the skidway or *landing*.

Sloop — a sled for *skidding* logs from the stump area to roadside. It was often the front sleigh of a set of hauling sleighs, with a bunk attached.

Sluice — a long, sloping trough built into a dam, through which water and timber can flow.

Steam donkey — a portable power unit (originally a steam or donkey engine) mounted on skids and equipped with winch drum(s) and cable(s).

Strip road — a road used to *skid* and *forward* the wood from a cutting strip that is wide enough to suit the gauge of the traffic using it and is left rough and more or less in its natural condition.

Sulky — a two-wheeled vehicle, usually with a seat for the driver.

Swamper — a person who opens a trail or road by felling trees in preparation for *skidding* or hauling.

Total machine hours — the sum of *scheduled machine hours* and *overtime*. It is the total time associated with a machine for a given shift. Total machine hours is the total of *productive machine hours*, machine downtime due to active repair or service, and machine downtime due to other delays.

Tote road — a road or track used for hauling supplies to a logging camp.

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The mission of the Forest Engineering Research Institute of Canada is to provide its members with knowledge and technology to conduct cost-competitive, quality operations that respect the forest environment.

La mission de l'Institut canadien de recherches en génie forestier est de fournir à ses membres les connaissances et la technologie leur permettant de réaliser des opérations de qualité à coût compétitif, tout en respectant l'environnement forestier.

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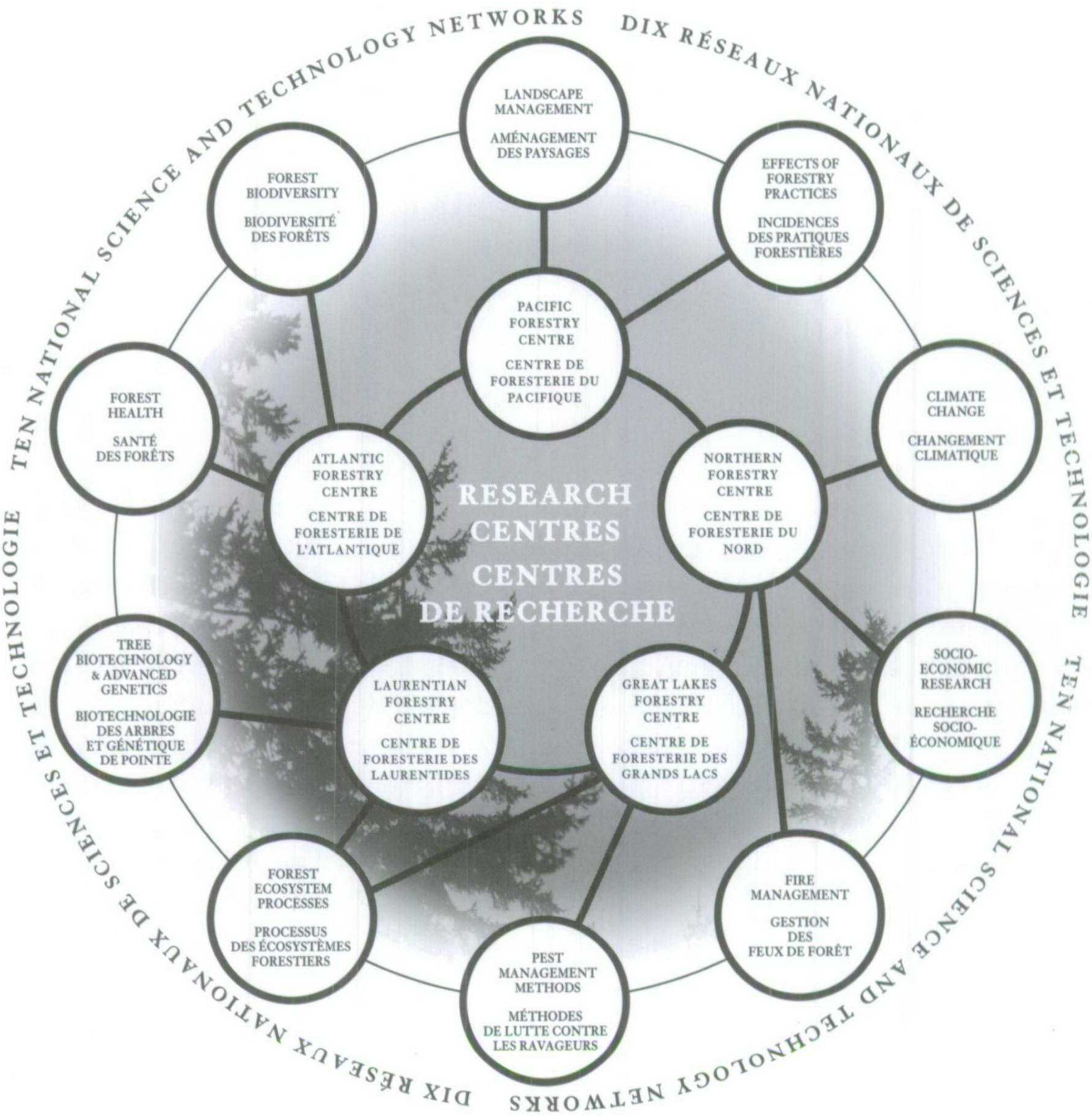

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Canadian Woodlands Forum, CPPA And Its Sustaining Members Group

Canada's forests have been a cornerstone of our country's development ever since the first settlers landed years ago.

For decades now, the Canadian forest industry has been continually changing to meet new challenges, through the development of improved technologies and practices, and of world-class products.

This book is a testimony to this change. CPPA's Canadian Woodlands Forum and especially its Sustaining Members Group are proud to have contributed to its development.

Our dedication to continued excellence on woodlands operations in Canada will help ensure that change, which has helped mold our past, will also be instrumental in shaping our future.

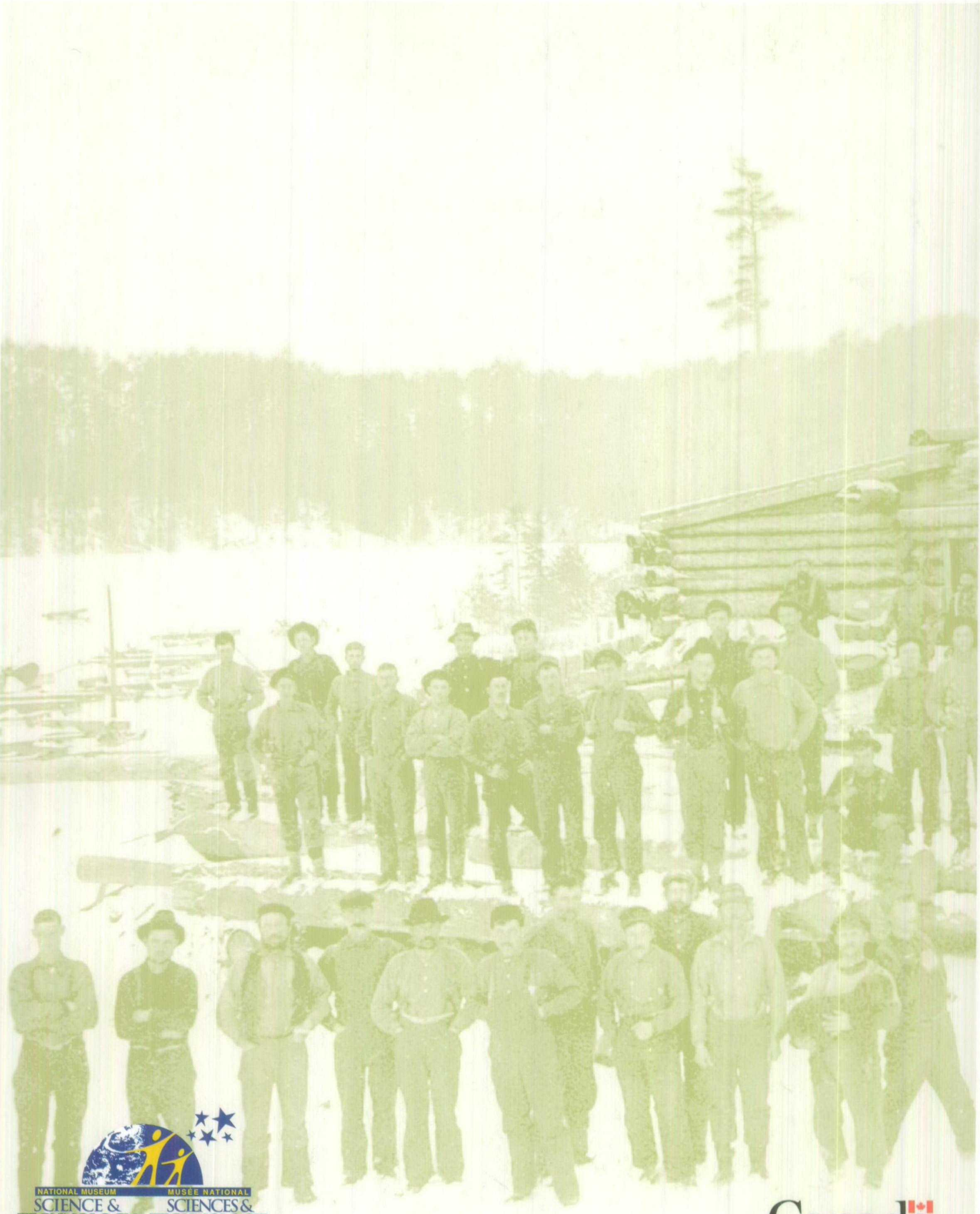
Depuis que les pionniers s'y sont installés, il y a des dizaines et des dizaines d'années, les forêts canadiennes ont été la pierre angulaire du développement de notre pays.

Au cours de ces décennies, l'industrie forestière canadienne a été en constante évolution afin de s'adapter aux nouveaux défis, par la mise en valeur de technologies et de pratiques de plus en plus perfectionnées et de produits d'envergure mondiale.

Ce livre témoigne de cette évolution. Le Forum canadien des opérations forestières de l'ACPP et surtout son groupe des membres auxiliaires sont fiers d'avoir contribué à sa production.

Notre engagement à intégrer l'excellence dans toutes nos activités forestières au Canada fera en sorte que ces changements, qui ont façonné notre passé, deviennent pour nous un gage d'avenir.

Forum canadien des opérations forestières, ACPP et son groupe des membres auxiliaires



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