

SURVEY OF FOREST TECHNOLOGY RESEARCH
IN FINLAND

THEODOR WEGELIUS

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Abbreviations

AFF Acta Forestalia Fennica

MTJ Publications of Institute of Forest Research

PTJ Publications of Association of Forest Technology

SPP Finnish Paper and Timber

Survey of Forest Technology Research in Finland.

The fact has often been pointed out that the forestry sciences have had a relatively modest part in the manifold and continuously growing series of sciences. But at the same time it has to be admitted that wood is one of the natural products that people have needed most in their economy and its use has not decreased with the passing of time. On the contrary, it has increased and diversified. In this line, it can be easily observed that the use of forests, or forest technology, is the oldest and most central of the sciences of forestry. As long as there was an abundance of forests, the wood needed was obtained easily therefrom on the basis of passing convenience by taking the most beautiful and suitable trees. Only after the forests decreased and the securing of continuous tree crop was endangered, forest management and the regulations by the state and society appeared on the scene.

In the beginning and still during the last century forest technology as an individual field of science was directed entirely toward the anatomical properties of wood and their uses and toward the chemical composition of wood. It was not before the end of the century that attention was given to the actual forest work, mainly in the cutting, logging, and transportation of the trees. The invention of the cooking of wood pulp and cellulose opened at that time broad fields of work within the processing and use of wood.

The changed social conditions, higher wages, and lack of labor during this century have placed the psychological and political aspects in first place to an increasing extent and the science of work and administration has gained an important position among the numerous auxiliary sciences in forest technology.

The previously mentioned technical developments have led to a state where forest technology can no longer be considered a unified branch of science as was the case earlier when it included only the wood and its properties. On the contrary, forest technology has to be considered now a very complicated and difficult-to-master science complex which includes quite varied auxiliary sciences. According to the traditional concept, forest technology includes the knowledge of forest products and their properties, of logging, processing, and use, which knowledge is obtained through experience and scientific experimentation and is arranged systematically. It is clear that the understanding of such a large field in itself requires a thorough knowledge of biological subjects-botany, chemistry,

and physics — and in addition a very far-reaching technical training. If the broad importance of the science of work and administration is further taken into account, it might be easily understood that there exist no possibilities to consider forest technology constantly as a separate and uniform branch of science. The development has no alternative but to advance along lines that objects of research entirely independent of each other, such as those of the natural sciences, technology, psychology, and of work and administration, will be separated into independent fields of science. At the same time it must be taken into account that organizational forest technology is linked to other classical forms of science, primarily to silviculture and forest mensuration. The silvicultural treatments often have a decisive effect not only on the quality characteristics of wood but also on the technics of logging and transportation, and the measures of the tree and the stem form determine its suitability for different uses. In the measuring of wood it is almost impossible to draw the exact border between forest mensuration and forest technology since even such essential problems as cross-cutting of sawtimber trees and the stack density of piled wood are common to both.

Because of the multiplicity of the sciences in forest technology, the actual research work has been divided gradually in many countries so that it is carried out in different institutions. The classical objects of research, such as the study of anatomical structure and composition of wood, and basic biological research have perhaps best remained within the duties of forestry colleges, while on the other hand the interest of rapidly developing industry in increasing and improving processing methods has created large research centers with the object of expanding and developing the technics and products of mechanical processing of wood, wood pulp industry, and chemical wood industry. The rapidly continuing rationalization and mechanization of forest work and transport simultaneously with the growing importance of the science of work and administration have likewise come into focus and have required the founding of separate scientific organizations and institutions.

In forest-rich Finland the use of forests has long roots and our people have consumed wood for thousands of years. The consumption as fuel is perhaps the oldest form of chemical use, but the making of fertilizer by burning the woodland for cultivation, the making of charcoal for the production of metals, and the making of tar for medicine, wood preserving, joint sealing, and for lubrication are also age old. Our sawmill industry originated as early as the 1500's when international trade extended to the coasts of Finland, and when wood and related products are said to have had first place among the articles that Finland had to offer abroad. Thus it is said that the coastal cities of the Baltic Sea received boards, wooden dishes, and tar from Finland. To satisfy both this beginning export and the growing domestic need, the building of sawmills using water power was started for sawing boards. In this way the sawmill industry originated.

Knowledge about the making and exporting of tar extends over a period of more than 300 years. Around the 1650's wood tar was exported from Sweden-Finland in the amount of approximately 10 000 tons annually and the major portion is known to have been made in Finland although the greatest part was marketed through Stockholm. The share of tar of the value of our total export was at those times approximately 50 %. Savo and Carelia were, in addition to Ostrobothnia, the main tar-making centers. Characteristic of the tar market was state control and the export was for a long time the monopolized right of tar companies. At the turn of the 17th Century it was seen that the tar making had begun to lay waste our forest lands. The interest in forest conservation policy grew so strong that after the depression caused by the 1713—21 Period of Great Hate, forest statutes of 1734 prohibited the barking of living trees and the making of tar from them. The business and industrial policy and wars of Continental Europe affected the demand and market for tar during the mentioned century when even the battleships were made of wood. The tar was needed principally in the construction of wooden ships and in preserving hemp ropes. Around the turn of the 18th Century the tar tradesmen of the coastal cities of Ostrobothnia were growing rich. In the 1810's and 1820's the annual export of tar was 15—18 000 tons and in 1822 the portion of tar was 30 % of the total export of the country. From the 1840's to the 1860's the making of tar and pitch was still larger and in 1863 reached the peak of 30 000 tons.

Although the export of sawmill products had old traditions, it remained within very modest limits for a long time. It was caused by the fear of destroying the forests which prevailed in the 1600's and 1700's. Special permits, which were difficult to obtain, were needed in order to found sawmills. It is true that the forest statutes of 1734 allowed unlimited sawing in areas where there was an abundance of forests, but where the extent of saw-timber forest was estimated to be small, a detailed study had to be carried out before the sawing of timber was allowed. The sawmills founded without a permit and likewise the ones for which the estimation of sawlogs was not adequate had to be destroyed. The later statutes followed mainly the same lines. It is difficult to obtain exact figures on the export of sawn wood because the majority of Finland's export went through Stockholm — directly abroad. For example, Finland's export in 1640 was reported only as about ten standards of board, however, not counting the fairly large amounts of wood which were taken to Estonia in the boats of island dwellers. During the Period of Great Hate the wood market of Finland was stopped but recovered again after peace was made. In 1739 Finland exported approximately 6 000 standards of board, but the export of board at that time began to again growing importance in comparison to the export of tar. This is partly due to the fact that the making of boards by sawing became more common, even though it is said that in the 1760's boards were made also by ax in Finland. In the mid-1700's Finland had already approximately a hundred water-powered

sawmills, most of them in the coastal region of Southern Finland, and a few wind-driven saw mills. Generally, however, the wood market of Finland remained rather small in the 1700's and no notable development took place. The strongest development in the sawmill industry had occurred in the province of Viipuri. Here the amount of sawing was not strictly limited but the saw owners had the right to saw according to conditions. Under these favorable conditions the sawmill industry of the province of Viipuri had the opportunity to develop so that it could compete with Sweden-Finland in the export of lumber during some years. For example, in 1788 the export of the sawmill industry of Sweden-Finland was approximately 18 000 stds. and that of the province of Viipuri over 17 000 stds. When to the last amount is added the export of Hamina, which at that time was approximately 4 000 stds. a year, it is clear that South-eastern Finland at that time was able to excel all Sweden-Finland in the export of boards.

It is obvious that at these times when there existed no scientific research in any other field either, nothing noteworthy was published concerning forestry. It was not before the Period of Prosperity, which followed the Period of Great Hate and lasted until the War of Finland, that attention was drawn to questions of forest economy. The wood-using industries — the iron industry, tar-making industry, and the production of lumber which was developing into an export industry — were fighting for their wood-securing rights which were restricted by many regulations, especially since the fear of destroying forests was a continuous threat. Since at the same time in the Turku Academy capable representatives of natural and economic sciences, such as Kalm, Gadd, Mennander, and Hellen, who purposefully directed the research to the practical fields, there appeared as the work of the students of the Academy many Master's theses dealing with the important current questions of forest economy. Very interesting is, for example, the investigation by Lithander, »Oförgripelige tanckar om nödwändigheten af skogarnas bättre wård och ans i Finland,» on which attention is given to the possibilities of America's competing in the market of wood. In it an interesting conclusion from the standpoint of forest technology was reached that American wood, especially oak, pine, and spruce, cannot compete with our species because the resistance to rotting and harmful insects is weaker. Even our tar is better than American tar, which spoils the ships almost like spirit of nitre. The prerequisites for obtaining good wood, according to the author, are here increased by the possibilities of transporting the wood conveniently in winter and floating it in the spring along streams and rivers. Studies were also made to find use for those tree species which at that time had no marketing possibilities. Of these can be mentioned the investigations into the numerous forms of use of the wood of aspen and birch. Aspen can be easily lathed and carved, and because of its white color it is used as floor boards, for example, in England. Aspen lasts longest in structures entirely immersed in water, as in dams and base of mills. Because of its lightness it is also suitable for making boats and

many kinds of objects can be carved from it. Aspen to be used in outdoor structures, however, has to be cut in the spring during the rise of sap and must be left lying on the ground until the bark begins to peel by itself, because it will then become light and much harder than any other wood. In addition, the possibility for the use of rotted aspen as tinder, the good properties of the ashes of aspen in the glass industry, and many uses for the bark of aspen are discussed. In another study properties of birch are explained. The author has noted the occurrence of curly grain and the properties of curly wood. He also explains extensively the use of birch bark in tanning and dyeing leather, as a filler for flour during times of famine, and as the basic ingredient in making lampblack and tar. And in addition, many directions are given for making wine and beer from the sap of birch. Rather interesting is C. G. Widqvist's study, »Menlöse tankar om bräd-sågning,» of 1772 which is the first thesis published in Finland concerning the wood processing industry. The author recommends the use of water-powered sawmills in sawing for export but suggests hand sawing for use when domestic needs are in question. The investigation contains accounts of the technical execution of sawing and is interesting in the respect that it also includes cost estimates and norms of how much work can be done in a day. Sjöstedt (1792) examines favorable felling time from the standpoint of quality and also gives many directions for the ways in which new forms of forest use should be attempted, such as collecting pitch, making tar and potash. Jewelius' study shows interest in tar manufacturing. Finally there should be mentioned the investigation by Adam Widqvist in which detailed directions are given about the measurements of rafters, and there appear also many working records in forest work.

All these studies bear interest in that in connection with other questions of forest economy they also touch upon questions of forest technology. From them appear the methods of preparation and use at the time, ideas about cutting methods and the quality of the wood, and the possibilities for the use of different kinds of wood and wood products. It can also be recognized that the technical questions stayed strictly on silvicultural bases and in them the methods are always emphasized by which the destruction of forests can be prevented, which fear clearly appears in every one of his studies. In this way it was attempted, of course, to slow the possibly excessive and wasteful use of forests by the sawmill industry which strove to expand alongside technical developments.

The interest in economic research which was born in Turku Academy lessened toward the end of the functioning of the Academy until the middle of the last century when, in connection with the renewing of forest law and the establishing of the administration of State forests and planning of a higher level of teaching in forestry, attention was again given also to research and experiments in forest economics. There does not exist, however, much noteworthy research in forest technology from that period. It is true that the then director of forest managers, C. W. Gylden, in 1853 prepared a handbook for forest managers which was the

first of the field appearing in Finland. It contains brief directions for making the most important wood products, and also the most important forest working tools are explained.

In 1861 Aug. E. Soldan published a study, *On Tar Making and Its Development*. This book of 96 pages, appearing through the action of the government, pictures excellently tar making through the years. The portion of tar at that time was approximately 12—16 % of the export. In the war year of 1855 it once more exceeded 30 %. The export of sawn wood had gone up to 60 000 stds. at the time and had surpassed the chemical forest industry. Soldan had observed on his extensive trips around the country that tar making had really destroyed much forest. By calculations he could show that the daily wage of a tar maker was relatively low and the economical gain from forests by tar making was small, even though he realized the importance of the use of small pines from the standpoint of silviculture. Soldan suggested that the practice of using barked trees could gradually be ended and resinous pine stumps would be selected as raw material for tar, which practice at that time was common only in Lapland.

When the forestry school of Evo began its work in the early 1860's, there opened a place where the forestry sciences had slight possibilities for development. The small teaching force and modest departments, however, prevented the growth of scientific activities. The distinguished director of the school, A. G. Blomqvist, nevertheless published under these unfavorable conditions scientifically valuable literature, but it primarily dealt with biological problems and only in his monographs of our pine and spruce he has casually considered the technical properties of these woods. The versatile M. A., Y. E. Raivio dealt, however, in his many varied small publications, for example, with transportation problems and, furthermore, from this period can be mentioned P. W. Hannikainen's and H. R. Sandberg's accounts of travels in connection with which there has also been collected information belonging in the field of logging and transportation technics of wood.

At this time foreign literature was used almost entirely in the higher teaching of forestry and it can be generally noticed that all the forest technology publishing which took place at the time appeared in the publications of the Finnish Forest Union. As the most important newspaper articles there should be mentioned the writings by Lindman on the quality requirements of saw-timber trees, the writings concerning floating by Nummelin, Riddelin, Snellman, and Appelberg, and the tar studies by Sandberg and Blomqvist.

It is certainly a shame that the interesting lectures on technology by A. G. Blomqvist have not remained for later generations. His series of lectures dealt not only with the technical properties of different woods but also their chemical composition and fuel value. In addition, the lecture series at that time contained also broad lectures concerning the organization of forest work, working tools, and transportation techniques.

It was not before the higher teaching of forestry became a part of the University in 1908 and A. K. Cajander had founded the Society of Forestry in Finland in 1909 that the definite developing of our forestry science and the new »Golden Age» began. The role of forest technology, however, was during these times quite modest and its publications are few in number primarily for the reason that for a long time there was a lack of institutes and equipment for this kind of research. Only in the year 1926 was the Institute of Forest Technology established within the University and it took still four years more before the first holder of the office of Professor of Forest Technology, Ilmo Lassila, filled the position. Until then the University's forest manager, Dr. A. Benj. Helander, had taught forest technology from 1910—1919. As appears elsewhere in this survey, Helander especially was a well-informed man with wide interests in forest sciences. His production includes both silviculture and forest policy and, in connection with the last, broad historical accounts. But his main attention was directed, in addition to the vast amount of work he had to do, also to questions on forest technology. He discussed this special field of his in his broad textbook, *Forest Utilization (Metsänkäyttöoppi)*, published in 1918. This significant work was for a long time the only textbook in the field. The second edition appeared in 1922 containing 584 pages and is still a basic textbook in this field.

Of the other investigations in the 1920's there should be mentioned the handbook by Y. Talvitie on the making of charcoal and rosin and Helander's publication on the tapping of pitch. I. T. Hintikka has studied the curly-wooded varieties of common birch (*Betula verrucosa*) and European white birch (*Betula odorata*) which, as is known, is especially desirable in the carpentry industry and therefore high priced. In addition, there should be noted Olli Heikinheimo's study on the making and stocking of fuelwood and Renvall's studies on the structure and properties of the Scotch pine of Northern Finland (Olli Heikinheimo 1919 AFF 4; August Renvall 1923 AFF 26).

Contributions by Dr. Ilmo Lassila give color to the late 1920's. Lassila acted during those times as the forest manager of the University and qualified himself for the office of Professor of Forest Technology which soon was to be announced as open. In 1926 his publication, »The Mechanico-Technical Properties of Wood; Their study and its objects», appeared in which he explained broadly the research in the field and at the same time prepared directions with future research work in view. Lassila's plan was closely based on Cajander's forest site type theory. The same year he also published a historical study on the developments of the saw and saw frame and in 1929 appeared his investigation in forest technology, »On the Next Tasks of Wood-Technological Research in Finland» and »On Influence of Forest Type on Weight of Wood» (Lassila 1926 AFF 31, 1929 AFF 34, 1929 AFF 36).

The next decade began under more favorable signs. In 1930 the office of Professor of Forest Technology was established at the University and Lassila

was named to the position. The following year a corresponding research professor's position was established in the Forest Research Institute of Finland and at about the same time the professor's office for the mechanical technology of wood at the Institute of Technology and the Foundation of Forest Products Research of Finland began its work.

It is natural that new working possibilities had strong influence on the development in the field. The establishment of new professors' positions vitalized scientific interests and becoming eligible for them encouraged the representatives of the field to efforts which soon bore beautiful results. It can be noticed that investigations at first emphasized primarily the study of the quality characteristics of wood. Especially the investigations published in the Acta series and the Forest Research Institute's series show clearly the authors' insight into all branches of forest science and are solidly based on Cajander's theory of forest site types. The series of the Foundation of Forest Products Research, on the other hand, indicates the attempts to clarify the timely problems of industry and is interesting from the forester's point of view in that the quality characteristics of wood become an object of critical analysis.

The actual forestry scientists began the purposeful study of also the biological factors which influence the quality of wood. Of the research men working in the Forest Research Institute and the University there should be mentioned first of all Aro, Jalava, Lassila, Valtiala (Wallden), and Vuoristo. Valtiala acted as an assistant of forest technology both in the University and in the Forest Research Institute and died in a field hospital in 1941 from the wounds received in the Second World War. The death of a young, gifted and well-informed research man was a great loss to the science of forest technology. His most important publications deal with the strength properties and anatomical structure of wood (Wallden 1933 AFF 39). In addition, numerous articles in different periodicals are his handiwork.

Professor Ilmari Vuoristo was the first occupant of the professor's office in the Forest Research Institute. He was appointed to the position in 1938. His broad and energetic work was interrupted by his death in 1939 after severe illness. Vuoristo possessed in addition to exceptional inborn talent also a thorough education. He had earned his doctor's degree both in technical and forestry sciences and in addition worked for a long time in responsible positions in our country's sawmill industry. His mathematical insight was very broad. Vuoristo's diversified literary work is mainly included in the series of the Foundation of Forest Products Research, Acta, and the Forest Research Institute. For the publications of the Foundation he was written accounts of a fundamental nature on the dependence of wage costs on the size, making, and transport of sawlogs in North Finland. He has enriched the literary work of the Society with his many investigations into the wages and work records in the making and transporting of sawlogs in far-Northern-Finland and with studies of the volume relation

between the trunks of saw-timber trees and sawlogs. In addition, we can find in the publications of the Forest Research Institute numerous high-level, scientific presentations which are directed, for instance, to the price relations of pine saw timber of various sizes, the value relations of sawlogs, the influence of the top diameter of the sawlog on the selling price of sawn products (thesis), time studies in making spruce pulpwood, the quality studies of spruce pulpwood used in the wood pulp industry, and to studies on the difficulties involved in floating. In addition, he assisted in bringing about important textbooks by writing the chapters on logging and on winter transport routes. It can be seen that his plow made deep furrows and that his work was really pioneering. (Vuoristo 1932, 1933 PTJ, 1934 AFF 40, 1935 42, 1935 MTJ 20, 1935 23, 1938 25).

With Vuoristo at that time there were competing Paavo Aro and Matti Jalava for the professor's office in the Forest Research Institute. The production of the latter was also wide and varied. It must be said that these three research scientists directed their interest toward the different branches of forestry and that their investigations well complete each other. The work of Vuoristo has been reviewed above. Aro's studies, on the other hand, are primarily related to the science of work and administration in which he is a pioneer, whereas Jalava's research has been aimed especially during the earlier period of his work at the technical properties of wood.

Vuoristo had successfully combined engineering and forestry sciences. Jalava, on the other hand, was by his schooling both a forest manager and economist and this combination also proved to be quite fruitful. Furthermore, Jalava had wide practical experience in the industrial field and he had broadened his outlook on study trips which covered many years and long distances. When working in the beginning of the 1930's as an assistant research man at the Forest Research Institute, he studied the strength properties of our Scotch pine, which study was the first of its kind in Finland and indicated that our native pine in technical respects could be considered as a fully qualified competitor of the pines of other countries. The best pine wood in Finland, according to the investigation, would grow on the *Vaccinium*-type in Central Finland, which also seems quite credible. Jalava has also assisted in explaining the world's forest resources and their possibilities for use, and in working at the Forest Research Institute he made valuable investigations of a fundamental nature into such matters as the changes in the moisture content, size, and shape of wood (Jalava 1930, 1932, 1933, 1934 MTJ). In the measuring of forest products and particularly of stacked wood, Jalava must be considered a pioneer. His exhaustive studies are based on wide experience. Of these the following should be mentioned: »On Measuring Roundwood,» »On Measuring Stacked Wood and Overmeasures,» and the »Report of the Forest Products Measuring Committee» (Jalava: MTJ 1929, 1934, 1936). Also in many textbooks and handbooks, such as Keksintöjen Kirja (Book of Inventions), the publications of Tapio, Puutavarakaupan Käsikirja (Handbook of Wood Pro-

duct Trade), Tapion Metsäteknologia (Tapio's Forest Technology), and Metsäkäsikirja (Forestry Handbook), he has pictured distinctly the many problems of measuring technics. When Jalava in the late 1930's was the research engineer of the Foundation of Forest Products Research, his interest was directed to the technical properties of wood and the suitability of wood as a raw material for industry. At that time both the plywood and sawmill industries were in question. In connection to this the properties of our birch were defined for the first time. Of Jalava's investigations published by the Foundation of Forest Products Research the following ought to be mentioned: »On the Strength Properties of Birch,» »The Felling and Floating of Birch for Vaneer and Plywood,» and »Plywood Studies I» (Jalava 1937 PTJ). He was still also thinking of the strength properties of other Finnish tree species as well. »The Effect of Bluing on the Strength Properties of Pine» (PTJ 1938) and from his time at the Forest Research Institute as a professor (1944—48) »On the Strength Properties of Finland's Scotch Pine, Norway Spruce, and Birches» (MTJ 1945) and the textbook, The Structure and Properties of Wood, in 1952, serve as examples. The productive pen of Jalava has also given its color to the textbooks and handbooks of forest technology, perhaps more than that of any other person. In the Iso Tietosanakirja (Large Encyclopedia) most of the writings concerning forest technology are made by him so that his definitions are in effect and similarly the textbooks of forest technology are written mainly by him. To mention a few, there would be his creditable chapters in Keksintöjen Kirja on the world forest resources and forest product situation, the measuring of forest products, the structure and properties of wood, the technical strength of wood, home consumption of wood by the rural population, and the use of wood in telegraph and telephone poles, railway crossties, etc. (1933), and Handbook of Wood Product Trade (1950) and Forestry Handbook (1957). Also, Jalava's investigations on leaving trees untrimmed after felling are the first of their kind (PTJ 1940).

Paavo Aro is the third strong name in forest technology in the 1930's. His schooling was very broad and he had a thorough knowledge of forest mensuration after working as a forest assessor, in addition to which he had worked as an assistant both in the silvicultural and forest political institutes of the University and as a special researcher in the Department of Forest Technology at the Forest Research Institute. Furthermore, he had gained deep international insight from his research work in the International Forest Center. Succeeding Professor Jalava, he became the Professor of Forest Technology in the Forest Research Institute in 1948. Aro's research consists of both the measuring of forest products and also, and mainly, the science of forest work. In the 1930's he carried out investigations at the Forest Research Institute, for example, on the division of total fellings into merchantable wood and wastes, on the bark quantity and barking losses with spruce pulpwood and pitprops, on the stack density of most common Finnish piled wood, on the effect of shrinkage caused by drying

on the amounts of wood appearing in statistics, and finally the extensive investigations on the effect of the diameter at breast height and the cutting diameter on the amounts of merchantable wood and felling waste which became his thesis (Aro 1929 MTJ 13, 1929 14, 1931 14, 1932 14, 1935 20). Later, as a professor in the Forest Research Institute, he has studied the volume and measuring problems of trimmed spruce and pine stems and has prepared tables about them and also on the barking losses in slender spruce and pulpwood birch (Aro 1958 MTJ 49 and 50). His attention has, however, been mainly directed to the science of forest work and it can even be stated that in this important field he has left the deepest mark among the forestry scientists of Finland. The science of forest work and administration is, as was already mentioned at the beginning of this survey, surprisingly young and new in our country. It is remarkable to note that the first publication in the field appeared as late as 1929 written by Lassila and it dealt with the making of stacked wood from the standpoint of the science of work (Lassila 1934 AFF 40). Written by Aro there were published the first studies about the forest trade men. This production by him was later completed by the time studies in the making of birch fuelwood, a tool guide, and many studies concerning appropriate and efficient tools, their structure and use (Aro 1934 AFF 40, 1936 MTJ 23, 1941 Silva I 4, 1942 AFF 50). In projects of international scale his handwriting is often seen as suggestions for such things as the making of the subdivision of work and working time uniform in studying forest work, and especially important leadership education and its significance are admirably brought out. Aro has also compiled our solid volume tables and stumpage price diagrams and has enriched our textbook literature by writings in various fields of the sciences of forest work.

Of the foresters of the 1930's there should further be mentioned Dr. O. Seppänen as a representative of technology. He prepared reports on such things as cutting tools and studied the truck transport of wood products and long-distance transport of unprocessed wood (Seppänen, O. 1900 Työtehosuora 28).

Besides the men engaged in actual forest technology, such as Aro, Jalava, and Vuoristo, the representatives of the engineering sciences also carried out technical work within the Institute of Technology and the Foundation of Forest Products Research not only for the purpose of developing processing methods but also in order to determine the properties of unprocessed wood. Of these especially Jussila, Levon, Sahlman, Siimes, Edw. Wegelius, and Ylinen stand out from the list. Among the publications by Siimes is a detailed series of investigations on work efficiency in the sawmill industry (Siimes 1932 PTJ 5, 1932 6 and 1935 21). The interests of Levon and Sahlman are primarily directed to the artificial seasoning of wood, instead (Sahlman 1938 PTJ 9, 1933 11; Levon 1928). The indicators of the quality of wood for the raw material of the plywood industry attracted attention also in the airplane industry, as is evident from the publications of Ylinen, Levon, and E. Wegelius. The quality of sawn wood, as

is known, is especially important in exporting and for this reason there exist strict sorting directions. The Foundation of Forest Products Research undertook very determinedly a study of quality classification and through its action there was published a group of studies on the interrelations between trees and sawn wood. Of these investigations there should be mentioned those of Eino A. Jussila and Hilmer Brommels (Brommels 1931 PTJ 2, 1932 8, 1934 16; Jussila 1936 PTJ 22, 1936 23, 1937 26).

The actual technical studies of sawn wood and plywood will probably be left outside the already broad field of forest technology. The same seems to be true also for the research work in wood chemistry and cellulose and paper technology which has been practiced successfully both in the Central Laboratories of our industry and in the Institute of Technology since the First World War. As noted representatives of this field may there be recalled Aschan, Bergman, Komppa, Routala, and Roschier as well as Hägglund and Klingstedt of Åbo Academy. In this connection there might be cause to point out that Finland's famous chemist, Gust. Komppa, was also a charter member of the Society of Forestry in Finland and that his famous investigation, »Zur Kenntnis der Nadelöle einiger in Finnland gewachsener ausländischer Nadelhölzer,» was published in the Acta series of the Society (Komppa 1934 AFF 40).

In the 1930's originated also the first publications on the quality of pulpwood as industrial raw material. Of these the investigations of Ilmari Vuoristo, A. Benj. Helander, and Th. Wegelius are noteworthy (Vuoristo 1936 MTJ 23; Helander 1933 PTJ 14, Wegelius, Th. 1939 AFF 48, 1937 SPP 7 a, 1939 7 a, 1941).

It is natural that the research on floating would become the object of study at quite an early stage in the country of thousands of lakes. The floating statistics of our country serve as an example and they are published mainly by the Foundation of Forest Products Research. As compilers, Saari, Pöntynen, Keltikangas, and Vöry have done great work. Vuoristo's studies on the difficulties encountered in floating have been mentioned earlier. Many problems in the technics of floating, in addition, are described in the yearbook of the Association of Finnish Flotation. And finally, the thesis of O. Seppänen (Seppänen, O. 1937 AFF 46) and Oksala's handbook, *Floating Technology*, in 1936 should be mentioned as literature in the field. It is quite remarkable that land transportation received surprisingly little attention still at that time. It is true that there are brief studies on the truck transport of wood in the yearbooks of the Association of Flotation and the Association of Privately Employed Foresters, and Vuoristo published in collaboration with Harri Hallenberg in 1937 a handbook on the construction and care of winter transport routes. It was only after the wars that the transportation problems became the object of critical analysis.

As the ominous clouds of war rose to the horizon at the end of the 1930's, attention was driven to the making of charcoal and producer gas because of the

threatening gasoline shortage. This new branch of forest technology is illustrated by a few brief studies by Vilho Seppänen and H. Kirkklund. In a textbook of wood chemistry published in 1936 Routala already devoted attention to these matters.

The hard war years stopped the promising research work in forest technology, as in all the other fields of forestry, for many years. However, the healing of the wounds of war required even in forest economy urgent intensifying action in operations and necessary research work, and neither the Forest Research Institute nor the Foundation of Forest Products Research had the needed man power or money. The Forest Department of the Work Efficiency Association (1942) and Metsäteho, the Forest Work Study Section of the Central Association of Finnish Woodworking Industries, (1945) were founded to meet the need. Later, a research organization, Floating Efficiency, was established partly for the purpose of clearing up the floating problems of Northern Finland and finally the Bureau of Logging Technics of the State Board of Forestry for carrying out research on the technics of logging. During the three most recent years there has been in action the Smallwood Commission which was established with export fee funds to develop the use of small wood.

The economic life has set before the foresters ever more difficult problems to be solved. The continuously tightening competition on the world market and the rising work costs bring up very definitely the necessity of rationalization of forest work and the developing mechanization requires still more professional training and research in special fields. For that reason the founding of new research organizations has had the greatest effect on the developing of the many branches of forest technology. It must be noted with great satisfaction how this division of labor has had a fruitful influence on the producing of a new and outstanding generation of investigators. Many fields peripheral to forest technology, such as the sawmill, plywood and veneer, pulp and paper industries, and wood chemistry have been taken care of by other entirely technical research organizations, such as the State Institute of Technical Research, Central Laboratory, Inc., etc. Thus the State Institute of Technical Research has taken the functions of the Foundation of Forest Products Research as a heritage, whereas the research in pulp and paper technology and wood chemistry is still more concentrated into the Central Laboratory. But at the same time the actual forest subjects and primarily the important problems related to logging and transportation have been brought to the critical observation of science so that the science of forest work finally begins to receive the central significance which belongs to it from the standpoint of the national economy.

Of the research organizations carrying out work studies, Metsäteho especially has done during its more than ten years of operation much useful research work from the standpoint of practical needs. The study of the bases for wages in the felling and transport of different types of products, adaptability studies of

various kinds of forest working machines and equipment, the developing of new felling and transport methods, and the study of certain technical floating problems have to be especially mentioned.

The leading principle of the Work Efficiency Association has been the educational work for the development of rational manual equipment, machines, and working methods in the form of courses and exhibitions. Alongside of this, research directed to different kinds of tools has been carried out. Floating Efficiency's investigations have been aimed at solving the floating questions in Northern Finland. Of these problems there ought to be mentioned above all the difficulties in floating caused by electric power plants and the possibilities of bundle floating, the joint sorting of pulpwood, machine sorting, and sea towing.

The attempts of the Bureau of Logging Technics of the State Board of Forest is to determine the possibilities of mechanization in forest work in state forests and to rationalize the logging technics and related organization. In connection with this the State Board of Forestry has also established an experimental station at Hirvas near Rovaniemi. The fact that our country finally has this type of establishment, a special research center for forest work, has an especially great value.

The Smallwood Commission has donated funds to institutes and investigators for the research in logging technics and utilization technics of small wood. For instance, the Department of Forest Technology at the Forest Research Institute and the Central Laboratory have been able to determine with the support of these funds the adaptability of different machines and methods in the logging of small wood and the suitability of different kinds of furnaces for the use of small wood as fuel and the applicability of small wood as the raw material for various industries.

The Department of Forest Technology at the Forest Research Institute has directed its attention mainly to problems of the nature of basic research. Of these there could be mentioned the questions of the quality of pine sawlogs and birch, the effect of silvicultural treatments on the quality of wood, and the studies concerned with preserving and storing wood. Studies of measuring merchantable lumber have always been a part of the tasks of the Forest Research Institute. Recently the objects of these kinds of investigations have been the stack density and barking loss of pulpwood, small wood, and birch cellulose wood in far-Northern Finland, measuring loss of chopped fuelwood, and the possibilities for measuring the volume of bundles. Even greater tasks of this nature have been completed, such as the measuring and volume tables for pulpwood and volume tables for sawlogs of the basin area of Southern Finland, Oulu-river, Ii-river, and Northern Finland.

During the post-war years Prof. Paavo Aro and Dr. Veijo Heiskanen have been the most productive writers of the Forest Research Institute. Aro's work has been reviewed previously. At first Heiskanen carried out many investiga-

tions by the commission of Metsäteho and found answers for such questions in wood transport as carrying in barges, loading in trucks, etc. Since he acted as the senior research assistant at the Department of Forest Technology of the Forest Research Institute, he has given attention primarily to the volume estimation of saw-timber trees and to the ascertaining of the means of quality classification. The publications, »The Accuracy in Appraisal of the Volume of Pine Timber Trees,» »On the Drying of Firewood and Its Consideration in Storing,» his thesis, »Investigations into Pine Tree Grading Methods and Their Accuracy,» »The Influence of Log Grade on Floating Ability and Floating Difficulty in Pine Saw Logs,» »The Influence of Log Grade on the Cutting Difficulty of Pine Saw Logs,» »Studies on Pruning of Birch,» »One the Interdependence of Annual Ring Width and Saw Log Quality,» »Quality of the Common Birch and the White Birch on Different Sites,» »Volume Tables of Saw Timber Trees Based on Diameter at Breast Height,» and »On the Accuracy in Measurements of Pulpwood Boles in far-Northern Finland» should be mentioned (Heiskanen 1950 MTJ 38, 1953 41, 1954 44, 1955 45, 1957 48, 1958 49, 1954 AFF 61). In addition, Heiskanen has published a number of other writings on the quality grading of sawlogs.

Metsäteho, the Forest Work Study Section of the Central Association of Finnish Woodworking Industries, received as its task the carrying out of detailed investigations for the many unclear questions related to just bases for wages for different kinds of forest work, which bases must take into account all the varying factors under different conditions. It soon appeared, however, that the bases for wages in forest work are only a part of the objects requiring rationalization. The sensible use of labor as well as the development of methods and equipment are most certainly equally important for the smooth running of work, especially when the labor question is a limiting factor. It is obvious that with joint efforts it is possible to reach experimental research results sooner and with less expense than if everyone were to work individually. For this reason these types of questions of rationalization became a part of the work of Metsäteho. From the beginning Metsäteho has had as one of its tasks, besides the carrying out of experiments and studies and the drawing of practical results from them, also the reporting of these results. The publication series of Metsäteho which was thus started deals with the most central questions of logging and is by its content very valuable and important. Likewise it has to be admitted that Metsäteho has had a great worth in developing new and productive scientists. The publications of Metsäteho which deal with time studies, the developing of work methods, the use of mechanical equipment, and rationalization of logging are already 40 in number and in addition over 150 smaller reports on timely questions have been published. Putkisto, Makkonen, Tuovinen, and Hakkarainen should be mentioned as the most productive investigators. The investigations of Putkisto are aimed mainly at the logging technics of wood pro-

ducts. His thesis stands out as the most important of them dealing with the possibilities of the use of the farming tractor in forest transport. The aim of this investigation was to determine the manner in which our country's stock of farming tractors could ease the forest transport situation and the way in which the work should be organized and roads built with tractor transport in view. In connection with this Putkisto has also developed the building technics of packed-snow roads. Of the investigations of Putkisto there should be noted his publication about the lifting of wood products from water, and many writings and studies about road construction, the technical equipment and structure of transport equipment, and his investigation on logging of vaneer birch and on floating (Putkisto 1947 *Metsäteho* 4, 1947 5, 1952 30, 1956 36). He has also contributed noticeable to the compiling of textbooks and handbooks of forest technology, such as Tapio's Forest Technology and Forestry Handbook. Makkonen, on the other hand, has principally been working with time studies. His literary work has certainly in many ways been helpful in developing objective and balanced bases for wages. He has, for instance, determined the effect of the density of the stand marked for cutting on the making of stacked wood and with many time studies added new knowledge about the making of sawlogs and pulpwood and about the factors influencing work results. Also the making of tree-length fuel has been under his attention and his creditable thesis is a study in horse transport of wood products. In addition, Makkonen has studied the stack density and its changes in pulpwood made of birch, aspen, and pine (Makkonen 1948 *Metsäteho* 9, 1949 18, 1950 25, 1950 26, 1952 28, 1954 32, 1956 33, 1957 37, 1958 39). The most extensive publication of Hakkarainen deals with the use of forest work time by the workers. In addition, he has studied the use of forest work time by the driver, numerous questions related to the construction of forest roads and truck transport of wood products (Hakkarainen 1949 *Metsäteho* 19, 1956 35 and 1957 38). Tuovinen's research reaches into a number of fields. He has devoted his attention to the storing of wood products and to the different storing methods and has explained many problems of floating technics. Also, the logging of pulpwood in Northern Finland has been the object of his attention and, furthermore, the investigations on the sinkage and quality losses and the application of bundling methods should be mentioned (Tuovinen 1948 *Metsäteho* 8, 1946 11 a, 11 b and 12, 1949 20, 1950 24, 1952 29, 1956 34, 1958 40). In addition to the afore mentioned publications of *Metsäteho* may there be mentioned those by Vöry, »The Costs of Living of Forest Workers,» »Analysis of the Time Study Materials of Some Forest Jobs,» and »Statistical Determination of the Average Work Performance in the Preparation of Timber» (Vöry 1947 *Metsäteho* 3, 1954 31, 1954 32) and Eklund's study of the pulling resistance of timber rafts and of the possibilities of developing rafting (Eklund 1952 *Metsäteho* 17).

The Forest Division of the Work Efficiency Association has given attention

mainly to the improvement of felling since its founding in 1942. The work has been directed to tools and manual work, on one hand, and to the mechanization of felling, on the other. Vuoristo should be mentioned as the first initiating force, who already in 1936 conducted experiments under the commission of the Work Efficiency Association on the use of a row of sleds and on the standardization of logging sleds. During the years following the war the director of the Forest Department, Dr. Kantola, instead characterizes the forest technological research work of the Work Efficiency Association. He has published many tool guides and has studied the influence of professional skill and of tools in felling. His thesis deals with the mechanical loading of coniferous sawlogs from ground storage to trucks and, in addition, in many of his writings he has examined fellings and truck transport (Kantola 1947 *Työtehoseura* 42, 1948 49, 1949 52, 1954 70, 1954 71, 1955 75 and 1957 80). Puoskari has studied the most important tools, Arvi Makkonen chain saws and sawing (Arvi Makkonen 1951 *Työtehoseura* 62, 1953 68, 1954 19, 1958 82). Furthermore, Granvik's investigations on the possibilities of using motor vehicles in hauling wood and in the maintenance of hauling roads for trucks (Granvik 1919 *Työtehoseura* 53) and Granvik's and Levanto's studies of power sawing on the field (Granvik—Levanto 1953 *Työtehoseura* 66) have been published through the Work Efficiency Association.

The Smallwood Commission has had its effect mainly in the donating of funds to different institutes, such as the Central Laboratory and the Forest Research Institute, and to private investigators in order to solve the problems of the technics of logging and use of small wood. These investigations have appeared in many series, such as the publications of the Central Laboratory, the Forest Research Institute, *Metsäteho*, and the State Institute of Technical Research. In addition, the Commission has had its own publication series which now already includes 70 publications. As the most important authors there ought to be mentioned the chief research scientist, Risto Eklund, and numerous research men of *Metsäteho*, the Forest Research Institute, and the State Institute of Technical Research.

The foregoing review indicates clearly that the forest technological research work is finally going ahead at full speed and that the after growth in the branches is surely secured. It can likewise be noted with satisfaction that the division of labor among different research organizations in its rather highly developed form has proved to be the right action as well as the fact that logging technics have received the attention which is justified by its central position in our economy. It is also natural that the share of the Society of Forestry in Finland in the field of technology has recently been relatively small when compared with other fields of forestry. The technical questions by their nature are such that they require a rapid solution in order that the production machinery would not stop. The biological research, instead, has more of the nature of basic research which

for that reason is often set aside by private enterprise, such as the research done by industry. The investigations published in the series of the Society are most often basic research by nature so that studies concerned with the structure and composition of wood have a definite place in them. As an example there can be mentioned the research on plant morphology such as, for instance, Ollinmaa's thesis on the anatomical structure and properties of the tension wood in birch (Ollinmaa 1955 AFF 64).

It is also of primary importance that the individual research man has possibilities to have his research result published in the respected and widespread publication series of the Society of Forestry. An excellent example of this is the investigation on the theory of wood utilization of how pine pitch could be used as a raw material for lubricating oil, published as the thesis of Jaakko Murto (Murto 1951 AFF 59). In this paper Murto gives a detailed description of the formation and character of pitch, the making and obtaining of distillation wood and of stump tar as raw material for lubricating oil.

It has often been pointed out that forest technology is quite new among the forest sciences and that earlier it has been in a rather unimportant position in comparison to other sciences. If we look into the post-war production, it can clearly be seen, however, that things are changing. We realize the necessity of technical knowledge also in this connection. In thinking of the development in the long run we will most certainly come to the conclusion that the importance of forest technology will continue to grow. It may be that the special research in engineering technology, such as the mechanical processing of wood, wood chemistry, and research based on fibres, will be left beyond the interests of foresters. Forest technology and especially the study of structure and logging technics are, however, so important and central and are bound so tightly to both forest economy and silviculture that its position is surely secured within the work of our Society.