

TRENDS OF THE WOOD PRODUCTS HIGHER EDUCATION IN NORTH AMERICA

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Abstract:

Wood products curriculum and education in North America have been changing last two decades. Some of the universities are loosing their wood products programs while some are merging with other bio-named departments. It is still fact that wood products graduates are still in demand but with a different perspective than several 10-15 years ago. It is important that expectation of industry should be taken into consideration to revise and develop new curriculum of the current programs. This article briefly reviews some of the wood science programs in North America and their background within the scope of overall trend and development.

Key words: *wood science; forest products and timber technology programs; higher education.*

INTRODUCTION

Forest products are commodities that have been used by mankind for thousands of years. Main forest products industry including sawn wood, wood based panels, pulp, and paper has an important market share of overall economy (Bowyer 2000; Barbu and Paulitsch 2016). A learnt profession has something to do with a developing body of knowledge, formulation of ethical standards to conduct a certain performance, and to recognize a common interest using this knowledge in the form of service to the others in a society (Ellis 1964). In that respect forest products, specifically the wood products profession plays an important role in North America. It is a fact that the history of the forest products education and research in the form of wood science is less than a century old (Perlin 1991). Of course wood products education in North America has very significant role on overall utilization of forest resources within the scope of conservation and sustainability (Goodel 2013).

Wood science is not a very versatile professional relative to other recently developed new professions such as food science, biosystems, and material science. However, there is quality research and public service from wood scientists which is a significant accomplishment given the many programs with many students and only a small contingent of faculty to serve the large audience of wood science programs. Many graduates from these programs play a significant role in leadership on the forest products industry. Currently there are about two dozen universities and two national laboratories in the USA and Canada in wood products education and research (Goodel et al. 2010, Barbu and Goodel 2017).

OBJECTIVE

Objective of this article is to emphasize overall trends in wood science education with a brief review of programs at universities in the USA and Canada.

INSTITUTIONS FOR WOOD SCIENCE HIGHER EDUCATION IN USA AND CANADA

There are approximately ten institutions in the US having programs specialized in different aspects of wood science and forest products. The rest of the programs are mostly represented under different departments such as "natural resources" or forestry with only a few faculty members with limited number of courses and teaching forest products to forestry major students. Since, enrollment in forest products has dropped by over 60 to 70%, graduate programs are also reduced. As a result of this trend some schools are under pressure to eliminate the forest products program. There are seven universities with only one wood products faculty member in the "natural resources" or forestry program. It is highly expected that these positions will be eliminated due to budget cuts in the next decade. These eliminations will play an important

role in reshaping forest products education. More than 70% of forest products faculty positions have been eliminated in the US. Even though there is excess demand for forest products students by the industrial sector, many companies in the US have turned to hiring industrial engineering students to fill this gap. It is well known fact that long term basic research is very critical to forest product industry in the US. Financial support by government and private industry for forest product research has been declining last two and the half decades. Some of these forest product companies have eliminated research facilities. The demand for forest products is estimated to increase 25-30% by the year 2030 and in order to satisfy this there will be a definite need for education and research programs in forest products. Countries outside the US are supplying most of the graduate students in US forest products programs. Some of these programs are accredited by the Society of Wood Science Technology (SWST). Different actions need to be taken to reshape forest products programs in the US:

- Development of new products in the area of fiber enforced engineered materials with collaborations with other departments such as biosystems and other engineering disciplines.
- Rebuilding the relationships between wood products programs and industry to meet the actual needs of the industry. This should also fill the absence in theoretical research that is fundamental for applied research required by the industrial sector.
- Revamping curriculums in wood products program based on the needs of society and industry (Goodel et al. 2010; Goodel 2013, Barbu and Goodel 2017).

Some of the universities having wood science program in the US and Canada are briefly described below:

Department of Wood Science and Engineering, College of Forestry, Oregon State University, Corvallis

Founded in 1868, Oregon State University has a student body of over 30,600 in a two campus system in Corvallis and Bend Oregon. Students can choose from more than 200 undergraduate and more than 80 graduate degree programs in 11 colleges, including over 20 degrees offered online.

The College of Forestry was established 1913 and currently the program has over 1,000 students, about 820 in undergraduate and 205 in graduate courses, offering 20 degree programs in the following four departments: Forest Engineering, Resources & Management, Forest Ecosystems & Society, Wood Science and Engineering, and the National Center for Advanced Wood Products & Design (NCAWPD). The NCAWPD was established 2015.

The Department of Wood Science and Engineering (WSE) is a very rare name in USA keeping "wood" in its name. Its mission includes educating new professionals for challenging careers, providing advanced learning for professionals in the work place, discovering new knowledge and solving problems through innovative research and transferring knowledge to users and practitioners. It is one of the largest and most diverse renewable materials programs in North America. WSE, well known for its industrial contacts, is offering a multi-disciplinary approach to the study of wood with increasing demand for new materials and intensifying global competition demand innovation, new discovery and well-educated professionals. The WSE research program areas are about the biodeterioration, materials protection, and product durability; composite materials; forest products business and marketing; green building and environmental performance -timber engineering, mechanics, and structural design but also wood aesthetics and natural coloration. The degree has changed to "Renewable Materials" for bachelor, and was kept as "Wood Science" for the master and PhD studies (about 35 students). Undergraduate enrollment is growing, currently at about 50. The faculty staff has 23 members, 15 of them with tenure, 7 adjunct or courtesy members and 3 office staff. Since 1999 about 60 graduates reached higher position in R&D at national and international level. In 1999, founded in Corvallis (OSU) and Blacksburg (Virginia Tech); the National Science Foundation (NSF) Industry/University Cooperative Research Center (IUCRC) for Wood-Based Composites having as partners the universities of British Columbia (UBC), North Carolina (NCSU), Maine (UM), Mississippi State (MSU), and other industrial members. From 1927 to 2016, the WSE Department (and its predecessors) has granted the following degrees: 659 BSc, 388 MSc, and 106 PhD (numbers are approximate) (Barbu 2017a, Oregon State Univ. 2016).

School of Forest Resources, College of Natural Sciences, Forestry, and Agriculture, University of Maine, Orono

The University of Maine was established as the Maine College of Agriculture and the Mechanic Arts under the provisions of the Morrill Act, approved by President Abraham Lincoln in 1862. In 1897 the original name changed to the University of Maine. The institution opened 1868 with 12 students and two faculty members. The Maine Agricultural and Forest Experiment Station was founded as a division of the University in 1887. In 1912 the Maine Cooperative Extension, which offers field educational programs for both adults

and youths, was initiated. The first master's degree was conferred in 1881; the first doctor's degree in 1960. The University of Maine has an enrollment of 11,200 students in 2016.

In 1902 the Maine legislature granted money for "public education in forestry." It was used to start a Department of Forestry at the University of Maine. In 1993 the College was renamed and combined to form the College of Natural Resources, Forestry, and Agriculture.

The Wood Science option was consolidated into an undergraduate program Forest Operations, Bioproducts & Bioenergy (FBB) option in the School of Forestry in 2012. To meet society's increasing need for sustainable resources, efficient and environmentally acceptable options are needed for the management, harvesting, and transportation of timber and biomass for energy production and for manufacture of products, e.g. lumber, paper, and wood composites. The interdisciplinary BSc in Forest Operations, Bioproducts and Bioenergy (FBB) at the University of Maine aims to develop individuals (a) with the knowledge and abilities to better manage timber resources and forest operations in an environment of increasing public scrutiny and environmental concern; (b) with an understanding of the processes and challenges related to the efficient and environmentally acceptable harvest and conversion of forest resources to bioproducts and bioenergy; and (c) with an appreciation for the business principles and the associated local, regional, and global markets. The Forest Operations, Bioproducts & Bioenergy program is accredited by the Society of American Foresters and by the SWST. The graduate program in Wood Science and Technology at the University of Maine provides opportunities to earn either Master of Science or doctoral degrees. There are opportunities for research in wood to energy conversion, renewable nanomaterials, wood composites, and cellulose nanocomposites. There are several research centers at the University of Maine including the Advanced Structures and Composites Center and the Forest Bioproducts Research Institute. Graduates find work in industry, academia and government. Only five students at present enrolled at FBB for the Wood Science option (Barbu 2017a, Univ. Maine 2016).

Department of Sustainable Biomaterials, College of Natural Resources and Environment, Virginia Polytechnic Institute and State University, Blacksburg

Founded in 1872, Virginia Tech has the largest number of degree offerings in this state, more than 125 campus buildings, off-campus educational facilities in six regions, a study-abroad site in Switzerland, and agriculture research farm near the main campus, which is located in Blacksburg. Virginia Tech offers 215 undergraduate and graduate degree programs to more than 31,000 students (82.5% undergraduate; 58.3% male) and manages a research portfolio of more than \$450 million. It is ranked 41st in university research in the United States.

Virginia Tech's College of Natural Resources and Environment (CNRE) is the only college specializing in natural resource education, research, and outreach in this state. The CNRE contains four different departments: Geography, Forest Resources and Environmental Conservation, Fish and Wildlife Conservation, and Sustainable Biomaterials. These departments currently offer eight undergraduate majors and a variety of options.

Established in 1979 as the Department of Wood Science and Forest Products (WSFP) in the College of Agriculture, the department has matured and grown and is now one of four departments in the CNRE. The first Department Head was Prof. Geza Ifju, who grew the department from 4 faculties in 1979 to 12 when he retired in 2000. In the 1980s through the 1990s, the WSFP department grew also in enrollments from a handful of BSc students to close to 100 students - the largest program in the country at that time. The following 10 years, enrollment of BSc students in the department steadily declined until 2010 (21 students for the 17 faculty members in the department). The department is recognized at the state, national and international levels as a leader in the education of highly-qualified professionals in the discipline. Renamed some years ago from WSFP in Department of Sustainable Biomaterials (DSB) and restructuring two new degrees it increased the enrollment by eight times the number of undergraduate students to approximately 170. The DSB is the largest department of enrolled students in the US. The program grew as soon as the new name was available and the two new education program with more "sustainable" and "greener" options were promoted. The addition of the green packaging degree that also emphasizes "design" which is very popular in the new name of that bachelor degree "Packaging Systems and Design" has also helped. About 100 students are in the "Packaging Systems and Design", and 70 students in the "Sustainable Biomaterials" bachelor degree. 35-40 are graduate students at master and PhD level. The faculty of DSB is composed of a body of professionals counting 10 professors, 2 emeriti, 5 adjunct professors, 3 associate professors, 2 assistant professors, 3 senior researchers and 6 permanent staff in administration and technique (Barbu 2017b, Virginia Tech 2016).

Composites Materials and Engineering Center, Voiland College of Engineering and Architecture, Washington State University, Pullman

Washington State University (WSU) is a public land-grant university which was founded in 1890 and currently services around 25,000 students (52% women, 29% from abroad). With facilities throughout the State of Washington, the main campus is in Pullman (20,000 students). WSU has 11 colleges that foster scholarly achievement. Graduate and professional programs attract top minds from 79 countries. The R&D expenditures were over \$300 million. The university offers 90 academic majors for undergraduates, 76 master's degree programs, 64 doctoral programs, 3 professional degree programs and over 20 online degree programs. 10 professors are National Academy members.

The Composite Materials and Engineering Center (CMEC) is comprised of an interdisciplinary facility administered through the Voiland College of Engineering and Architecture (VCEA) at WSU. For over 70 years the Wood Materials and Engineering Laboratory (WMEL) was established in 1946 exclusively for research in the Washington State Institute of Technology with Prof. George Marra as its 1st director. It became a part of the Department of Material Science and Engineering in 1972, and then in 1985, it was established as an independent laboratory within the College of Engineering and Architecture. WMEL discovered more efficient use of the forest and creative ways to transform wood waste into useful building products and developed areas of specialization in particleboard, fiberboard, waferboard, oriented strand board, and medium density fiberboard technology.

Pullman became a gathering place for the world community involved in wood and lingo-cellulosic composites, particularly at the annual International Washington State University Particleboard/Composite Materials Symposium (IPCMS) established 1967 by Prof. Thomas Maloney with about 500 people from 30 countries in each spring (today in Seattle known as "International Wood Composites Symposium" still the unique event of North America in this field but at less than the half no. of participants). The advanced degrees awarded up until this time were primarily master in Material Science and Engineering, and Doctorates in Engineering Science. The book of Maloney "Modern Particleboard and Dry-Process Fiberboard Manufacturing", which is also used throughout the world and continues to be requested and often referred today as the "Bible" in this sector of the forest products industry. WSU's educational programs for wood materials and engineering is unique in the United States with its administrative home in VCEA. Graduate students are generally admitted through the departments of Civil and Environmental Engineering, Mechanical and Materials Engineering, Chemical Engineering, or Biological Systems Engineering; as well as the interdisciplinary Materials Science and Engineering PhD. In 1996, the degree was changed through Civil and Environmental Engineering. More than 150 advanced degrees have been earned by students who worked under the guidance of the CMEC (Barbu 2017a, Washington State Univ. 2016).

Wood Research Laboratory, Department of Forestry and Natural Resource, College of Agriculture, Purdue University, West Lafayette

Purdue University in West Lafayette (Indiana), was founded in 1869. Total enrollment in 2015 was 40,500 (30,000 undergraduates). Almost 30% of students are enrolled in the College of Engineering, but Purdue University's College of Agriculture (with 8% enrolment) is one of the world's leading colleges of agricultural, food, life, and natural resource sciences.

Forestry instruction at Purdue University began in 1905 with a two-course sequence titled "Forestry" which was taught in the Biology Department. In 1914, forestry courses were listed for the first time under the heading "Forestry" and was recognized as the beginning of forestry at Purdue University. An authorization was received from the Graduate School in 1944 to offer a Master's degree in forest production, forest economics, forest management, forest mensuration, silviculture, wildlife, and wood technology. The same year, the Wood Research Laboratory was established in the Forest Products Building. Authorization for offering a PhD program was received in 1961. Its current name The Department of Forestry and Natural Resources (FNR) was adopted in 1974. The FNR undergraduate enrollment peaked at 666 students in 1977 while graduate enrollment rose to about 80 students, as it is also today. Currently, the mission of FNR is to train the next generation of professionals in natural resource sciences and sustainable biomaterials process and product design.

The Wood Research Laboratory (WRL) is the unit of the FNR responsible for conducting research and teaching in wood science. Forest products research began at Purdue in 1904 when it became one of several timber testing stations under contract with the U.S. A Wood Technology curriculum was established in 1944. At this time, a dry kiln was constructed to research the drying of walnut blanks used for gun stocks and with experiments on special oak stock for making practice artillery shells. In 1960, Prof. Michael O. Hunt undertook extensive studies relating to the use of particleboard and related materials. Also Prof. Stan Suddarth received a grant from the US Forest Service for a goal to automate the kiln drying process. In 1962, Prof. Carl Eckelman undertook research related to the strength design of furniture. In general, the WRL had many pioneering contributions to wood science such as: wood truss design for residential and

light-frame industrial buildings; evaluation of strength properties of structural lumber using machine stress grading; design and evaluation of wood-based composite products as well as development of application for their use; product engineering, quality improvement, strength design of furniture and its performance. Current research projects conducted at WRL are about log scanning, lumber processing, school furniture for developing countries, building construction from small diameter and low value timber, etc. Presently, the WRL is responsible for undergraduate and graduate wood science education including undergraduate majors in Sustainable Biomaterials - Process and Product Design; and two minors, Wood Products Manufacturing Technology and Furniture Design. The WRL is also responsible for graduate studies and offers MSc or PhD programs in Wood Science and Technology. Currently, it is a small program of about 10 to 15 undergraduate students in Sustainable Biomaterials - Process and Product Design Major and just about same number is enrolled in Furniture Design and Forest Products Manufacturing minors. In general, 5 to 10 graduate students are enrolled in the Wood Science and Technology. The WRL staff consists of 4 professional faculty members, 1 laboratory technician, and 1 clerical support (Barbu 2017b, Purdue Univ. 2016).

College of Agriculture, Natural Resources and Design, School of Natural Resources, West Virginia University, Morgantown

West Virginia University was founded in 1867. The State of West Virginia was formed the following year and, shortly thereafter, the state's legislature accepted the terms for the Morrill Act to raise the money to start the new land-grant college they called the Agricultural College of West Virginia. In 1868, the school's name was changed to West Virginia University (WVU). Currently, WVU has 14 colleges and schools offering 353 majors. Hundreds of distance education and online classes are available. WVU enrollment is approximately 30,000.

The WVU Wood Science and Technology (WST) program is an option within the School of Natural Resources at the Davis College of Agriculture, Natural Resources and Design. The WST program was first accredited in 1989 and was re-accredited in 1999 when it was the bachelor degree in Wood Industries. The name of the program was changed to Wood Science and Technology in 2004 and reaccredited by SWST under that name in 2009. The WST Program also prepares students for careers in the production of wood products such as architectural woodwork, furniture, cabinetry, composite materials, and engineered wood products. The graduate WST program offers two levels of advanced degrees the Master of Science in Forestry (MScF) with an emphasis in WST, and the PhD. The overall WST educational program is currently stable at 25 undergrad students, 10 graduate students and 6 faculty members. The faculty are moving forward with a modified curriculum and a new program name in time for the next accreditation visit in 2019 (Barbu 2017b, West Virginia Univ. 2016).

Center for Renewable Carbon, College of Agricultural Sciences and Natural Resources, University of Tennessee, Knoxville

The University of Tennessee, Knoxville (UTK), highest ranked public university in this state, was founded 1794 and is a public, comprehensive sun- and land-grant university. Today, the university offers education across nine undergraduate colleges and 11 graduate colleges. The main campus is located in Knoxville. The university counts among the nations elite research universities with more than 300 degree programs and spends more than \$200 million annually on research. The university co-manages the Oak Ridge National Laboratory (ORNL) which is the US Department of Energy Science and energy laboratory with an annual budget of \$1.4 billion. The university hosts 28,000 including 22,100 undergraduates. In the 2017 universities ranking, U.S. News & World Report UT ranked as 103rd among all national universities and 46th among public institutions of higher learning. In total, 87% of undergraduates are from the state of Tennessee, while 15% of graduate/professional students are international (over 90 countries).

The College of Agricultural Sciences and Natural Resources (CASNR) is a four-year institution with seven academic programs in a variety of natural, food, and social sciences; it also hosts the states School of Veterinarian Medicine. In the Department of Forestry Wildlife & Fisheries (FWF), part of CASNR, 241 undergraduates, 33 masters and 20 PhD students are enrolled. In particular, for the major in forestry, 79 undergraduates, 10 masters, and 14 PhD students are currently enrolled. FWF offers a single MSc and PhD major programs in natural resources. For undergraduate students, majors are offered in forestry resources management, urban forestry, and wildland recreation.

The Center for Renewable Carbon (CRC) is a research center positioned within the The University of Tennessee, Institute of Agriculture (UTIA) of which CASNR administers the teaching responsibilities. The CRC conducts advanced interdisciplinary research in the field of biobased materials and provides innovative solutions to global challenges in energy, engineering by utilizing resources. The CRC has been involved in research in the past decade exceeding \$300 million in funding levels. Research in advanced bio based materials includes raw material processing, characterization and product development in order to investigate

economic viability of nanocellulosic materials, chemicals and fuels derived from renewable sources. The CRC had a unique program in the US in process analytics and statistical process control which has trained more than 1000 industry personnel in the last decade. The CRC has eight tenured faculty, two non-tenure research assistant professors and one distinguished professor. Since 2012, MSc and PhD academic degrees are awarded in forestry with a concentration in "Bio based Materials and Wood Science Technology" (Barbu 2017b, Univ. Tennessee 2016).

Department of Bioproducts and Biosystems Engineering, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota, St.Paul

The University of Minnesota was founded as a preparatory school in 1851, seven years before the territory of Minnesota became a state. Over a century ago, when the University's Forestry Program began, Minnesota's natural resources looked vastly different than now. Mindful of these changes, the Department of Forest Resources has been continually evolving.

College of Food, Agriculture and Natural Resource Sciences (CFANS) created in 2006 via the merger of two colleges and a department consists of 12 academic departments and 10 research and outreach centers across Minnesota. The college offers degrees in 13 undergraduate and 13 graduate majors plus more than 25 minors. The Natural Resources Science and Management (NRSM) Graduate Program is among the top ranked programs of its kind. The National Research Council's latest rankings, released in 2010, place the NRSM program as high as number two nationally. Eight areas of study encompassing graduate course offerings from the Departments of Forest Resources; Bioproducts and Biosystems Engineering; Fisheries, Wildlife and Conservation Biology; and other units are offered. With 100+ students enrolled in the NRSM program, the student body represents a wide variety of educational backgrounds, geographic origins, and career objectives.

The Department of Forest Resources has 22 professorial faculties with 21 of these being tenured or tenure-track. FR also has 28 full-time research, scientist, and teaching staff that play a major role in carrying out the department's mission. Forest Products track is designed for graduate study specializing in areas such as: wood and fiber as raw materials; deterioration of wood; wood mechanics and structural design; wood moisture interactions and drying; processing and performance of composites; economics of manufacturing systems; technology and processing of solid wood products; marketing, design and production of housing components; and energy-efficient building construction (Barbu 2017c, Univ Minnesota 2016).

Department of Sustainable Bioproducts, College of Forest Resources, Mississippi State University, Starkville

The university began as the Agricultural and Mechanical College in 1862. The College received its first students in the fall of 1880. The School of Forest Resources had been established in 1954. The Department of Forestry began in the same year within the College of Agriculture. In 1955, the first two professional forestry degrees were awarded. In 1961, the School of Forestry became a separate entity from the College of Agriculture.

The Department of Sustainable Bioproducts began in 1964 as the Forest Products Utilization Laboratory as authorized by the Mississippi Legislature. In 1967, the Department of Wood Science and Technology was established and approved to offer master's degrees. The bachelor's degrees in wood science and technology was approved in 1975. The Furniture Research Unit was created in 1987 to support the burgeoning furniture industry in Mississippi, the number one producer of motion furniture. In 1989, the Department of Wood Science and Technology was changed to the Department of Forest Products. Most recently, in 2013, the department name changed to the Department of Sustainable Bioproducts to reflect the renewable, natural and sustainable resources used in the industry. The Franklin Furniture Institute has tested furniture for every furniture manufacturer in the nation. Scientists in the department hold a record number of patents for termite control, wood preservation, non-destructive testing, and the development of new products. Graduate study in the Department of Sustainable Bioproducts leads to the MSc degree in forest products or a PhD in forest resources with an emphasis in forest products. Major areas of study include composite wood products, environmental biotechnology, wood preservation, business and production systems, wood chemistry, and furniture. Graduate research assistantships are available and include tuition waiver and medical insurance reimbursement for in and out of state students. The Forest Products degree was consolidated into an option within Forestry. In 2017, the department had 32 graduate students (9 MSc, 23 PhD) from 14 countries, and 10 undergraduates enrolled in the new program in biomaterials. The faculty is comprised of 6 professors, 2 associate professors, 5 assistant professors, one assistant research professor, 8 emeritus professors, and 7 adjunct faculty (Barbu 2017a, Mississippi State Univ. 2016).

Department of Forest Biomaterials, College of Natural Resources, North Carolina State University, Raleigh

Founded in 1887, when the first class of 72 students enrolled, North Carolina State University (NCSU) counts nowadays more than 34,000 students and nearly 8,000 faculty and staff. NC State's research expenditures are approaching more than \$325 million annually, with almost 70% of faculty engaged in sponsored research and 2,500 graduate students supported by research grants. NCSU is ranked third among all public universities in industry-sponsored research expenditures. It is ranked among the US top 50 public universities and ranked by Princeton Review as a best value for students. The departments, Forestry and Environmental Resources, Parks, Recreation and Tourism Management, and Forest Biomaterials are ranked among the nation's best in their fields.

The Department of Forest Biomaterials (FB) is part of NCSU's College of Natural Resources (CNR). It was founded in 1929 as the NC State's School of Forest Resources and is one of the oldest and largest departments of its kind in the nation. In 1948, the Division of Forestry established its first wood utilization program, featuring a curriculum centered on wood technology and lumber products merchandising. A year later, formal research programs and laboratory teaching methods were introduced in order to provide students with a way to combine their fundamental knowledge with practical skills better preparing them to join the ranks of industry upon graduation and to enjoy success in their careers. By 1950, MSc degrees and PhD's in Wood Technology were available. In 1951, a special pulp and paper program that combined the School of Forestry, Department of Chemical Engineering and Department of Chemistry was announced. Meanwhile, a wood products laboratory had been built and equipped through funding and donations. More mill working equipment and furniture manufacturing machines were donated, and a second wood products laboratory was created. Other facilities for both wood science and paper science areas followed in rapid order, including the Hodges Wood Working Laboratory and the Robertson Laboratory of Pulp and Paper Technology. In 1960, a fifth year program was inaugurated to allow students to obtain a BSc degree in pulp and paper technology in four years, complete the requirements for a BSc in chemistry engineering during a fifth year (a program that continues today). By the end of the 1960's, NC State had obtained the largest collection of tropical wood in the U.S. and become a leader in study, research and instruction involving tropical woods and their uses. The 1980's saw an increasing emphasis on environmental science and biotechnology in the wood, paper and pulp industries. Demand for NC State graduates exploded, and foundation support and endowed scholarships continued to grow, with 50% of all paper and pulp students receiving scholarships. By the mid-1980's (and continuing today), NC State had the largest undergraduate wood, paper and pulp student enrollment in the US. In 1999, as the wood products program continued to expand and support North Carolina's wood-related industrie, the paper science faculty significantly revised its undergraduate curriculum. In 2000, a grant was approved for a 100% distance learning-based MSc of Wood and Paper Science, the first pulp and paper degree of its kind in the world. In recognition of these research initiatives, the Department of Wood and Paper Science was renamed the Department of Forest Biomaterials in 2010. And in 2013 the Wood Products degree was expanded to explicitly include class in sustainability, and renamed to Sustainable Materials and Technology. Enrollment in a BSc in Wood Products Business Management and BSc in Wood Products Manufacturing & Engineering is currently at 36. FB is currently home to 20 full-time faculty, 12 active adjunct faculty, 9 staff members, 5 research associates, more than 150 undergraduate students and 48 graduate students, participating in both on-campus and distance education curriculum. It has over 2,000 alumni (Barbu and Goodel 2017, North Carolina State Univ. 2016).

Department of Agricultural and Biological Engineering, College of Agricultural Sciences, Pennsylvania State University, Mont Alto

In 1855 the Commonwealth chartered the Pennsylvania State University (PSU) at the request of the Pennsylvania State Agricultural Society. Founded in 1930, the Department of Agricultural and Biological Engineering in Penn State's Colleges of Agricultural Sciences and Engineering, provides high quality engineering education and research. The educational programs offered are the BSc in Biological Engineering, BSc in Agricultural Systems Management, and MSc and PhD in Agricultural and Biological Engineering. Faculty have been consolidated into an Agricultural & Biological Engineering Department.

Wood Products will phase out as a new undergrad (and grad) program in Biorenewable Systems is developed that will retain a "wood" core, but also embrace other bioproducts. Currently Wood Products has about 20 students (Barbu 2017c, Pennsylvania State Univ. 2016).

Departments of Forest and Natural Resources Management and Paper and Bioprocess Engineering, State University of New York, Syracuse

The State University of New York (SUNY) was founded at Potsdam, New York in 1816. Since 1948 SUNY has grown to include 64 individual colleges and universities that were either formerly independent institutions or directly founded by the State University of New York. SUNY provides access to almost every

field of academic or professional study within the system via over 7,000 degree and certificate programs. Total enrollment is over 467,000. Nearly 40% of New York State high school graduates choose SUNY. The alumni number over 2.7 million graduates.

Department renamed to Sustainable Construction Management and Engineering (SCME) with the elimination of the Wood Products Engineering degree. The SCME are now offered through the departments of Forest and Natural Resources Management and Paper and Bioprocess Engineering. SCME has been dissolved as a department. It will continue to offer courses in topics of Wood Products Engineering for students interested in wood science, properties of wood as a construction material, wood identification, and materials marketing. The new department offers a BSc in Construction Management, and graduate degrees in Sustainable Construction Management and Wood Science. Graduate programs leading to MSc or PhD degrees are offered in three options: Construction Management, Sustainable Construction, and Wood Science. A concentration in Wood Products Engineering provides optional coursework in the manufacturing, properties and marketing of wood products. Currently SUNY has a Construction Management major. Enrollment has been stable at about 85 students (Barbu 2017c, State Univ. of New York 2016).

Department of Forest, Rangeland and Fire Sciences, University of Idaho, Moscow

The University of Idaho opened its doors in 1892, when it welcomed about 40 students and one professor. In 1896, the university graduated its first class when four students marched across a stage to receive their diplomas. Two years later, the university awarded its first graduate degree. Today, the university is home to nearly 12,000 students and nearly 3,159 faculty and staff. It continues to be a leading place of learning in Idaho and the West, because although it is ever-responsive to the changing needs of its students and society, it never forgets its roots and traditions.

The Department of Forest, Rangeland, and Fire Sciences gives a wide range of ecology and management skills pertaining to forests and landscapes. Graduates of Forest Resources degree program are extensively recruited by employers in public and private sectors. New degree in "Renewable Materials" in a Forest, Rangeland and Fire Dept. Already they are growing enrollment at 17 (Barbu 2017c, Univ. of Idaho 2016).

School of Forestry and Wildlife Science, Auburn University, Alabama

Auburn University today is a comprehensive grant institution helping fulfill the dreams of nearly 25,000 students. The university began, as the small, East Alabama Male College, which was chartered in 1856 and opened its doors in 1859 as a private liberal arts institution.

The School of Forestry and Wildlife Science offers degree program (MSc and PhD) in Forestry, Wildlife Sciences and Natural Resources, and a Masters of Natural Resources (MNR). Three MNR options are available: Natural Resource Management, Advanced Forestry Studies, Professional Forester Applied Economics (Barbu and Goodel 2017, Auburn Univ. 2016).

College of Engineering, Forestry and Natural Sciences, Northern Arizona University, Flagstaff

Founded in 1899, Northern Arizona University (NAU) is a public university with academic programs, research, public service, and creative endeavors that enrich lives and create opportunities in Arizona and beyond. NAU counts 151 number of degree programs, 31 average class size and 30,000 students enrolled.

At the College of Engineering, Forestry and Natural Sciences (CEFNS) the next-generation engineers and scientists are trained for careers. Degree programs are available for Forestry, International Forestry and Conservation, Forest Health and Ecological Restoration, Forest Science (Barbu 2017d, Northern Arizona Univ. 2016).

Department of Natural Resource Ecology and Management, School of Forestry, Oklahoma State University, Stillwater

The Department of Natural Resource Ecology and Management (NREM) have expertise in conducting interdisciplinary instruction, research, and extension education which focus on the natural resources of fisheries, forests, rangeland, and wildlife within and beyond the boundaries of Oklahoma. The NREM faculty support undergraduate and graduate programs in Fire Ecology, Fisheries, Forestry, Natural History, Rangeland, Wildlife and Wildlife Biology and Preveterinary Science. The NREM curriculum prepares students to plan, implement, and research the management, protection, and sustainable use of natural resources. The department provides an integrated education in renewable natural resource management, conservation, and utilization, as well as a valuable perspective for understanding and solving critical contemporary environmental problems at local, regional, and global scales. NREM has 27 faculty members in different areas including one professor in wood science (Barbu 2017d, Oklahoma State Univ. 2016).

College of Agriculture, School of Renewable Natural Resources, Louisiana State University, Baton Rouge

In the State of Louisiana, the forest industry contributes over 50% of the total value of all agricultural, animal and fish/wildlife commodities. In addition to lumber, plywood, OSB and the production of other primary products, valuable secondary products are also produced such as furniture and kitchen cabinets.

In 1994 the LSU Agricultural Center established the Louisiana Forest Products Laboratory (LFPL). In 2003 the name was changed to the Louisiana Forest Products Development Center (LFPDC) to better reflect the breadth of our expertise and client base. The Center, now an integral part of the School of Renewable Natural Resources, provides technical assistance to the primary and value-added processing wood products industries in Louisiana. Since its inception, the LFPDC has made great strides and is currently firmly positioned as one of the most recognized and productive forest products research and outreach centers in the United States (Barbu 2017d, Louisiana State Univ. 2016).

Forest Products Laboratory, U.S. Department of Agriculture, Madison

Nation's only federally funded wood utilization research laboratory the Forest Products Laboratory (FPL) is primarily or partly responsible for many of today's wood-based technologies, including wood preservatives, glulam beams, oriented strand boards, and fiber-based packaging.

At the turn of the 19th century, logging had proceeded across much of the eastern United States and demands for wood products were rising rapidly. In 1910, FPL was established in Madison (Wisconsin), to find ways to conserve scarce timber resources. For almost 100 years, the mission of FPL has been to use the Nation's wood resources wisely and efficiently, while at the same time keeping our forests healthy. The research began with preserving railroad ties, and now we are venturing into nanotechnology and finding ways that our research can contribute to mitigating the impacts of climate change. Early research highlights of FPL were: the reduction of timber demand for railroad ties by 75% through preservatives research, the increase of average lumber yield per log from 25% to 60%, the use of wood frame technology used in over 90% of the Nation's homes and the first prefabricated home designed and constructed in US. The FPL research staff has the experience and expertise needed to make us world renowned among forest products research organizations and an unbiased source of information. FPL researchers, currently employed over 60 scientists with an average of 20 years of experience in their related fields. The range of wood research spans from fiber and chemical science to composites. Whether it's putting a self-adhesive, environmentally friendly stamp on an envelope or walking on a hardwood floor, FPL has in some way contributed to making those products and innovations (Barbu 2017d, Forest Products Lab. 2016).

Department of the Wood and Forest Sciences, Faculty of Forestry, Geography and Geomatics, Laval University, Quebec City

Laval University, with 45,000 students enrolled at undergraduate and graduate levels in 2014, is the oldest francophone university in North America, founded in 1663. Faculty of Forestry, Geography and Geomatics (FFGG), founded originally in 1910 as School of Surveying and Forest Engineering has a total of 1,266 students enrolled in 2014, of which 959 are enrolled at undergraduate level in three departments (Geography, Wood and Forest Sciences and Geomatics), while 175 are enrolled at master and 132 at doctoral level. These students are educated by 67 professors of the FFGG, of which 31 are the professors teaching the students of the Department of the Wood and Forest Sciences. The FFGG has also 310 employees offering administrative and technical services, of which 181 are with DWFS.

The Department of Wood and Forest Sciences (DWFS) is the result of merger of three departments in 1985, those of Ecology and Pedology, Sylviculture and Forest Management and Exploitation and Utilisation of Wood, existing as such since 1965. The Wood Engineering Program (WEP) represents a unique engineering program in Canada, educating wood engineers who become members of the Order of Engineers of Quebec. This program is unique in Quebec and in Canada because it is the only WEP accredited (since 2002) by the Canadian Engineering Accreditation Board (CEAB) in Canada. The WEP (120 credits of which 90 in required courses and 30 in optional courses) is conceived as a program educating wood engineers through development of 12 engineer qualities within required (compulsory) courses, while the students are also offered a possibility of choice of 12 credits among optional courses in order to get access to 4 concentrations (mentioned in their diplomas if they choose that option) in: 1) Wood Construction, 2) Engineered Wood Products, 3) Green Chemistry and Biorefinery and 4) Industrial Engineering and Manufacturing Systems. WEP offered at Laval University is a cooperative program, which means that the students are required to perform 3 internships in industry (during fall, winter and summer trimesters) during their four years' curriculum, with a possibility to add yet a fourth (optional) internship. In 2014 a total of 48 students enrolled in WEP (undergraduate level) was recorded, while at graduate studies in wood sciences, 9 students were enrolled at master and 24 at doctoral level. These students are educated in an exceptional environment provided by the Research Center for Renewable Materials by 8 professors

teaching in the WEP. The CRMR, founded 2013 in continuation of Wood Research Center founded in 2002, regroups 47 researcher regular members and 13 associated members from Laval University, University of Quebec in Trois-Rivières, Abitibi-Témiscamingue and Chicoutimi, as well as from two technical colleges, from FPInnovations, CECO bois and from Natural Resources of Quebec and of Canada. There are a total of 179 graduate students and postdoctoral fellows associated to the CRMR (Barbu 2016b, Laval Univ. 2015).

Department of Wood Science, Faculty for Forestry, University of British Columbia, Vancouver

The University of British Columbia (UBC) is a global centre for research and teaching, consistently ranked among the 40 best universities in the world. Since 1915 when UBC officially established with three Faculties: Arts and Science, Applied Science, and Agriculture, its West Coast spirit has embraced innovation and challenged the status quo. Its entrepreneurial perspective encourages students, staff and faculty to challenge convention, lead discovery and explore new ways of learning. At UBC Vancouver campus 25 faculties and schools are established. Today, UBC has over 61,000 students of which more than 13,000 are international coming from 155 countries and over 15,000 faculty and staff. The annual budget of the university exceeds the CDN \$ 2.3 billion and it is ranked 34th in the world according to Times Higher Education for 2015.

Between 1915 to 1918 was officially established the Faculty for Agriculture which later hosted the first forestry course. In 1920, Department of Forestry was authorized at UBC and 1923 first BSc degree in Forest Engineering was awarded. Ten years later the first MSc degree in Forest Engineering was awarded. In 1949 the MSc of Forestry and PhD programs were authorized and in 1951 the Faculty of Forestry was established. 1957 signifies the welcoming of the Sopron students and staff to the Faculty of Forestry at UBC. The students of the Sopron School of Forestry in Hungary were forced to flee their homeland when the anti-Soviet Revolution failed. This mass immigration provided BC with a new perspective on forestry and a major contribution to the industry. In 1981, the Departments of Forest Resources Management, Harvesting and Wood Science, and Forest Science are established. One year later a major in Wood Science and Industry was introduced to BSc. In 1997, the BSc in Wood Products Processing was established. After 1990 a significant wave of graduates students from Eastern Europe join MSc and PhD courses of this faculty within UBC. In 2016, approximately 1,027 undergraduate students and 260 graduate students (about 50/50 split between MSc and PhD) are enrolled at the faculty. Forestry has 61 professors and a number of instructors/sessionals that are responsible to deliver its six undergraduate programs.

The Department of Wood Science (DWS) was formed in 1982 as one of the three departments including Forest and Conservation Sciences and Forest Resources Management that comprise the Faculty of Forestry at UBC. The DWS offers both undergraduate and graduate programs leading to BSc, MSc, and PhD degrees, respectively. The undergraduate program Wood Products Processing (WPP) includes advanced wood products processing, industrial processing technology, business management and marketing, and science and engineering. Currently, the WPP has 170 students that also offers the option of co-op where students will spend periods of time with companies gaining practical experience and being paid for a total of at least one year. The graduate degrees are offered in many fields related to wood science & technology, biotechnology and the forest products industry, processing and business. All of the nineteen professors in the DWS supervise over 70 students in a 60/40 (PhD/MSc) split working towards their post-graduate degrees in wood science. The Centre for Advanced Wood Processing (CAWP) was created, in consultation with the University's Forestry Advisory Council, with input from the National Education Initiative on the Canadian Wood Processing Industry (NEI), to address the need for advanced technical and managerial training for the value-added wood products manufacturing sector. CAWP is an interdisciplinary initiative administered by the DWS. The CAWP supports part of the WPP program and provides industry support through consulting and R&D projects both at national and international level. Industry education is also a strong activity of this centre (Barbu 2016b, Univ. of British Columbia 2015).

Center of Integrated Wood Design, University of Northern British Columbia, Prince George

Located in northern British Columbia, UNBC is one of Canada's best small and research-intensive universities. UNBC provides undergraduate and graduate learning opportunities that explore cultures, health, economies, and the friendly, inclusive, and supportive environment. It was in 1990 that the members of the BC legislative assembly passed the UNBC Act, officially creating it. The dream of having a northern university goes back much further, to the 1960s, when the land on which UNBC's Prince George campus is currently situated as a university reserve.

The Master of Engineering Program is rooted in the specific needs to the British Columbian and North American wood construction industry, adding value from the sawmills to the building site, and well aligned with strategies and priorities that lead into sustainable construction. This program focuses on educating students in the field of modern wood structures including up-to-date structural design, seismic design and mixed structures, as well as building physics, energy efficiency and sustainability. The knowledge

obtained in this program enables students to actively contribute to the evolution and innovation in the construction industry. The aim of the MSc of Engineering in Integrated Wood Design program is to educate and train engineers and qualified professionals. Students come from a variety of undergraduate programs in BC, Canada, and worldwide. The curriculum consists of 16 courses with a total of 51 credits over 12 months, developing integrated design and research skills. The entire program is offered in a block structure to increase efficiency and attractiveness for students, faculty, and international experts (Barbu 2016b, Univ. of Northern British Columbia 2015).

Forest Product Innovations, Vancouver

FPInnovations (FPI) is a not-for-profit world leader forestry research organization, which specializes in the creation of scientific solutions in support of the Canadian forest sector's global competitiveness and responds to the priority needs of its industry members and government partners. FPI was established in 2007 through an amalgamation of Forintek (established in 1918 as Forest Products Laboratories of Canada, which later became Forintek Canada Corp.), Paprican (the Pulp and Paper Research Institute of Canada, since 1925), Feric (Forest Engineering Research Institute of Canada, since 1975) and a partnership with CWFC (Canadian Wood and Fibre Centre of Natural Resources Canada). FPI is strategically positioned to perform research, innovate, and deliver state-of-the-art solutions for every area of the forest sector value chain, including forest operations and fibre assessment, primary and secondary wood products manufacturing, supply chain analytics and decision support systems, transport logistics and roads, advanced building systems, bio-based chemicals and biomaterials, biorefinery and energy, pulp and paper, packaging, consumer products and nonwovens.

FPInnovations has more than 500 skilled staff, working in its world-class R&D laboratories, pilot plants, and technology transfer offices across Canada in Montréal, Vancouver, Québec City, Thunder Bay, Hinton and Ottawa. FPInnovation is offering complete value chain solutions with an annual operating budget of about CDN \$90 million, more than 400 industrial and government members across Canada, partnerships with more than 25 universities and other institutions in Canada and abroad. It has 300+ patents in key forest processing markets around the world, 100+ patented technologies and processes, 100+ R&D projects, seven pilot plants (durability and protection, composites, medium density fiberboard, wood engineering, lumber manufacturing, cellulose nanocrystals, lignin), about a dozen R&D programs, one pilot paper machine, and Canada's largest CT imaging centre. FPI has been a partner of many forest sector university networks such as ForValueNet, Value Chain Optimization, NEWBuilds, SENTINEL Bioactive Paper, Green Fibre, Biomass Conversion, Lignowork, ArboraNano, Fibre Centre, hosted at universities including Univ. Laval, UBC, Montreal, Toronto, Queens, Dalhousie, Lakehead, McMaster, Polytechnique, McGill, UNB, UNBC, Alberta, UQAT, UQAM, among others (Barbu 2016b, Forest Product Innovations 2015).

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