Outline of Lecture

I. Innovation and Canadian Productivity
II. Examples of Innovative Companies
III. Disruptive Technologies
IV. Disruptive Technology Platforms along the Forest Sector Value Chain
Innovation Defined

The extraction of economic, social or environmental value from knowledge

People

Policy

The Innovation Ecosystem

Discovery & Invention

The discovery, invention and commercialization value chain

Researchers S&T

$ in

KNOWLEDGE

TECHNOLOGY

INNOVATION

PRODUCTIVITY

PROFITS

$ out

Companies Goods & Services

GROWTH
… not all are successful and many succumb to the “Valley of Death”

- Discovery and invention happens in the scientific community – University, Research Institutes etc.
  - A process where $ are used to develop ideas, discoveries, knowledge, technology, etc.
- Innovation happens on the shop floor
  - A process where ideas, discoveries, knowledge, technology, etc. are covered into $ (GDP growth, productivity improvements, sales and profit).
- “Valley of Death” deepens with scientist “push” which is not aligned with “pull” from productivity and market needs
- “Surviving” companies manage this well
  - Stora Enso movement into Building Systems/Solutions

Canada has mostly used indirect tax incentives rather than direct support to companies who are bridging the “valley of death”
Canada has been investing in invention and knowledge generation and expecting the outcome will be innovation and higher productivity

- Canadian academic research, overall, is strong and well-regarded internationally
- Canadian business innovation is weak by international standards and is the primary cause of our weak productivity growth and declining competitiveness

1. The State of Industrial R&D in Canada Council of Canadian Academies, 2013
2. Paradox Lost CCA, 2013
3. Innovation Canada: A Call to Action, 2011

Weak multi-factor productivity (proxy for “disembodied” innovation) largely explains the productivity gap between Canada and US
Can be argued that Canadian businesses, particularly in the resource sector, have been as innovative as they have needed to be.

**Canadian forest sector research and innovation agenda**

- Research focused on commercial solutions
- Build new partnerships with universities and others
- Strengthen technology receptor capacity (Valley of Death)
- Optimize current and future product value streams
- Emphasize transformative technologies
- Capitalize on bio-economy window
Paradigm shift in how technology is developed and implemented; NewBuilds network is a case in point

New business model for research, development and deployment
Technological developments in the forest sector can follow either an “Evolutionary” or “Revolutionary” pathway...

**Technology Options**

**STOP & FIX**  
Evolutionary or Incremental technologies applied to core business; can include process efficiencies, expanding markets and applications or adding and enhancing attributes to current products

**STOP & LAUNCH**  
Revolutionary or Transformative technology leads to entirely new products or value chains or, new ways of doing business that result in more economical consumer trade-offs and eventually displacing established competitors

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Forest Industry technological development has been both “Evolutionary” and Revolutionary in nature and applied along the full value chain

- Clonal & Somatic Embryogenesis propagation
- Marker-Assisted Tree Breeding
- Drones & Lidar
- 3-D Landscape & Bio-diversity Management
- Ecosystem Services

- Timber Processing Heads
- Continuous Presses
- Log X-Ray Scanning
- Real Shape and Grade Lumber Scanning
- High Efficiency Recovery Boilers

- Specialty EWP
- Specialty industrial and appearance application
- Hybrid components and systems
- Emerging markets

- Value Chain Optimization
- Product and Market Diversification
- Automation of businesses and manufacturing processes
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Walmart is a pioneer in Value Chain Optimization by exploiting the early digital revolution

1. Inventory
2. Cash Cycle
3. Growing the Brain
   • Learning
   • Data sales
4. Global supply chains

Cawood and de la Roche, Dying or flying? Strategies for riding the curve of change, Forest Products Journal 1999
Home Depot is a “big box” home improvement retailer – serving 3 customer segments

- Do-It-Yourself (DIY)
- Do-It-For-Me (DIFM)
- Professional

Core Competences:
- Product Manufacturing
- Value Engineering
- System Solutions
- New Product Development
- Design & Marketing
- Further Processing
- Shelf Space
- Local store locations
- "Last Mile" Distribution
- Influence product development

Home Depot’s Role in the Value Chain

- The company’s scale give them the influence in the value chain to:
  - Rationalize product distribution and remove costs
  - Work throughout the supply chain to develop products and product bundles that provide the customer with “solutions” and gives the company proprietary positioning

Home Depot “value proposition” is providing innovative product and services offerings
IKEA “backward integrates” to drive innovation and maintain a competitive price structure...

IKEA’s Role in the Supply Chain

![Diagram of IKEA Industry supply chain]

Core Competences:
- Product Manufacturing
- Value Engineering
- Global Supply Chain
- Shelf Space
- Further Processing
- Product development
- Design & Marketing
- Assembler
- Retailer

- … while ensuring required volume to supply their global sales expansion
- IKEA’s internal supply division is a leading force behind the company’s ability to innovate and be a globally competitive future retailer

…. has also forward integrated; partnering with Skanska to “create affordable homes for ordinary people”

![Images of BOKlok housing projects]
BillerudKorsnäs develops innovative products to meet the demand for sustainable solutions...

... and is pursuing emerging technologies such as interactive & intelligent packaging...
… with the objective of driving sustainability throughout the value chain

Blue Ocean Strategy

Adapted from BillerudKorsnäs

Over last 8 years, UPM has re-branded itself into a value-added bio-products company—The Biofore Company

Adapted from UPM annual report
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Global Mega Trends that are having “disruptive” impacts on our society

<table>
<thead>
<tr>
<th>Trend</th>
<th>Description/Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>World population will reach ~10 billion by 2050</td>
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<tr>
<td></td>
<td>• Asia and Africa are the regions with the greatest growth</td>
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<td></td>
<td>• Developed Countries have older age profiles and declining birth rates</td>
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<tr>
<td>Urbanization</td>
<td>• In both developed and developing economies, people are moving from rural to urban</td>
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<td></td>
<td>• Mega-cities (10+ million) are growing the fastest – especially in Southern</td>
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<td></td>
<td>• Pressure on infrastructure, Environment, and Social Systems</td>
</tr>
<tr>
<td>Globalization</td>
<td>• Global trade continues to grow, even with “populus” political pressures</td>
</tr>
<tr>
<td></td>
<td>• Economic power shifting to developing Nations – India, China, Brazil etc.</td>
</tr>
<tr>
<td></td>
<td>• International Banking and Multi-National Corporations enabling</td>
</tr>
<tr>
<td></td>
<td>• Greater social response adjustments required</td>
</tr>
<tr>
<td>Income Inequality</td>
<td>• Directionally - Inequality between countries decreasing, Inequality within countries increasing</td>
</tr>
<tr>
<td></td>
<td>• Wealth concentration increasing even faster than income</td>
</tr>
<tr>
<td></td>
<td>• Inequality has potential to undermine democratic society</td>
</tr>
<tr>
<td></td>
<td>• Migration driven by knowledge of inequality</td>
</tr>
<tr>
<td>Disruptive Technologies, e.g., Digitization</td>
<td>Changes business model</td>
</tr>
<tr>
<td></td>
<td>• Used in decision making, manufacturing, communicating, interacting and transacting with customers, suppliers and employees</td>
</tr>
<tr>
<td></td>
<td>• Still in infancy for new business models and impacts</td>
</tr>
<tr>
<td>Sustainability</td>
<td>• Meeting today’s needs without compromising ability of future generations</td>
</tr>
<tr>
<td></td>
<td>• Climate change driving control of greenhouse gas emissions</td>
</tr>
<tr>
<td></td>
<td>• Sustainable solutions will be disruptors to some industries – Energy</td>
</tr>
<tr>
<td></td>
<td>• Wood products well positioned</td>
</tr>
</tbody>
</table>
Disruptive Technologies share four characteristics

• High rate of technology change
  – Rapid rate of change in capabilities in terms of price/performance relative to substitutes and alternative approaches
  – Experience breakthroughs that drive accelerated rates of change
  – E.g. genomics for personalized medicine or advanced materials (nanomaterial) for strength or conductivity

• Broad potential scope of impact
  – Touching individuals, companies and industries and affecting wide range of machines, products or services
  – E.g. mobile internet impacting global information sharing or Internet of Things (IoT) connecting and embedding intelligence in billions of objects around the world

• Large economic value that could be affected
  – Value at stake must be large in terms of profit pools that may be disrupted, additions to GDP that may develop, and capital investments that may be rendered obsolete
  – E.g. advanced robotics for labor savings or cloud technology for distribution of IT technology

• Substantial potential for disruptive economic impact
  – Transform how people live and work, create new opportunities or shift surpluses for businesses, and drive growth or change comparative advantage for nations
  – E.g. next generation genomics transforms how doctors treat disease, energy storage changes how, where and when we use energy

Social and economic impacts may be considerable

Disruptive technologies are powerful forces that unseat entrenched incumbents.

<table>
<thead>
<tr>
<th>Disruptive Technology</th>
<th>Disrupted Incumbent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Camera</td>
<td>Feb 2012: Announced it will no longer make cameras</td>
</tr>
<tr>
<td>Smartphone</td>
<td>Nov 2012: Announced it intended to discontinue wireline service</td>
</tr>
<tr>
<td>E-Commerce</td>
<td>Sep 2011: Closed final brick &amp; mortar locations</td>
</tr>
</tbody>
</table>
The pace of technological change is accelerating

- **Moore’s law**
  - 5th paradigm of a much broader exponential principle of computation
  - Probably the most famous law implies that chip capacity doubles every 18 - 24 months
  - Same law hold true for other technologies, but at varying time rates
  - Ceilings reached, but then usually a break-through occurs

- **Law of Accelerating Returns**
  - Each successive generation is used in developing the next generation
  - Faster tools to design and build faster tools
  - Rate of progress of an evolutionary process increases exponentially over time, and the returns increase exponentially
  - Greater cost efficiency usually leads to greater resources resulting in a second level of exponential growth

Costs associated with application of new technologies drop dramatically as they mature

### Technology costs are rapidly decreasing

<table>
<thead>
<tr>
<th>Technology</th>
<th>Year</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genome Sequencing</td>
<td>2000</td>
<td>&gt;$500 million</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>&lt;$1,000</td>
</tr>
<tr>
<td>Computing Costs</td>
<td>1992</td>
<td>$222</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>6¢</td>
</tr>
<tr>
<td>Data Storage</td>
<td>2006</td>
<td>25¢</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>zero</td>
</tr>
<tr>
<td>Solar PV module</td>
<td>2006</td>
<td>$3.25</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>$0.57</td>
</tr>
</tbody>
</table>
Adoption rates of technology are increasing – what took years now takes months

- Time needed for basic inventions to enter mass use has steadily decreased
- Cycles of technology induced societal and economic change are becoming faster
- Increasingly changes will come from the convergence of sciences and technology impacting industries that have been slow to change
  - Energy
  - Transport
  - Construction

Organizations are having a difficult time absorbing the pace of technological change

- Technology changes at an exponential rate
- Organizational changes are slower
  - Changes in behavior and culture take time
  - Only so many changes in people, processes, and technology that an organization can productively absorb at once
- Implications
  - Management must strategically choose which technological changes to embrace, given constrained bandwidth to absorb organizational changes
    - Ruthlessly choose those that align with strategy
  - Management tends to over-estimate capabilities - Better at things than we actually are
    - Strive to be a more agile organization to accelerate the rate at which you can absorb change
    - Diverse work force
Technologies that are now disruptive or have the capability of being disruptive in near term

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Description</th>
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<tbody>
<tr>
<td>Mobile Internet</td>
<td>Increasingly inexpensive, computing and communicating devices with internet connectivity</td>
</tr>
<tr>
<td>Artificial Intelligence</td>
<td>Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgement</td>
</tr>
<tr>
<td>Internet of Things</td>
<td>Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization</td>
</tr>
<tr>
<td>Cloud Technology</td>
<td>Use of computer hardware and software resources delivered over a network or the Internet as a service</td>
</tr>
<tr>
<td>Advanced Robotics</td>
<td>Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans</td>
</tr>
<tr>
<td>Autonomous vehicles</td>
<td>Vehicles that can navigate and operate with reduced or no human intervention</td>
</tr>
<tr>
<td>Next generation genomics</td>
<td>Fast, low-cost gene sequencing, advanced big data analytics, and synthetic biology (writing DNA)</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>Devices or systems that store energy for later use (including batteries)</td>
</tr>
<tr>
<td>3 D printing</td>
<td>Additive manufacturing techniques to create objects by printing layers of material based on digital models</td>
</tr>
<tr>
<td>Advanced materials</td>
<td>Materials designed to have superior characteristics (e.g. strength, weight, conductivity or functionality)</td>
</tr>
<tr>
<td>Advanced oil and gas</td>
<td>Exploration and recovery techniques that make extraction of unconventional oil and gas economical</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>Generation of electricity from renewable sources with reduced harmful climate impact</td>
</tr>
</tbody>
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The Forest industry has its own disruptive technological platforms that will impact its future

1. Digitalization
   - Is the technology of using digital data to change a business model and provide value producing opportunities
   - Digital and Internet which includes the Internet of Everything (IoE), Big Data and Advanced Analytics, The Cloud, Quantum computing, Connectivity and Blockchain, Virtual Reality and Augmented Reality

2. Automation and Advanced Manufacturing
   - Is the technology of using digital enabled manufacturing process
   - Robotics, Sensor, Artificial Intelligence (AI) and Machine Learning, Automation, RFID tags, Biometrics, rapid prototyping, custom product creation, 3-D printing

3. Genomics
   - Is the technology of DNA, gene sequencing and function with digital data
   - Synthetic Biology, Gene Editing, engineered proteins and enzymes, biotechnology

4. Advanced Materials
   - Is the technology of changing properties of materials with the usage of and manipulation particles at the atomic or molecular level (0 – 100 na in size)
   - Nanotechnology, nanomaterials and nanostructures

Digitalization - Lidar provides a readily obtainable digital image of the forest that improves forest management and lowers costs

- Lidar (Light Detection and Ranging) remotely measures distances and produces a digital image
- More accurate inventory with LIDAR tools
  - Much faster, cost-effective inventory updates and decision making
  - Improved harvest scheduling
- Combine with other satellite imagery provides for improved silvicultural investments (e.g. site productivity, fertilization)
  - Drought stresses
  - Disease monitoring
  - Genetic selection
Automation - Companies like Katerra are taking advantage of the opportunities “disruptive technologies” present to the construction industry

- Katerra is a technology company that is optimizing every aspect of development, design and construction of buildings with focus on:
  - Aesthetics
  - Sustainability
  - Cost and speed of construction (7X faster than stick-built)
- Integrated factory manufacturing components and systems based on mass customization
  - Full digital integration from front office design team, prefab plant and jobsite
- Manufacturing approach can be further enhanced with increasing use of robotics and AI

3-D printing of structures is in its infancy with several proto-types

- 3-D printer, 20 feet high, 120 feet long and 40 feet wide printed and assembled this fully functional office in just 17 days
- 3-D printer in use expected to double every year from almost 62,000 in 2013 to nearly 2.5 million by 2018
- Technology is not fully matured; reported issues around structural failures
- Opportunity to bring together development of new wood-based composite materials, advanced robotics and additive manufacturing technologies
- Near-term applications will be manufactured pre-fab components which could include hybrid systems containing a wood based component and the production of interior decorative elements and furniture
Genomics - Genetic selection in the US South has shortened rotations by 10 years and improved tree form

- Genomics tools allow for
  - Verify the identity of seed orchard trees using DNA fingerprinting for precise tracking of every family
  - Improve the value of existing MCP® (Mass Clonal Pollination) families for an even greater return on investment
  - Quickly identify the very best trees with the best families to speed development of new varieties
  - Genetically improve forest tree species at a much faster pace than traditional breeding approaches

Advanced materials - produced from wood fibre will be “complementary” or “disruptive” to traditional wood products

### Cellulose Nano Crystals (CNC) & Cellulose Fibrils (CF)

- **CNC**
  - Nanometric dimensions, large aspect ratio, and excellent mechanical and chemical properties of CNC has potential applications in areas, including materials science, electronics, and medicine
  - CelluForce a JV between Domtar FP Innovations is unique due to its benefits of being a renewable, sustainable, non-toxic, and biocompatible nanomaterial

- **CF**
  - Performance Bio-Filaments JV of Resolute and Mercer
  - Kruger CF for strengthening their hygiene products

**CatLignin**

- VTT of Finland has developed CatLignin technology for producing reactive lignin from pulp industry side streams currently used for energy production
- CatLignin is a replacement for phenol in phenol formaldehyde resins and could become a new, high-value product for pulp mills.
- CO₂ footprint of lignin is only approximately 20% of the footprint of phenol
Some key take home messages

1. Disruptive technologies can be both a potential threat or an opportunity
2. Considerable added-value remains to be extracted from the forest sector value chain
3. The North American forest sector generally reluctant to fully engage and could be better prepared to capitalize
4. The research community needs to be more proactive in aligning with forest sector priorities and strategies

Achieving new heights through research, technology and innovation

Thank you