FOREST BIOTECHNOLOGY

GLOBAL OPPORTUNITIES FOR SOMATIC EMBRYOGENESIS

MBA 848

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1.0 Introduction

Forestry biotechnology is a burgeoning industry promising the potential to lower forest management costs and foster a more sustainable, healthy and productive environmental resource. The various products involved in forest biotechnology serve the forest regeneration and mill operations parts of the forestry value chain. These products or processes are primarily proprietary and their marketability is dependent on commercial application and viability as well as regulatory approvals. These regulatory requirements vary for each market, as do the expenditures on intensive forest management practices and forest regeneration.

The ever-changing technology industry is a relatively new market force, driving change for the last 30 years since the advent of high technology computing and gene mapping. Conventional plant biotechnology, or plant breeding, has been used for thousands of years for the improvement of crops however the actual science of plant genomics is only about 150 years old. Plant genetics is an industry that has been around since 1866 when Augustine Monk Gregor Mendel first published his research entitled *Experiments on Plant Hybridization* where he identifies invisible “factors” later to be known as genes.[1] Gregor died in 1884 without acknowledgement or scientific recognition of his work which is now considered the foundation of modern genetics. In 1866, August Weismann, a German physiologist, coined the term "germ-plasm" stating that the male and female parents contribute equally to the heredity of the offspring. Germplasms are now considered the main product in somatic embryogenesis (SE), a forest biotechnology process for vegetative propagation of indefinite supplies of somatic embryos from superior chosen plant stock. Vegetative propagation refers to any method used to replicate individual plants, as opposed to seed propagation.

Science has made many discoveries since Mendel, but only recently have scientists been able to explore the structure of DNA and the effects of gene-sequencing on growth characteristics. The science holds many potential benefits for forestry in commercial applications for nearly the entire value chain but, for the most part, is still primarily in research and development phases. The few commercial applications that currently exist for the market relate directly to sustainable forest management and stock regeneration through the use of SE on eucalyptus, walnut and selected pine species.

The global forest industry is a massive integrated network of exports and imports of services and products. World trade in agricultural products, 2002 was 583 billion dollars and 9.3% share in the trade of world merchandise.[2] The Food and Agriculture Organization of the United Nations (FAO) states that global trade in forest products for 2001 was over $140 billion.[3] Of this global trade market, reforestation is estimated to be $11 billion for North America and over $50 billion for the world market. This value includes spending on seedlings, planting, site preparation, pesticide applications, and monitoring. Clearly, sizable expenditures are being implemented across the globe in ensuring forest sustainability and fibre quality is maintained. The European Forest Institute (EFI) posts a Forest Products Trade Flow Database that reports on annual bilateral trade flows covering all main forest products and all countries for all years from 1962 until 2001.[4] Through querying this database, we can asses the imports and exports of any forest product to and from any country. The database is searchable for data from 1996 to 2001. A sample query is provided in Table 1 reporting all forest product exports from Canada to the noted countries. These queries show that Canada maintains an export surplus with every noted country with the exception of Sweden and Finland, leading to credence of our experience and skill in forest management.

This analysis first outlines some of the current research and development in forest biotechnology as well as describing the current commercial applications that are available for markets. A comprehensive analysis of global markets and opportunities will be explored utilizing the key issues for marketability such as competitive forces and regulatory structures of key markets. The analysis will further explore the trade policies and organizations in some of these critical global markets followed by an identification of specific opportunities in the identified markets. All assumptions and conclusions are formulated based on the explorations of this research. This framework is then utilized to develop strategic recommendations for capitalizing on the identified opportunities and selecting a prime target market for implementation.

This analysis seeks to explore the global regulation of forest biotechnology, the applicability of the science to commercial application, the degree of global competition in the market, the global opportunities that may exist, and suggestions for strategic capitalization of opportunities in a target market.

2.0 Forest Biotechnology Products

Between 1986 and 1997, about 25 000 field trials were conducted on more than 60 transgenic crops with 10 traits in 45 countries. Trials conducted in the United States and Canada accounted for more than 70% of the total, followed by Europe, Latin America, Asia and South Africa.[5] This data shows that there is increasing operational application of forest biote4chnology and that firms are seeking regulatory approval and public acceptance for these products.

The Canadian Environmental Protection Act, 1999 defines biotechnology as the application of science and engineering in the direct or indirect use of living organisms or parts or products of living organisms in their natural or modified forms.[6] Essentially, it is the modification of any organism through science and technology. Forest biotechnology is defined as the application of science and technology to modify organisms used in the forest industry. Current operational forest biotechnologies include the generation of commercial tree species with advanced growth and fiber quality characteristics, root systems mycorrhizae that enhance nutrient uptake and pathogen resistance, and oxidizing bacteria used in purifying mill effluent and soil reclamation.

The FAO classifies the areas of modern forest biotechnologies currently used in the forest industry into three categories:

1) Biotechnology tools to assist in designing and monitoring forest tree conservation programmes.
2) Technologies that enhance vegetative propagation and support large-scale production of uniform materials.
3) Genetic modification of forest tree species for addressing traits such as virus resistance, insect resistance, lignin content and herbicide tolerance.[7]

These classifications cover all current and potential technologies that would create value for the market. The outcomes of these technologies may decrease forest management costs, shorten growth to maturity time, enhance fibre quality and yields, mitigate the need and costs for pesticides and fertilizers, and foster a more sustainable and healthy environment. Forward thinking scientists consider trees potentially serving as the ideal biological manufacturers for pharmaceutical or chemical production due to their slow growth and controllable input variables. However, much of this is yet theoretical with the exception of a few key areas where research is being applied.

Natural Resources Canada (NRCAN) identifies three areas of current forest biotechnology research being implemented by Forestry Canada and various federal and institutional organizations. These research areas are:

1) Identification of genetically superior trees and genetic diversity
2) Tree Propagation Through Tissue Culture
3) Tree Improvement Through Genetic Engineering
4) Environmental impact assessment of biotechnology-derived products.
5) Forest Protection Using Biological Pest Control Methods[8]

Current projects with the Canadian Forest Service include:

- Genetically Modified Baculoviruses;
- Environmental Impacts of Forest Biotechnology;
- Conifer SE;
- Genetically Modified Trees; and,
- Genetically Engineered Baculoviruses for Forest Insect Management Applications[9].

Canada is leading the innovation and intellectual property rights in this industry. In fact, of the few global commercial ventures in the area of tree propagation through SE is a firm in Victoria. Cellfor Inc. (Cellfor) is leading the industry with the first commercially viable model for creating value through genetically superior seed and this technology has been developed to currently create commercial applications with the tree species eucalyptus, pine, and some spruce. SE remains the only current operational application of forest biotechnology that has been submitted, and in some cases approved, for environmental release. Cellfor and other firms are explored in more detail in Section 3 of this analysis.

An organization in Washington, DC called Resources for the Future (RFF) posts a discussion paper about the future impacts of forest biotechnology on the global wood supply and states that the benefits are enormous given the potential to realize savings in pesticides applications and increased growth and quality of fibre.[10] The risks seem far less critical than for genetically modified agricultural products given societal concerns over health from consumption and environmental contamination or transgenic toxicity. Given the extended growing patterns of trees, the uses of forest products not as foodstuff, and the low risk of altered genes to move out of transgenic material to the natural environment make the use of biotechnology in the forest industry much more attractive to the public. The author further goes on to state that this will impact the global forest product supply and allow less industrial nations to create value in forest activities, which in turn will drive down costs and enhance consumer value.

The forest regeneration or seedling market in North America is worth an estimated $50 billion USD per annum with seedlings ranging in cost from 1¢ (conventional methods) to 12¢ (SE systems) each.

3.0 Competitive Analysis

An analysis of the market is essential in order to create a proper understanding of the forces that drive consumer value for forestry products. The numerous forest products generated in Canada are a testament to global demand and nearly every world market has a need for quality fiber products. Forest biotechnology also engages in competitive behaviour and there are many firms building a competence in this field as the science becomes more implicit and defined through patent approvals and field applications.

3.1 Porter's Five Forces

Figure 1 shows a competitive forces model analysis utilizing Porter's Five Forces.[11] This model illustrates the forces that will affect a firm operating in the forest biotechnology business sector and the analysis of these forces frames the strategic positioning of a firm's objectives. This analysis starts with analyzing the threat of new entrants and the barriers to entry of the market, explores the power of both buyers and suppliers in the marketplace, outlines the threat of substitutes for the targeted product or service, and finally assesses the degree and status of competitive rivalry driving strategic decision making.

While forest biotechnology engages in competitive behaviour, there are few firms building core competencies in this sector. The North American market, as with other regulated nations, engage in proprietary knowledge rights to the products created in forest biotechnology. As a result, building the ability to market a product is highly dependent on capital investment into laboratories and testing combined with the research and development skills and experience of innovating leading scientists. As the science becomes implicit knowledge, defined and codified through patent approvals and field applications, further enhancements in the technologies will create additional opportunities for developers that enter the field. But these entrants will have to invest in their own proprietary knowledge that allows them to operate in this sector. The barrier to entry, therefore, is high due to the dependence on investments into human resources and research and development leading to intellectual property rights.

In the model, the buyers represent the purchasers of forest biotechnology products from a research and development firm taking their investment to market. The firm's position in the value chain, as explored in Section 3.2, shows that the purchasers can range from large forest companies and land management firms to small woodlot managers and farmers. The larger the purchaser, the more power they can exert on the success of the product. This is illustrated in the competitive forces model by the three levels of purchaser power and where purchaser types exist.

The suppliers in the model are a negligible force on the firm's competitive position. The supplier could be considered someone with a seed or parent plant of exceptional traits and flawless characteristics, ideal for cloning and vegetative propagation. In this event, the supplier would have a product worth value in the market and will be able to command the highest market bid price. However, for the most part, the supplier will be the internal research and development teams that toil and discover new technologies, processes or products. The investment into internal operations reaps rewards when intellectual property can be established and a product successfully taken to market. Therefore, the supplier power is negligible and dependent on the internal capabilities, core competencies, and investments of the firm.

The threat of substitute products for forest biotechnology is currently significant. Considering the high costs of vegetative propagation and gene sequencing, and recent impacts on softwood lumber trade in North America, have seen an impact into investments in forest biotechnology. Also, conventional seedling nurseries can produce viable hearty seedlings in approximately four months for about 1¢ while SE technologies and vegetative propagation techniques yield seedlings at a cost of about 12¢ to 15¢. As technologies develop further and enhancements to processes and techniques are made through experience, the costs of propagating a tissue culture should prove to supply seedlings at fractions of conventional costs. Given that forest biotechnology is in research and development phase and the industry has incurred a large capital investment, products are expected to remain at total cost pricing.

Competition is scarce in the industry right now primarily due to the aforementioned requirement for success as being the investment in research leading to proprietary commercial knowledge. However, of the firms leading this industry, firms in Canada have taken a strong position in the global market. Canadian firms currently active in this field include PlantSelect, a Dartmouth firm offering Tissue Culture, SE and Stock Plant Management systems.[12] There is also Cellfor, a Victoria firm producing seeds and seedlings on a commercial scale for customers in North America, South America and Australasia.[13] The unique market position Cellfor is in has given them a critical advantage over intellectual property rights of commercially viable processes. This enables customers to rapidly develop and deploy genetic improvement to forest plantations.[14] Through SE systems, they have developed the technology that allows the replication of individual trees to occur indefinitely from which they can produce millions of copies of an initial seed or germplasm. They are currently developing technology to identify and breed better seed for future generations.

Other competition in this sector is most easily illustrated with a patent search at the United States Patent and Trademark Office. A Boolean search for CONIFER and SOMATIC and EMBRYOGENESIS yielded 70 results held by corporations or individuals primarily in Canada and the United States with large corporations like Weyerhaeuser and Westvaco, and smaller independent researchers and university departments.[15] These corporations and individuals are summarized in Table 2. This cursory search through forest biotechnology patents, relating specifically to SE, shows that competitors range from large multi-national corporations like Weyerhaeuser to small independent scientists like Dr. Stephen Attree, a University of Saskatchewan independent researcher. It also shows that the core of competition is in North America, with very few European firms placing knowledge rights. A further analysis into the European market and the investment into forest biotechnology show that European firms are not very active in this field with all activity occurring at university level or research organizations sponsored by government funding. Figure 2 illustrates how a firm positions itself with respect to patent breadth and competitive position. This figure shows that competitive position for forest biotechnology is driven largely by the forces of patent breadth and intellectual property.

Porter's analysis illustrates that the most effectual force on a forest biotechnology firm is the degree of competitive rivalry and the direct linkage to intellectual property and patent breadth. Another important force includes the power of large multi-national firms, like Weyerhaeuser, and their ability to exist in several levels of the forest product value chain through vertical integration.

3.2 Porter's Value Chain Model

Utilizing the value chain model developed by porter, we can evaluate the position of a forest biotechnology firm in relation to the value chain of forest products. Analysis of the value chain model is done through a systematic approach examining the development of competitive advantage for a firm. The approach focuses on the identification of a set of interrelated, generic, value creating activities which are common to a wide range of firms.[16] Figure 3 illustrates the Cellfor Value Chain and where their business model fits into the forest industry. This model represents the position of this forest biotechnology firm and how the supplier, or the owner or the germplasm, holds the necessary inputs to create value enhanced seed. The products the of forest biotechnology firm are then delivered down the value chain to growers and land managers that harvest the benefits and capture the genetic gains. Value sharing is then transferred back through the value chain by sharing results, monitoring data, and superior seed stock. Therefore, a forest biotechnology firm can best create value by building strong relationships with quality germplasm producers as well as ensuring there is effective communication and networking between the land managers and nurseries to incorporate their products into forest management planning activities.

3.3 Porter's Competitive Strategy Model

Milton Friedman declares, with respect to the social responsibility of business, that the sole of purpose of business is to achieve profit for the shareholder while following law and social norms.[17] Profit is generated by creating value for the consumer through competitive strategies. The three competitive strategies outlined by Porter can be implemented in any combination by a forest biotechnology firm. These strategies, as they specifically relate to forest biotechnology, are as follows:

- **Competitive strategy model 1: Cost leadership**
  - Developing new lost cost methods for seedling regeneration, act as a substitute to the conventional seed propagation market
- **Competitive strategy model 2: Differentiation**
  - Differentiation through enhanced quality of forest products
- **Competitive strategy model 3: Focus**
  - Focus on innovative and leading edge research and development

Table 3 outlines an analysis of the VRIO framework as applied to forest biotechnology. This analysis shows that the value enhancing abilities of forest biotechnology, specifically SE, can prove to be marketable and enhance value to consumers.

4.0 Social, Economic and Political Factors of Forest Biotechnology

The strengths and weaknesses of an ideal and theoretical forest biotechnology firm are outlined in Table 4. This analysis shows that in order for a forest biotechnology firm to compete effectively, they must first ensure their products create value and can achieve commercial profit through financial and environmental sustainable practice. This analysis further explores the opportunities and threats facing the forest biotechnology industry which shows that as knowledge becomes more tacit and shared among practitioners, the implementation of forest biotechnology will have more impact on value enhancing activities. Further, the opportunities for a forest biotechnology firm in Canada are plentiful, and while the threats of powerful lobby and special interest groups combined with heavily regulated implementation exist, Canada provides strong research networks from which to build core competency as well as strongly supported intellectual property rights. This analysis further shows that intellectual property rights and patent breadth combined with approved regulatory application are the primary drivers to successful market implementation. Regulatory influences on forest biotechnology are explored in detail in Section 5.0.

The societal and systemic influences on forest biotechnology are different for each country where forest biotechnology is regulated. Specifically to Canada, First Nation groups and special interest groups, such as the Sierra Club and Greenpeace, have massive influence on public perceptions and Canadian governmental reactions which occasionally lead to subsequent imposition of regulations or changes to forest management policy. The pressure from Sierra Club combined with the subsequent public outcry of logging in places such as the Stein Valley and Clayoquot Sound in the late 1990's, prompted the British Columbia government to completely revise their forest management policies, resulting in the Forest Practices Code of 1997. These groups pose the greatest influence on policy makers and as such should be integrated into decision making to anticipate the impacts their concerns may have on novel, sustainable and environmentally safe forest product innovations.

5.0 Market Opportunity Identification

The analysis has shown that regulatory constraint on market and environmental implementation forms a critical part of commercializing any biotechnology venture. As we begin to understand the regulatory environment facing forest biotechnologies, this creates a need to understand where opportunities will exist globally, and into the future. In a research paper conducted by the World Wildlife Federation, commissioned by the United Nations, the authors explore the theory that foreign direct investment in forest product markets is strongly linked to "pollution havens" and that producers seek to establish operations in areas where regulatory constraint is lowest, leading to policy and institutional failures and damaging environmental pollution. [18] However, these assumptions of linkage between FDI and sustainability do not necessarily hold true for forest biotechnology. In less regulated environments where intellectual property law is not fully recognized, low cost producers of forest biotechnology could not exist due to the high costs of research and development and the costs of establishing working patents and forging commercial products. In forest biotechnology, the intensive skills and experience required to execute SE, combined with costly lab equipment and lengthy nursery costs, would preclude low cost producers in nonregulated environments to invest. There would be no need to regenerate the forests because there would be no formal regulatory structure to impose the application of sustainability costs, such as forest regeneration, monitoring, and future yields. As a result, the identification of opportunities should focus on the more regulated environments where forest biotechnology can create value through the full and proper assessment of, not only present values for commercial product, but for future value of commercial product, both conventional and enhanced through biotechnology. This future value of realized financial gains through genetic enhancement, such as quality, growth-to-maturity, and yields, can only be included in investment analysis for operations in regulated environments, where environmental sustainability is measured and monitored through legislation. It is through the commitment to environmental sustainability that forest product manufacturers can incorporate the costs of sustainability into their management planning. The costs of sustainability of the resource are included in investment analysis. And so too is the future value of that resource. All of forest management centers on the future management of the resource and, as such, the gains from forest biotechnology stand to create extensive value. A less regulated environment would not support a business making expenditures on environmental sustainability because the investment would be lost if they did, they simply could not make a profit and competitors who did not follow these environmental stewardship principles would capture greater market share due to lower prices. Even in regulated markets, forest biotechnology, with its high costs and strict regulation, is far from competitive to conventional methods and a market can only exist for the products if the future value, the product enhancing characteristics it offers, is considered. Therefore, the focus for opportunities should remain in the regulated environments of the world where: a commitment and valuation of sustainability exists and; a commercial forest resource export market exists. A formulation of the market opportunities, therefore, can be determined by referencing the WTO trade statistics of agricultural products and identifying the prime exporters and countries with strong intellectual property law and environmental regulation. These countries include:

1) Canada
2) United States
3) European Union
    a) *Sweden*
    b) *Finland*
    c) *Germany*
4) New Zealand
5) Australia

a) *Global – Cursory exploration of China and Central America*

While the United Kingdom contributes a great deal to forest biotechnology research, due to the lack of managed forest and commercial forestry operations, there seems little opportunity for Canadian forest biotechnology in the U.K. Forest product exports from the U.K. are primarily a result of value added processes on forest product imports. Opportunities do exist, however, in connecting with researchers, sharing tacit knowledge, and influencing and contributing to discussions on policy making and regulation.

6.0 Regulatory Review for Major Markets

Understanding the regulatory environment of the forest biotechnology market is critical to successful market commercialization of products or processes. The World Trade Organization (WTO) posts a database of all global product trade by each country and for each sector from 1996 to 2003.[19] It shows that more than 65 countries engage in international trade in agricultural products with 2003 global trade worth over $583 billion, with forest products comprising approximately 18% of the total. Each of the countries active in global trade of forest products acts with their own national regulatory system, which can affect trade policies and tariffs.

The regulations in place pertaining to the use of SE varies from country to country and is most often closely tied to the regulations in place with utilizing other plant biotechnologies.

This section of the analysis explores the regulations in place pertaining to SE in the Canadian and United States markets as well as identifying the regulating authorities that monitor and enforce these regulations. In addition to exploring these North American markets, a cursory review of the regulations pertaining to forest biotechnology in the UK, Australia and New Zealand is also explored.

6.1 Canada

As the process is defined for Canadian regulation, SE products are considered animate products of biotechnology. Regulations in Canada pertaining specifically to forest biotechnology are not firmly in place however are currently regulated under the Canadian Environmental Protection Act, 1999 (CEPA, 1999), Part 6 under the authority of Environment Canada. The Act states:

Part 6: Animate Products of Biotechnology (Sections 104-115)

This act outlines the requirements for the assessment and introduction of living organisms that are the products of biotechnology where:

- *"living organism" means a substance that is an animate product of biotechnology.*
- *"significant new activity" includes, in respect of a living organism, any activity that results or may result in the entry or release of the living organism into the environment in a quantity or concentration that, in the Ministers' opinion, is significantly greater than the quantity or concentration of the living organism or the exposure or potential exposure of the environment to the living organism that previously entered or was released into the environment.*[20]

The Act further details requirements for information and reporting pertaining to new organisms and the inclusion of its characteristics and parameters in the Domestic Substances List (DSL). The New Substances Notification Regulations (NSNR), also regulated by Environment Canada, requires this information on any substance intended for import or manufacture and is not listed on the DSL. CEPA, 1999 provides Environment Canada with authority to address pollution problems on land, in water, and through all layers of the atmosphere. Currently, forest biotechnology is considered a toxic innovation as defined by CEPA, 1999 and is prohibited for use in Canada. Other forest biotechnology products are regulated under several acts, which assess products for safety. These include the Seeds Act for genetically modified trees, the Plant Protection Act for imports, the Fertilizers Act for bio-fertilizers and mycorrhizae all of which are regulated by the Canadian Food Inspection Agency.

In addition to federal regulation, forest biotechnology products are also subject to regulation from provincial authorities. The provincial Acts and Regulations that regulate the use of biotechnology in the Forestry sector are administered by several different departments including labor, transportation and environment.[21]

Currently in Canada, there are no forestry biotechnology products that have been approved for introduction into the environment.

6.2 United States

Biotechnology is regulated by three agencies in the United States (US). The United States Department of Agriculture (USDA) regulates plant pests, plants and veterinary biologics products. The Environmental Protection Agency (EPA) regulates microbial and plant pesticides, new uses of existing pesticides, and novel micro-organisms. And lastly, the Food and Drug Administration (FDA) which has oversight on products including food, feed, food additives, veterinary drugs, human drugs and medical devices. For the purposes of somatic embryogenesis and the creation of new plants, the USDA is the regulating authority for the US. The USDA regulates somatic embryogenesis with the following process:

Within USDA, the Animal and Plant Health Inspection Service (APHIS) is responsible for protecting US agriculture from pests and diseases. Under the authority of the Federal Plant Pest Act, APHIS regulations provide procedures for obtaining a permit or for providing notification, prior to "introducing" a regulated article in the United States. Regulated articles are considered to be organisms and products altered or produced through genetic engineering that are plant pests of that there is reason to believe are plant pests. The act of introducing

> *includes any movement into (import) or through (interstate) the United States, or release into the environment outside an area of physical confinement. The regulations also provide for a petition process for the determination of nonregulated status. Once a determination of nonregulated status has been made, the product (and its offspring) no longer requires APHIS review for movement or release in the US.*[22]

The field trials and monitoring programs stipulated in the regulations continue through four phases of approval: pending, acknowledged, issued approval, and finally nonregulated status. Table 5 shows the status of all applications to the USDA for the utilization of SE to create seedlings. These data shows that an approval has been issued only for Walnut to the University of California at Berkeley and also provides a good overview of the status of operational SE and what applications scientists believe are functional.

The US regulatory system is quite transparent and the status of all applications is easy to acquire. Regulatory constraint seems lowest in this market.

6.3 European Union

The European Union (EU) maintains strict regulatory policies regarding the use of genetically modified organisms that are consistent with policies developed in the United Kingdom (UK). In order to qualify for release into the environment, an incremental monitoring and testing program is implemented with explicit regulatory consent required at every step. There are two broad categories of release of genetically modified organisms, namely, Part B releases for research and development and small incremental research field trials, and Part C releases for the commercial application of an approved product. A thorough environmental risk assessment is initially implemented to assess impacts, after which the Joint Regulatory Authority from the Department for Environment, Food and Rural Affairs review in consultation with expert committees. In order to qualify, the release must be considered a very low risk, which means that the modified variety does not pose any greater risk than the natural equivalent of the variety. These Part B trials continue in the field at incrementally increased volumes and as approvals exist. Should these incremental tests be satisfied, consent from the Secretary of State for the Environment, Food and Rural Affairs. Each release carries comprehensive risk management conditions, inspections and monitoring. With respect to seed regulations, the new variety, whether or not the production involves genetic modification, must satisfy the same requirements as conventional varieties. In order to be included in the National List of Seeds or the European Common Catalogue, a series of tests to demonstrate distinctiveness, uniformity and stability must be met. This list is maintained and regulated also by the Department for Environment, Food and Rural Affairs.[23]

The regulatory structure in the other European Union (EU) member countries is very similar to that established in the UK. As the EU becomes more consolidated as a single body in the world economy, regulatory policies may also become more uniform. If this is the case, the UK, should they choose to join the EU, will have to adopt policies more in line with their member countries such as Finland, Germany and Sweden which have much more flourishing forestry industries. Currently, there are no genetically modified organisms approved for release in the EU due to intense social concern over public health and safety and environmental degradation however scientists and researchers continue to build data and precedence for possibilities of transgenic contamination.

6.4 Australia and New Zealand

Australia is following the lead of environmentally conscious countries such as Canada and the EU. Under the Australian system, a genetically modified plant needs to be approved for trial by the Genetic Manipulation Advisory Committee (GMAC) and the Federal Government's Interim Office of the Gene Technology Regulator (IOGTR). Much of Australian policy and legislation is created by the input and advisories from the GMAC which carries oversight on all reviews of operational requests for approval in the use of genetically modified organisms. These bodies oversee the release of all genetically modified organisms. Australian legislation is built on commonwealth law as well as regional legislation. The relevant legislation effecting forest biotechnology is the Gene Technology Act and Regulations of 2000 and 2001, respectively, and the Plant Breeder's Rights Act and Regulations of 1994. The Gene Technology Act 2000 establishes three key advisory groups to assist in the regulation of genetically modified organisms. Namely, the Gene Technology Technical Advisory Committee (GTTAC) assisting GMAC and advising on scientific results, the Gene Technology Ethics Committee (GTEC) to advise on ethical and social morality matters, and the Gene Technology Consultative Community Committee (GTCCC), to advise on societal perceptions and input regarding gene technology. This legislation is built on the central idea of the 'Precautionary Principle', which states that any and all action must be taken to avoid the risk of contamination and irreversible damage to the Australian environment where there exists insufficient scientific confidence in effects. In 2003, the first approval for release of a plant biotechnology was granted to genetically modified cotton. The application and approval process appears accessible and transparent in Australia, and while over 300 products are currently awaiting regulatory approval, the development of policies through stringent review continues to set precedence.

New Zealand is following the lead of Australia. The New Organisms and Other Matters Bill was passed by Parliament in October 2003. This resulted in changes to the New Organisms Act and the Biosecurity Act, both of which were enacted in 2001. This legislation details the processes and requirements for undertaking research and development of genetically modified organisms as well as field trial and approvals. The system also seems quite transparent and regulations support the development and innovation of biotechnology.

7.0 Opportunities and Overview in Identified Markets

This section seeks to outline the critical trade organizations and government support policies in place for accessing each noted market. The primary data source used to build this analysis was provided by the Info-export website of the Department of Foreign Affairs and International Trade.[24] For each country, refer to Table 1 for the export and import quantities of all forest products trade with Canada from 1996 to 2001.

7.1 United States

The United States is a leading global producer of forest products and pulp and paper yet holds a $15 billion export deficit. This is a testament to the vast consumption of forest products in the US. However, recent declines in consumption due to digital media have created problems in trade with the US. This decline in consumption lead to increased competition and over-supply to the US market, and when combined with a declining value of the American dollar and a financial crisis in Asia, the Canadian forest sector came under scrutiny once again. One cannot form a trade discussion about forest products between Canada and the US without first understanding the trade disputes over softwood lumber.

7.1.1 Softwood Lumber Disputes

Softwood lumber disputes between the U.S. and Canada go back over 100 years when finally in 1996, Canada and the US entered into the Softwood Lumber Agreement, which essentially stated the free-export of 14.7 billion board feet from Alberta, British Columbia, Ontario and Quebec and that any amount over this was subject to either a $50 (up to 650 million board feet exceeding) or $100 (more than 650 million board feet exceeding) fee per thousand board feet. In exchange, the US agreed not to file further disputes over the lifetime of the agreement, to March 2001. At the end of the softwood lumber agreement, the debate started up once more. Petitions were filed by the US Coalition for Fair Lumber Imports and requested that duty charges in excess of 31% be applied to all Canadian forest product imports. The petitions further requested investigations into countervailing subsidies and anti-dumping claims, which were then enacted by the U.S. Department of Commerce (DOC). In August of 2001, the DOC issued its preliminary subsidy determination in its countervailing duty investigation of softwood lumber from Canada. The DOC found that Canadian softwood lumber exports to the United States were subsidized in the order of 19.31% and quickly instructed the U.S. Customs Service to begin applying the 19.31% to all shipments, retroactive to May 17, 2001. The anti-dumping investigations lead to the imposition of additional duties on imports ranging from 8.53% to 15.81%, depending on the producer, and began collecting these fees retroactively from May 5, 2002. The reason for the dispute was the claim that Canadian stumpage fees, or the charges that government institutes to private companies to harvest trees on public land, is not a transparent and codified process, that the application of stumpage fees is not uniform and, as such, acts as a subsidy to forest product manufacturers by lowering their cost of operations in comparison to other world producers. Permanent U.S. countervailing and anti-dumping duties totaling 27% were imposed on Canadian exports effective May 22, 2002.

The softwood lumber dispute and the forest product trade relationship with the U.S. have several ramifications on forest biotechnology through the support networks and funding available to research. Government support programs in Canada will include $29.7 million for the Canada Wood Export Program, $30 million to support research and development activities and $15 million for the Value-Added Research Initiative for Wood Products. Canada continues to challenge the U.S. trade action with NAFTA and the WTO meanwhile over $2 billion has been collected since May, 2002.[25]

7.1.2 United States Opportunities

Softwood lumber is one of Canada's largest exports to the United States, with over 19 billion board feet and $6.8 billion of lumber exports for 2003. Forest products trading with the U.S. comprise an important element of the largest trading relationship in the world, and in Canada there are many communities and businesses dependent on this relationship. Due to this recent dispute, there is vastly declining profitability of the Canadian forest sector and firms are looking for ways to evolve their core competencies and skills outside of traditional forest product relationships. Forest biotechnology provides that diversification without having to divest from core competencies. This creates an opportunity in the U.S. market for forest biotechnology by attracting investment into research and development as foreign investors look for ways to transform their capital out of traditional forest products. And while the trade relationship in traditional forest product continues to suffer with the U.S., opportunities will still exist for applying research and development and building new forest management skills that are relevant to the global market. With this in mind, firms should still be cautious when looking to the U.S. market for opportunity due to the existence of extensive competition, a large export deficit and the unforeseen evolution of strict trade policies.

The few critical success factors, that generate opportunity for a Canadian forest biotechnology firm in the American Market, include:

- Foreign investors seeking to divest from traditional forest products while maintaining a core competency in the industry;
- Transparent regulatory policies with enacted legislation; and,
- Primarily English-speaking economy.

7.2 European Union

The *UNECE/FAO Forest Products Annual Market Analysis, 2002-2004* provides general and statistical information on forest products markets in 2002-2003 and forecasts for 2004 in the UN Economic Commission for Europe region (Europe, North America and the Commonwealth of Independent States).[26] This data shows that the impact of the trade relationship between Canada and the U.S. has drastically impacted their own trade relationships. In 2002, the result was an 80% increase in net exports to the U.S. due to price competition and European supplier options resulting from increased Canadian supply prices. In 2003, this lead to quota and tariffs on European forest product supply to the U.S. while Europe still achieved record exports to the American market. The E.U. is enjoying a net positive effect from the ongoing trade dispute between the U.S. and Canada. Table 6 shows the activity of forest biotechnology applications to genetically modified tree species field trials for each country in Europe. It is estimated that the gross domestic product forest sector in the EU, including all member states, is worth $520 billion annually.

The forest biotechnology industry in Europe is well developed and maintains a core group of specialized research facilities that build on North American innovations and create their own novel products. Regulatory restrictions on application of genetically modified tree species has not yet been approved for any EU country, but research on applied forest mechanics and genetic enhancement continues. On March 5, 2003 the European Commission (EC) adopted the first report on the progress made on the implementation of the strategy on life sciences and biotechnology. This strategy reforms some aspects of the strategy, mostly with respect to food plant biotechnologies, yet addresses forest biotechnology through its association to genetic modification of an organism. And while the EU continues to develop policies and strategies for assessing environmental safety with respect to plant biotechnologies, there has been no adoption of broad legislation that is accepted by all member states.

7.2.1 Sweden

Sweden has historically been a world leader in the forest industry. Most premium forestry equipment and supplies are produced in Sweden and widely in use around the world, extensively in Canada as well. Sweden has an intensive forest management system dating back more than 100 years and slash-and-burn land management dating back more than 400 years. While much of their old growth forest has been lost due to unmanaged logging and changes to carbon emissions, Sweden continues to effect the availability of sustainable timber supply through their intensive forest management principles. Sweden is reaping the benefits of their intensive forest management with much of their managed land now into full rotation, producing an annual increase of about

4,000 km^2 each year and subsequently producing a net increase in annual sustainable allowable cuts and resulting in a more flourishing forest industry.[27] The industry continues to support research and development in biotechnology supported by an infrastructure of regulatory departments and universities.

The International Union of Forest Research Organizations (IUFRO) organizes Tree Biotechnology committee consisting of the Umeå Plant Science Center (UPSC), which is an association of two departments: the Department of Forest Genetics and Plant Physiology at the Swedish University of Agricultural Sciences and the Department of Plant Physiology at Umeå University.[28] This group reviews current scientific data and organizes formal presentations and discussion groups on policy issues and future research opportunities in forest biotechnology of which is all published online. The progressive views and open forums on forest biotechnology show that Sweden is poised to implement this science with the full support of regulatory national bodies. They will not be able to proceed without the approvals from the EC but nevertheless have applied SE and genetic enhancement to Swedish tree species in research and are undergoing regulatory submittal. As Sweden develops a stronger base of scientific data that validates control mechanisms and safety of implementation, it is expected to be among the first countries that will commercialize forest biotechnology products. Sweden also continues to maintain a forest gene bank, which is managed by the government and responsible for preserving the original genetic material of the country's tree species.

Critical success factors, that generate opportunity for a Canadian forest biotechnology firm in the Swedish Market, include:

- Intensively managed forests and forest management experience;
- Strong research and development expenditures by Government;
- Experienced and qualified research network;
- SE is close to being operational for Norway spruce;
- Government support research and development activities;
- Committed university research departments;
- Developed social infrastructure and societal networks;
- Legislation protects intellectual property; and,
- Progressive social view of biotechnology benefits to forestry.

7.2.2 Finland

58% of Finland's highly-productive forests, especially those in the southern and central parts of the country, are owned by private persons, with the state owning 29% and the remaining 13% owned by companies. There is a significant allocation to reserves and parkland in Finland with 3,441,900 hectares of the total 23 million hectares of forested land assigned to parks, peat-land areas, old-growth forests and wilderness areas. Finland remains Europe's most heavily forested country and forest industries contributed 29.3% to the total export of goods for Finland in 2003, yet employs only 3.2% of the labor force.[29] Primarily, due to the extensive private ownership of land, Finland's forest resources are family owned and operated which has not created congruity across the land base for intensive management plans and has minimized investments into human resources. However, each landowner has historically managed their private land in sustainable patterns so the forest resource remains plentiful, albeit fragmented. This has created a culture with extensive explicit knowledge about forest management giving rise to forestry forming a large part of the social structure of a Finnish community.

Biotechnology in Finland is much the same as in Sweden. There continue to be extensive research and development efforts in SE systems for the Northern

Scandinavian tree species but, as of yet, there has not been operational success. Government has been extensively supporting foreign investment through tax subsidies, as well as implementing programs to assist in fundamental research. The programs managed by the Academy of Finland and the National Technology Agency (TEKES) have strengthened Finland's biotechnological research base. Scientific and management support has been offered by TEKES, while most of the investments have come from SITRA (the Finnish national fund for scientific research). Finland's strategy has been to focus on areas in which it has a strong research base, which currently includes biomaterials and forest plant genomics.[30] As with Sweden, there continues to be opportunity for development funding of research for the application of Northern Scandinavian tree species for SE implementation and genetic enhancement engineering through strong government spending on research and development. Other support networks in Finland include the Finnish Forest Research Institute and the Vantaa Research Center for forest genetics registry, breeding methods, and ecological genetics, the Foundation for Forest Tree Breeding in Helsinki, the Finnish Forest Research Institute for biotechnology, resistance breeding, seed orchard research, and progeny testing.

Critical success factors, that generate opportunity for a Canadian forest biotechnology firm in the Finnish Market, include:

- Intensively managed forests and forest management experience;
- Strong research and development expenditures by Government;
- Experienced and qualified research network;
- Extensive forestry land base;
- SE is close to being operational for Norway spruce;
- Government support research and development activities;
- Committed university research departments;
- Developed social infrastructure and societal networks;
- Legislation protects intellectual property; and,
- Progressive social view of biotechnology benefits to forestry.

7.2.3 Germany

Germany remains one of the leading paper producing countries on the globe and have been implementing intensive forest management for over 400 years. Currently, Canada is reporting a trade deficit on forest product imports and exports to Germany as noted in Table 1. The domestic production in Germany far exceeds national demand and they remain a principal supplier of sawnwood and pulp and paper products to the EU market. This may seem like a market that is saturated with production and clearly efforts to export forest product or forest management services would not be easily achieved. However, forest biotechnology currently exists as proprietary and tacit knowledge and, as such, can be claimed and captured for proprietary use. Biotechnology firms can capitalize on the intensive forest management policies in place and private forest industry objectives that would help producers achieve faster rotations, enhanced fiber quality and higher profit margins.

The Biotechnology 2000 program launched by the Federal Government in 1990 is dedicated to the development of new processes and methods in genetic engineering and molecular biology. It comprises support grants allocated by the Federal Research Ministry, as well as priority projects coordinated by the Federal Research and Agricultural Ministries. Germany also hosts Biotechnica every other year, a fair for biotechnology, nuclear biology, lab technology and biotechnological products.

Critical success factors, that generate opportunity for a Canadian forest biotechnology firm in the German Market, include:

- Intensively managed forests and forest management experience;
- Developed social infrastructure and societal networks;
- Extensive research and development infrastructure and support;
- Enacted legislation protects intellectual property; and,
- Progressive social view of biotechnology benefits to forestry.

7.3 Australia

Australia remains the largest consumer of forest products in the Oceania region, where the Australia forest sector comprises approximately 1.1% of the Australia GDP and 7.5% to total manufacturing output.[31] As such, forest product manufacturing remains the second largest manufacturing industry in Australia, directly employing over 80,000 people. For 1999-2000, the annual turnover of forest products in Australia was $12 billion where total imports of forest products were $3.23 billion, primarily from Canada and the United States, and total exports exceeded $1.3 billion, primarily to Japan and New Zealand. The trade deficit for forest products is nearly $2 billion for 2001, which shows Australia consumes a great deal more forest products than it produces. The forest cover in Australia comprises approximately 21% of the total land area with commercial species including eucalyptus and pine, where over 90% of domestic production utilizes primarily softwood plantations. Plantations supply more than 50% of domestic forestry needs and are expected to achieve 70% by 2015, due to intensive forest management and advanced technologies. This is expected to create a net decrease in forest product imports. Plantations currently present the largest long-term growth opportunity for investment in Australia forestry. Plantations in Australia primarily focus on the growth of hardwood species of eucalyptus and softwood species of pine. The much faster growth to maturity of eucalyptus for industrial application makes it the more plentiful plantation growth type whereas pine, with its stronger fiber characteristics, is the preferred product for furniture and construction. Eucalyptus can achieve growth to maturity in approximately 40 years and pulp and paper rotation use in about 9 years, whereas pine achieves maturity at 80 years and rotations of about 35 years. Plantations represent the future of forestry in Australia and there are extensive government support programs and incentives to land owners to enhance plantation yields. For example, a program called *Plantations for Australia: The 2020 Vision* provides incentives to foster private investment into plantation management. These investments are primarily in forest biotechnologies, silviculture (growth-enhancing) systems, and wood processing.[32] More than one third of Australia's biotechnology companies are located in Victoria with the remainder evenly distributed between Queensland, New South Wales and Adelaide.[33]

7.3.1 Australia Opportunities

Australia appears to be the most attractive market for the application of SE and forest biotechnology. The opportunities offered in Australia are plentiful for forest biotechnology when regulatory structure, environmental suitability, operational processes of SE, and societal perceptions to biotechnology are considered. The industrial focus on plantation management is expected to achieve much higher yields in the future of Australia domestic timber production. Spurned by foreign investments and support programs which foster research and development to enhance production and yields in plantations, future domestic production is expected to replace import requirements. The support programs are government sponsored at the federal, regional and municipal levels, making access to support networks and relationships with regulators much easier to manage. The analysis of biotechnology regulation in Australia shows that the social perception of biotechnology applications to intensively managed plantations is very transparent and progressive, although also highly correlated with the regulation and perceptions surrounding plant biotechnologies. This distinction between food-product biotechnologies and non-food stuff biotechnologies should be addressed in regulation.

The operational use of SE to create superior genetic trees currently lies with eucalyptus, Douglas fir, selected pine species and selected spruce species, as evidenced by Table 5. This compliments the application to Australia forestry well where intensive plantation management and a suitable climate for the growth of eucalyptus and pine make SE a beneficial alternative. The large deficit of forest product consumption for Australia provides the platform to justify expenditures and enhancements to domestic production in Australia, which can be enhanced by forest biotechnologies. As Australia works through regulatory systems and policies for sustainable development, Canadian firms holding technical expertise and experience with intensive forest management systems can capitalize on several opportunities in the Australian market.

Critical success factors, that generate opportunity for a Canadian forest biotechnology firm in the Australia Market, include:

- SE is scientifically proven and functional for eucalyptus and pine, the primary Australian plantation species;
- Government support programs and incentives for plantation investment and research and development activities;
- Minimal established competition;
- Large deficit of domestic production to consumption;
- Regulatory infrastructure of legislation, advisory groups and oversight established;
- Transparent regulatory policies with enacted legislation;
- Primarily English-speaking economy;
- Suitable environmental conditions and extended growing season to North America;
- Developed social infrastructure and societal networks;
- Commonwealth law protects intellectual property; and,
- Progressive social view of biotechnology benefits to forestry.

7.4 New Zealand

New Zealand has been intensively managing their fast growing plantation forests for about 50 years, with previously managed lands now entering into the harvest rotation cycle. It has been calculated that by 2010, sustainable allowable cut will have increased 100% from 1998 levels.[34] New Zealand imports few forest products, utilizing domestic production to meet national demand while still maintaining an export of $1.9 billion in forest products for 2000. Primary commercial species are grown on both private and publicly owned plantations and include eucalyptus and selected pine species.

New Zealand has been a recent leader in forest biotechnology. A joint venture in 1999 between Monsanto Corporation, West-Fraser Mills, and Fletcher Challenge Forests injected $60 million of funding into a private forest biotechnology research facility in Wellington. This facility developed the first operational process for the SE of eucalyptus, and later pine. The knowledge created through this joint venture can be illustrated by seeing the subsequent intellectual property and regulatory approvals claimed in Table 2 and Table 5 by both ArborGen and Westvaco Corporation, the business entities of the joint venture. The research facilities in Wellington continue to lead the innovations and technologies of forest biotechnology in SE systems. As a result, there would be extensive competition in New Zealand from the other forest biotechnology firm, yet there still would remain opportunity if proprietary knowledge and patent space could be claimed. Apart from the strong competition in this market and the relatively small land base and growing stock, other opportunities for forest biotechnology remain essentially the same as for Australia.

Critical success factors, that generate opportunity for a Canadian forest biotechnology firm in the Australia Market, include:

- SE is scientifically proven and functional for eucalyptus and pine, the primary New Zealand plantation species;
- Government support programs and incentives for plantation investment and research and development activities;
- Primarily English-speaking economy;
- Suitable environmental conditions and extended growing season to North America;
- Developed social infrastructure and societal networks;
- Legislation protects intellectual property; and,
- Progressive social view of biotechnology benefits to forestry.

7.5 Global

The International Union of Forest Research Organizations (IUFRO) implements the Special Program for Developing Countries (SPDC) which seeks to expand and foster forest research capacity in developing and economically disadvantaged countries.[35] This is implemented through funding assistance to the training of scientists, collaborative research networking, and the scientist assistance program executing projects in Africa, Latin America, Asia, and Eastern Europe. The WTO symposium on environment and trade included several organizations in the pulp and paper industry. Discussion was primarily formed around forest product trade and environmental sustainability concerns. [36]. These and other organizations strive to develop global policies regarding the use and development of forest science research with the hopes of creating a uniform, transparent global standard. The global application of forest biotechnology can only be a relevant discussion once plant biotechnology legislation has been resolved in every nation. Apart from regions noted above, there are few countries developing transparent and enacted regulation that controls the use and protection of plant biotechnologies.

7.5.1 Central America

Extensive forestry development and forest production is very active in South America. Much of it is entirely unregulated and environmental degradation of South American forests remains a critical global issue today. Forest biotechnology may hold benefits to these economies to assist in the mitigation of environmental impacts. However, the legislation must exist that enacts intensive forest management regulation, in order to incorporate the future benefits that biotechnologies can provide. Despite this, there is still much effort in the development of forest biotechnology for this region. In Central America and the Caribbean, the pioneering work in biotechnology of forest trees has been focused on the development of in vitro micro-propagation protocols for a number of plant genera, including Bombacopsis, Cedrela, Cordia, Swietenia, and Tectona.[37] During the last two decades, activities in forest tree improvement have produced considerable results in terms of the screening of multipurpose tree species for agroforestry and forestry uses. For instance in the Central American region, almost 200 tree species have been tested in the field under varying site conditions. However, the linkages of these activities to breeding programs are practically non-existent. *Centro Agronómico Tropical de Investigación y Enseñanza,* a University in Costa Rica, is currently working with the FAO, the International Organization for Forest Research Organizations (IUFRO) and the

International Plant Genetic Resources Institute (IPGRI) to establish a Latin American forest biotechnology network. Future opportunities could exist for forest biotechnology firms offering solutions in erosion, reclamation and remediation, and intensive forest management.

7.5.2 China

There exists little opportunity for firms offering intensive forest management benefits and enhancement through biotechnologies in China. Until the Chinese economy can consolidate its fragmented land base of independent, predominantly very poor, farmers, environmental regulation and proprietary protection will not be possible. Currently, there is no consistent environmental legislation and intellectual property law that protects foreign investment in all regions of China. However, development efforts continue and the future of forestry in North China could be a viable industry. China's forests are an important source of medicinal and organic chemical resources, as well as natural pesticides and disease resistant genes that can be incorporated into timber, nut and shade tree species.[38] Other challenges in China include the rugged forested terrain and several common tree species not applicable to current commercial pulp and paper or sawnwood operations. However, China continues to be a world leader in forest product imports for construction of wood frame housing and a large market force as consumers of forest products. This market will play an increasingly critical role in Canadian forest product exports in the future as policies and legislation with U.S. trade becomes more complex.

7.6 Canada

The Canadian market and opportunities existing nationally are not explored in this analysis. However, as regulations and policies become more transparent and approvals for domestic use of certain biotechnologies progresses, other world economies will utilize the precedence established in Canada to enact legislation in their own nation. Our innovative and skilled forest researchers, management professionals, and policy makers will continue to lead developments and contributions to forest biotechnology. Significant trade organizations and government support policies for Canadian business include the Canadian Forest Service, Canadian Institute of Forestry and DFAIT.

8.0 Strategic Recommendation

The trends in global forestry seem to support the need for enhancement through forest biotechnology. These trends include a corporate shift in forest product development to tropical and less regulated countries, the need for faster growing wood products to meet environmental and financial sustainability and an average 1.7% global increase in global consumption of forest products.[39] These demands can be met through improved wood quantity and quality of forest biotechnology, such as SE, tree breeding, and rooting techniques. It will be critical that a forest biotechnology firm builds a strategy based on two prime factors: the depth and transparency of legislation and the extent of knowledge rights granted in the market. Legislation will be the primary driver for a forest biotechnology firm as protection of intellectual property will remain a key component of competitive edge. Legislation also enables the technology, providing the firm with the ability to implement the product through the regulatory approval process and achieve commercialization. Patent regimes are increasingly acting as barriers, because some countries are not in a position to pay royalties for access to knowledge or do not have firm policies and legislation for protection of intellectual property. Where the potential exists for technology transfer, large enterprises with well-developed research and development capacity capture a significant proportion of benefits. Countries that fail to develop indigenous science and technology capacity may become markets for capital and consumer goods or producers of low cost, inexpensive labor and low-cost access to raw materials to create goods for global markets. A forest biotechnology firm will therefore want to thoroughly investigate the implications of legislation and competitive knowledge rights before entering a market.

With these two directives in mind, and utilizing the analysis of opportunities identified previously, it seems clear that the most attractive market for implementation of a firm's knowledge and skill in forest biotechnology appears to be in Australia, followed by the EU. The Australian market is chosen for it's transparent legislation, the limited number of competitive knowledge rights established by competitive firms, and the progressive social attitudes towards forest biotechnology, the applicability of current functional SE processes, the vast land base, the extended growing conditions, the large export deficit in forest products, and the use of plantation forestry. Table 1 details the export surplus for Australia which is significant on a per capita basis. Our export surplus to the UK and Germany is also significant, however much of this is for value added processing then exporting, and often back to Canada. But Australia consumes nearly all the export surplus they receive from our forest products. The critical success factors relevant to Australia combine to create a well protected environment for competition as well as the ability to work with policy makers to enact legislation that enables the technology. It would also be relatively easy for a Canadian firm to communicate and establish good relationships with partners, joint ventures and suppliers due to the predominantly English-speaking environment.

In addition to the Australian market, Canadian firms will want to remain active in the research activities and public forums and conferences held in Europe, Canada and the United States, where the primary research is being conducted. There is still much development work to be done on the creation of legislation and monitoring regulations that meet the financial sustainability needs of the forest biotechnology industry as well as environmental sustainability of the land base and social sustainability of public health and value systems.

8.1 Strategizing Global Expansion

In preparing a global expansion plan for a forest biotechnology firm, there are several strategies that can be formulated. This model is applied specifically to forest biotechnology and the expansion into the Australian market. Figure 4 shows the four strategies of international operations and how they could specifically relate to forest biotechnology.[40] This model shows that the most preferred strategy for a Canadian forest biotechnology firm is a Transnational Strategy. The forest industry is expected to remain a very high cost pressure industry demanding local responsiveness to regulatory and societal perceptions. Firms will have to adapt their products and management or marketing programs quickly in order to ensure the products can meet environmental, social and financial sustainability. This transnational strategy could be implemented by sending a group of skilled, experienced researchers to Australia to find suitable low cost operations, and then begin to build local networks and core competencies through hiring in order to achieve the proper local understandings and responsiveness to the firm's activities. By capitalizing on skills and assets of the foreign subsidiary, the Canadian office can achieve global learning through insight gained from foreign operations used to enhance the Canadian home office, and also use the shared knowledge to enhance both operations.

Table 1 – Canadian Forest Products Trade Flow 1996 – 2001

Canada: exports of All forest products in thousand US dollars						
	1996	**1997**	**1998**	**1999**	**2000**	**2001**
Australia	$ 137,924.00	$ 123,547.00	$ 84,600.00	$ 101,700.00	$ 124,524.00	$ 66,810.00
Finland	$ 17,130.00	$ 23,631.00	$ 19,867.00	$ 21,876.00	$ 29,198.00	$ 14,390.00
Germany	$ 612,149.00	$ 615,835.00	$ 455,579.00	$ 402,716.00	$ 577,587.00	$ 369,373.00
New Zealand	$ 19,092.00	$ 18,825.00	$ 11,784.00	$ 11,749.00	$ 15,103.00	$ 8,655.00
Sweden	$ 19,982.00	$ 27,964.00	$ 24,033.00	$ 25,215.00	$ 22,113.00	$ 35,562.00
United Kingdom	$ 573,972.00	$ 466,520.00	$ 420,071.00	$ 405,844.00	$ 454,045.00	$ 381,961.00
United States	$18,679,356.00	$19,238,576.00	$19,556,164.00	$21,950,410.00	$22,468,808.00	$20,996,950.00
Canada: imports of All forest products in thousand US dollars						
	1996	**1997**	**1998**	**1999**	**2000**	**2001**
Australia	$ 388.00	$ 2,788.00	$ 606.00	$ 1,728.00	$ 2,291.00	$ 4,712.00
Finland	$ 41,382.00	$ 55,784.00	$ 81,445.00	$ 71,209.00	$ 70,186.00	$ 75,876.00
Germany	$ 40,923.00	$ 55,820.00	$ 55,308.00	$ 71,273.00	$ 94,963.00	$ 93,664.00
New Zealand	$ 1,825.00	$ 1,014.00	$ 2,766.00	$ 3,685.00	$ 3,333.00	$ 4,236.00
Sweden	$ 15,154.00	$ 15,101.00	$ 26,025.00	$ 25,759.00	$ 29,329.00	$ 28,815.00
United Kingdom	$ 20,498.00	$ 28,460.00	$ 37,152.00	$ 56,227.00	$ 48,596.00	$ 29,714.00
United States	$ 2,827,664.00	$ 3,340,349.00	$ 3,333,499.00	$ 3,646,889.00	$ 4,105,196.00	$ 3,752,363.00
Trade Surplus (Deficit)						
	1996	**1997**	**1998**	**1999**	**2000**	**2001**
Australia	$ 137,536.00	$ 120,759.00	$ 83,994.00	$ 99,972.00	$ 122,233.00	$ 62,098.00
Finland	-$ 24,252.00	-$ 32,153.00	-$ 61,578.00	-$ 49,333.00	-$ 40,988.00	-$ 61,486.00
Germany	$ 571,226.00	$ 560,015.00	$ 400,271.00	$ 331,443.00	$ 482,624.00	$ 275,709.00
New Zealand	$ 17,267.00	$ 17,811.00	$ 9,018.00	$ 8,064.00	$ 11,770.00	$ 4,419.00
Sweden	$ 4,828.00	$ 12,863.00	-$ 1,992.00	-$ 544.00	-$ 7,216.00	$ 6,747.00
United Kingdom	$ 553,474.00	$ 438,060.00	$ 382,919.00	$ 349,617.00	$ 405,449.00	$ 352,247.00
United States	$15,851,692.00	$15,898,227.00	$16,222,665.00	$18,303,521.00	$18,363,612.00	$17,244,587.00
http://www.efi.fi/efidas/						

Table 2 – Summary of Patent Assignees relating to Conifer SE

Number of Patents Held	Corporation or Individual
19	Weyerhaeuser Company (Federal Way, WA)
13	Westvaco Corporation (New York, NY)
4	Cellfor Inc. (Vancouver, CA)
3	Union Camp Corporation (GA/NJ/IL/PA)
3	North Carolina State University (Raleigh, NC)
2	Rutgers, State University of New Jersey
2	Institute of Paper Science & Technology (Atlanta, GA)
2	Attree; Stephen M. (Victoria, British Columbia, CA) – Now Cellfor Inc.
2	Carter Holt Harvey Limited (Manukau, NZ)
2	University of Saskatchewan (Saskatchewan, CA)
2	University of California (Oakland, CA)
1	Secretary of Agriculture (US)
1	Dekalb Genetics Corp. (Mystic, CT)& Cornell Research Foundation, Inc. (Ithaca, NY)
1	Ministry of Forests (Victoria, CA) Her Majesty the Queen in right of Canada, as represented by the Minister (Ottawa, CA)
1	Pioneer Hi-Bred International, Inc. (Des Moines, IA)
1	Agriculture and Agri-Food Canada (Ontario, CA)
1	University of Kentucky Research Foundation (Lexington, KY)
1	Edmonds; Timothy Kent &Cervelli; Robert Leo Halifax, Nova Scotia, CA
1	University of Hawaii at Manoa (Honolulu, HI)
1	Ohio State Research Foundation (Columbus, OH)
1	Wisconsin Alumni Research Foundation (Madison, WI)
1	University of Tennessee Research Corporation (Knoxville, TN)
1	New Zealand Forest Research Institute Limited (Rotorua, NZ)
1	Unilever Patent Holdings B.V. (Vlaardingen, NL)
1	Gupta; Pramod K. & Pullman; Gerald S. (Federal Way, WA)
1	Forgene, Inc. (Rhinelander, WI)
1	British Columbia Research Corporation (Vancouver, CA)
70	

Table 3 – VRIO Framework Analysis

Internal	**Product (Somatic embryogenesis)**	**Firm**
VRIO Framework		
Valuable	The product is valuable to the industry by potentially reducing costs through a faster time to maturity for plantations and a higher grade of wood to market.	Currently, there are very few firms in North America offering this industrial service so their differentiation in the industry is quite high.
Rare	This product is rare in that few firms can implement the technology as it applies to forestry applications and extensive research and knowledge investment would be needed to capitalize on the technology.	Currently, no firms are producing embryonic products for the forest industry in North America due to regulatory constraint. However, research efforts have not been successful with other species types.
Inimitable	There is no more efficient process for selecting and creating an optimized healthy seedling stock.	Other firms could invest into the knowledge and technology and compete with the same resources.
Organized	This product will help forest companies operating under environmental regulation and monitoring to achieve goals more efficiently and enhance consumer product. It should enhance the operations of most forestry regeneration and harvesting operations.	Firm must create a distinctive knowledge about the genomics of trees then utilizing that proprietary knowledge in a marketable product with somatic embryogenesis (SE) and vegetative propagation.

Table 4 – SWOT Analysis for a Forest Biotechnology Firm in Canada

Strengths Ideal Theoretical Firm	• The firm will have to be able to capitalize on joint venture investments of private industry into its industrial application. • They must have a highly qualified and diverse research staff and state of the art technologies to support gene sequencing and trait identification. • They must have a unique and rare product or process that has value enhancing implications to the industry and is patentable • Tacit knowledge is one of their strengths.
Weaknesses Theoretical Firm	• New competition from firms as the technology and knowledge becomes more implicit. • Much more research is needed into the applications of SE on other species and in other global climates. • Other more superior germplasms will be the ultimate marketable product once the knowledge is implicit.
Opportunities Forest Biotechnology Market	• Helping forest companies achieve higher growth rates, better quality wood fiber, better seedling establishment rates, and better tolerance to insects, disease and drought → **Value Enhancing** • Extensive research network with experienced scientists and professionals • Large natural resource base with Boreal forest and Eastern forests • Established industry infrastructure • High quality Canadian forest products • Innovative and industrious Canadian economy • Primarily English speaking economy makes English speaking European country communication easier • Low cost of professional labor in Canada • Comprehensive and accountable forest management practices in Canada • Ability to capitalize on European markets from established research protocols and regulatory approvals • Companies will have the first-mover advantage.
Threats Forest Biotechnology Market	• Extensive forest management regulation • Large firms dominate proprietary knowledge • International patent law only recognizes intellectual property that is registered in their market – no global patent office • Public acceptance and regulatory structures • Currently no legislated policies regarding biotechnology forestry applications • Public concern over environmental contamination and transgenic release impacts are high • Regulatory policies and procedures for application have yet to be developed and could impact detrimentally the specific products a forest biotech firm is investing knowledge into.

Table 5 – Regulatory Status of Somatic Embryogenesis in the United States

Permit	Institution	Organism	Received	Status	Issued	Effective	Release Location(s)
04-049-03n	ArborGen	Pine	02/18/04	Pending		03/19/04	SC
04-049-04n	ArborGen	Pine	02/18/04	Pending		03/19/04	SC
04-049-05n	ArborGen	Pine	02/18/04	Pending		03/19/04	SC
04-049-06n	ArborGen	Pine	02/18/04	Pending		03/19/04	SC
04-040-09n	ArborGen	Pine	02/09/04	Pending		03/10/04	SC
04-040-10n	ArborGen	Pine	02/09/04	Pending		03/10/04	SC
03-358-02n	ArborGen	Pine	12/24/03	Acknowledged		01/23/04	SC
03-329-01n	ArborGen	Pine	11/25/03	Acknowledged		12/25/03	SC
03-275-01n	ArborGen	Pine	10/02/03	Acknowledged		11/01/03	SC
03-274-02n	ArborGen	Pine	10/01/03	Acknowledged		10/31/03	SC
03-265-01n	ArborGen	Eucalyptus grandis	09/22/03	Acknowledged		10/22/03	FL
03-247-05n	ArborGen	Pine	09/04/03	Acknowledged		10/04/03	SC
03-239-03n	ArborGen	Eucalyptus grandis	08/27/03	Acknowledged		09/26/03	FL
03-232-06n	ArborGen	Pine	08/20/03	Acknowledged		09/19/03	SC
03-232-07n	ArborGen	Pine	08/20/03	Acknowledged		09/19/03	SC
03-232-08n	ArborGen	Pine	08/20/03	Acknowledged		09/19/03	SC
03-209-01n	ArborGen	Pine	07/28/03	Denied		08/27/03	SC
03-203-09n	ArborGen	Eucalyptus grandis	07/22/03	Acknowledged		08/21/03	FL, SC
03-184-07n	ArborGen	Eucalyptus grandis	07/03/03	Acknowledged		08/02/03	FL, SC
03-147-04n	ArborGen	Pine	05/27/03	Acknowledged		06/26/03	SC
03-121-04n	ArborGen	Eucalyptus grandis	05/01/03	Acknowledged		05/31/03	SC
03-112-01n	New York State U	American Chestnut	04/22/03	Acknowledged		05/22/03	NY
03-091-15n	ArborGen	Pine	04/01/03	Acknowledged		05/01/03	SC
03-076-06n	ArborGen	Pine	03/17/03	Acknowledged		04/16/03	SC
02-214-02n	ArborGen	Eucalyptus grandis	08/02/02	Acknowledged		09/01/02	SC
02-112-02n	ArborGen	Pine	04/22/02	Acknowledged		05/22/02	SC
02-112-01n	ArborGen	Pine	04/22/02	Acknowledged		05/22/02	SC
01-124-09n	Westvaco	Pine	05/04/01	Acknowledged		06/03/01	SC
01-124-08n	Westvaco	Pine	05/04/01	Acknowledged		06/03/01	SC
01-124-07n	Westvaco	Pine	05/04/01	Acknowledged		06/03/01	SC
01-092-06n	Westvaco	Pine	04/02/01	Acknowledged		05/02/01	SC
01-079-03n	Westvaco	Pine	03/20/01	Acknowledged		04/19/01	SC
01-079-05n	Westvaco	Pine	03/20/01	Acknowledged		04/19/01	SC
01-079-04n	Westvaco	Pine	03/20/01	Acknowledged		04/19/01	SC
00-353-10n	U of California/Davis	Walnut	12/18/00	Acknowledged		01/17/01	CA
00-305-01n	Westvaco	Pine	10/31/00	Acknowledged		11/30/00	SC
00-220-03n	Westvaco	Pine	08/07/00	Acknowledged		09/06/00	SC
00-167-03n	Westvaco	Pine	06/15/00	Acknowledged		07/15/00	SC
00-126-01n	Westvaco	Pine	05/05/00	Acknowledged		06/04/00	SC
00-034-18n	U of California	Walnut	02/03/00	Acknowledged		03/04/00	CA
99-174-02n	Westvaco	Pine	06/23/99	Acknowledged		07/23/99	SC
99-158-02n	Westvaco	Pine	06/07/99	Acknowledged		07/07/99	SC
99-158-01n	Westvaco	Pine	06/07/99	Acknowledged		07/07/99	SC
98-141-10n	Westvaco	Pine	05/21/98	Acknowledged		06/20/98	SC
98-042-07n	U of California/Davis	Walnut	02/11/98	Acknowledged		03/13/98	CA
98-042-08n	U of California/Davis	Walnut	02/11/98	Acknowledged		03/13/98	CA
97-210-02n	U of California/Davis	Walnut	07/29/97	Void		08/28/97	CA
97-209-04n	U of California/Davis	Walnut	07/28/97	Void		08/27/97	CA
97-189-01n	U of California/Davis	Walnut	07/08/97	Acknowledged		08/07/97	CA
97-189-02n	U of California/Davis	Walnut	07/08/97	Acknowledged		08/07/97	CA
97-182-09n	U of California/Davis	Walnut	07/01/97	Denied		07/31/97	CA
97-163-01n	ARS	Walnut	06/12/97	Acknowledged		07/12/97	CA
97-163-02n	U of California/Davis	Walnut	06/12/97	Acknowledged		07/12/97	CA
95-272-02r	U of California/Davis	Walnut	09/29/95	Issued	1/16/95		CA
93-004-02r	U of California/Davis	Walnut	01/04/93	Issued	3/26/93		CA
90-351-01r	ARS	Walnut	12/17/90	Issued	3/15/91		CA
89-220-01r	U of California/Davis	Walnut	08/08/89	Issued	2/15/90		CA

Table 6 – European GM Tree Field Trials by Country[41]

Country	Number GM Tree Field Trials	Country	Number GM Tree Field Trials
France	9	Germany	3
Finland	8	Netherlands	2
United Kingdom	5	Belgium	1
Italy	5	Norway	1
Spain	4	Portugal	1
Denmark	3	Sweden	1

Figure 1 – Porter's Five Forces Model of a Forest Biotechnology Firm

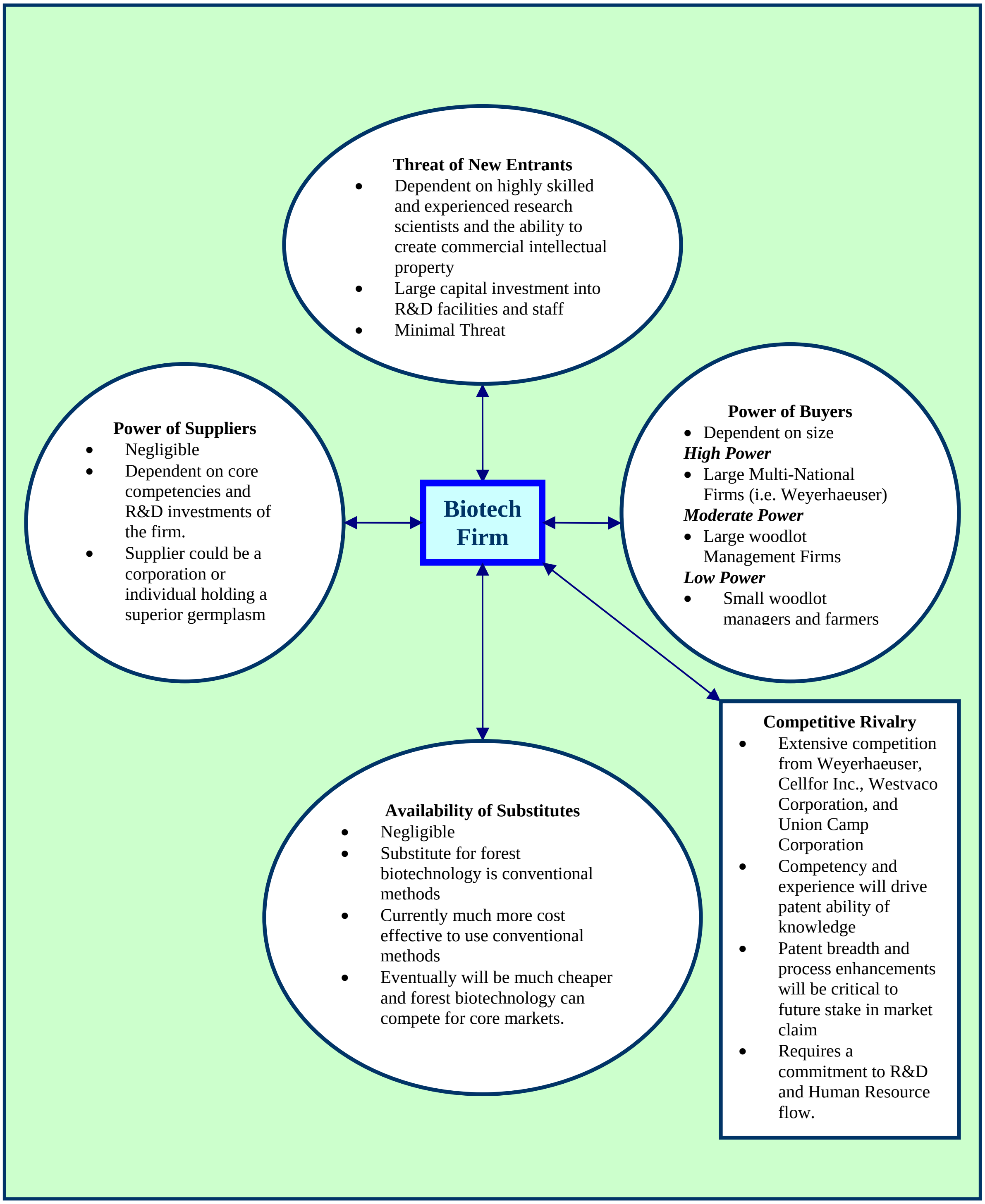


Figure 2 – Estimation of Claim Space over Somatic Embryogenesis

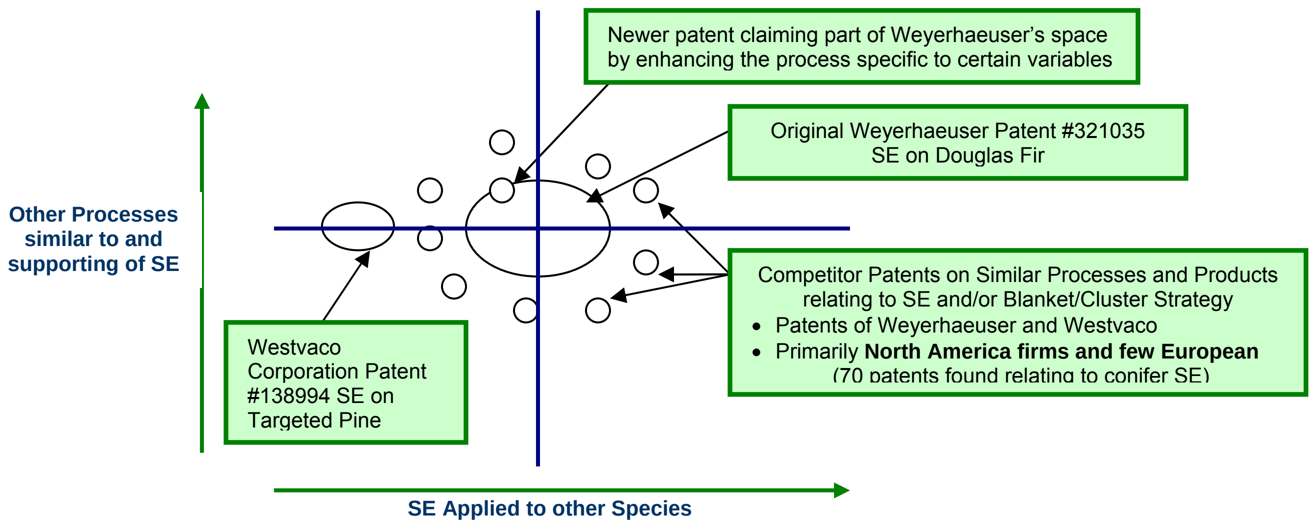


Figure 3 – Porter's Value Chain Model at Cellfor Inc.[42]

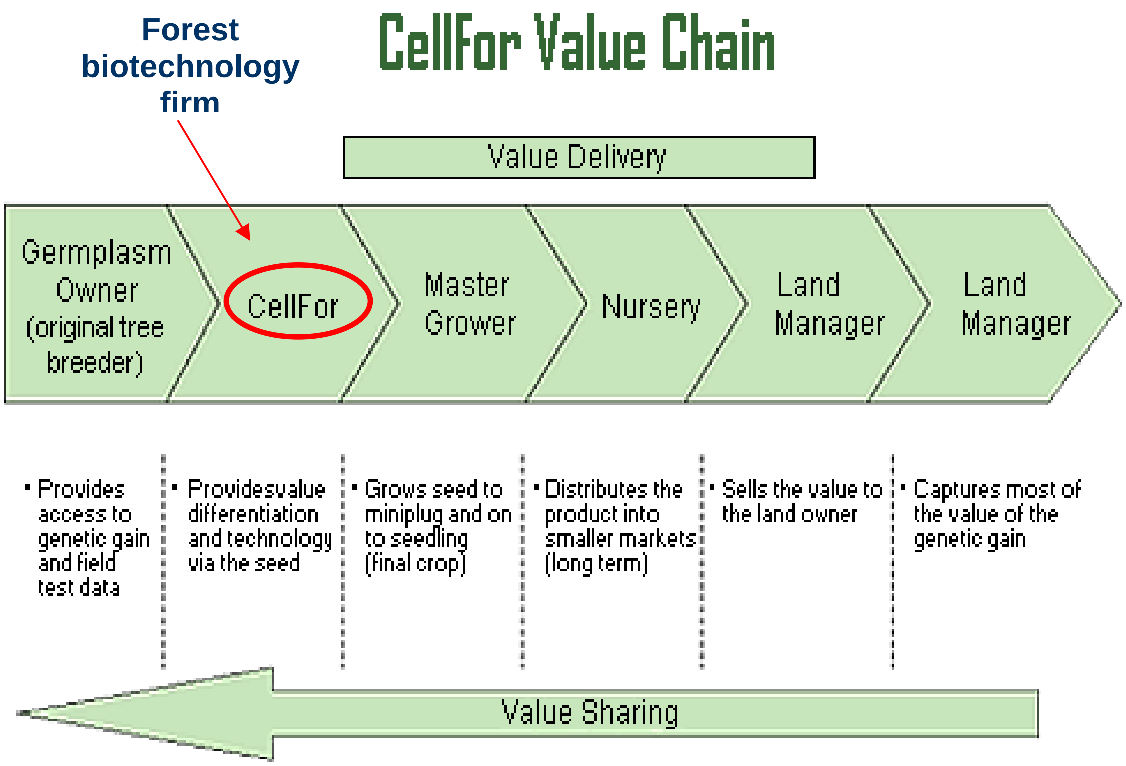
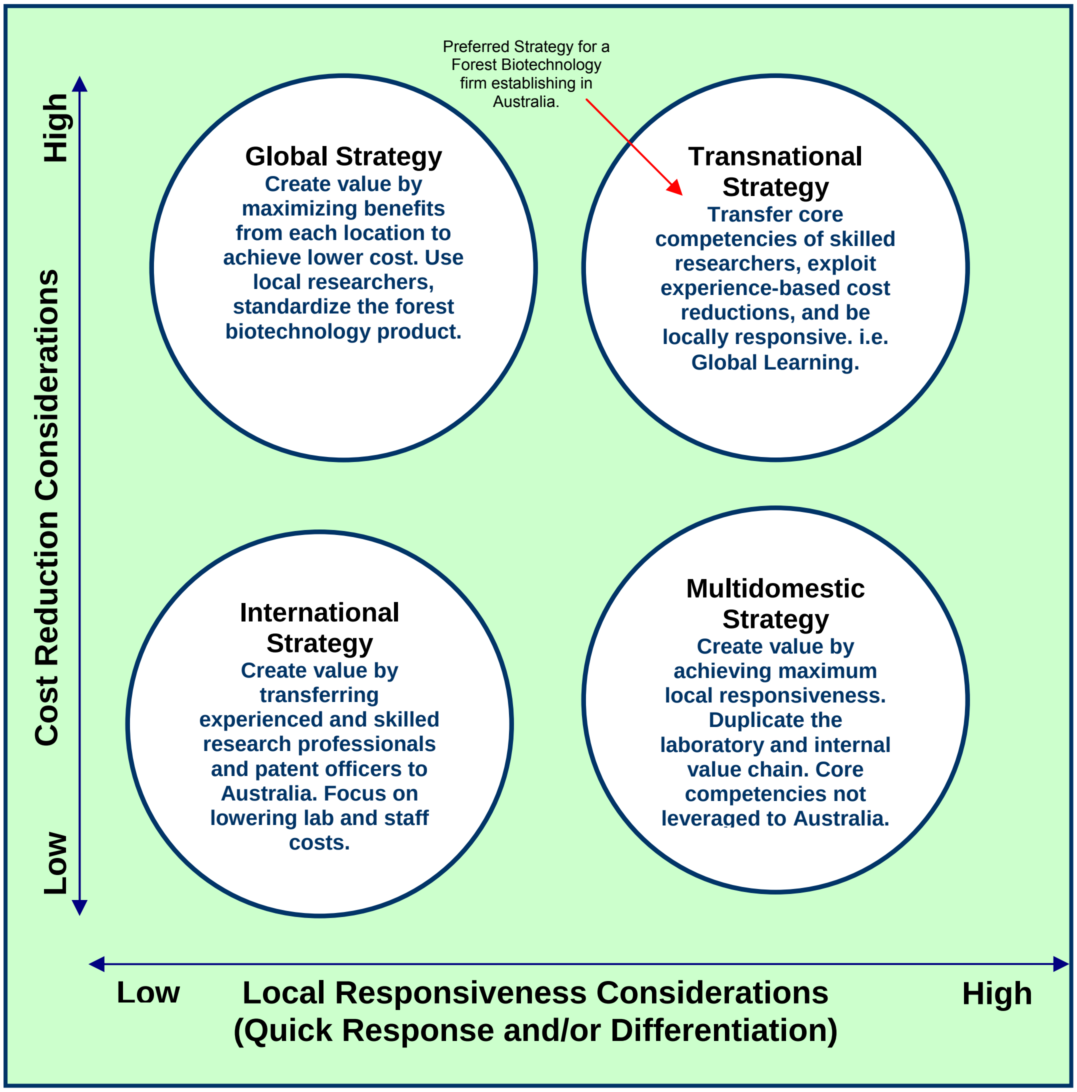


Figure 4 – International Operations Strategies for a Forest Biotechnology Firm



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All links were accessed between March 1 and March 23, 2004.