TECHNOLOGY TRANSFER AND KNOWLEDGE UTILIZATION: A REVIEW OF SYSTEMS AND ORGANIZATIONS RELEVANT TO WOOD UTILIZATION RESEARCH AND PRODUCT DEVELOPMENT IN THE UNITED STATES

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INTRODUCTION

> "... whether or not the best and most relevant research reaches the person with the problem depends on the efficiency of the communication links . . . therefore, the most important prescription for improving the use of research is to improve the means of communicating with the users of research" (Weiss 1979).

Objectives and Definitions

Public and private research focused on wood utilization and product development in the United States is an important source of innovation required for sustaining the worldwide competitive position of the wood-based industry. In 2008 an estimated 400 to 500 wood utilization research projects were implemented by 150 to 200 federal, state and private entities. Investments in publically implemented projects were in the range of $110 to $120 million, while, by some estimates, investments in projects sponsored by private concerns exceeded $2.5 billion in the same year (Ellefson and others 2010). Although reviews of research investments such as these have been made at various times in the past, there continues to be an interest in how the research community might better organize and manage its efforts to improve the use of research-produced technologies (National Research Council 2002). The very nature of the subject makes review and evaluation difficult . . .

> "Research is fundamentally about the exploration of new frontiers, punctuated by occasional flashes of insight that lead to new discoveries. These discoveries cannot be predicted very well in advance; nor can they be scheduled to arrive at particular dates" (Chesbrough 2003).

The intent of this review is to obtain a better understanding of the nature of technology transfer, especially as such involves wood utilization research and development. More pointedly, the review seeks to gain a better understanding of the (1) conceptual frameworks explaining technology transfer and the factors that such frameworks suggest as important to the use of knowledge provided by research, (2) public and private organizations that sponsor efforts to transfer technologies provided by research, and (3) conditions necessary for the effective transfer of technologies provided by research, especially those conditions called to mind by experienced researchers and research program mangers.

A review of technoloy transfer and knowledge utilization is useful to the extent that certain concepts and processes in involving research and development are well defined. For example, understanding processes involving the utilization of research calls for clarity in the definition of who is using the products thereof. To some, the users of research can range from other researchers that build on the findings of previous research, to those that use research to manufacture a new product or apply a new process. Still others may be users of basic research while others may seek research results that are regarded as more applied in nature. Exactly where on these continua a formal technology transfer program should be introduced is not always clear. Also uncertain to a review of technology transfer is the lack of uniformity in the definition of concepts and processes considered important to technology transfer. For purposes here, *technology transfer* is defined as the process by which research-developed knowledge is made available to a wide range of users who subsequently use it to develop new products, processes, applications, materials or services (knowledge utilization and technology transfer are used interchangeably), *research* is the planned search for new knowledge useful in developing new products or services, new processes or techniques, or significant improvements to existing products or processes, and *development* is the translation of research findings into a new product or process or a significant improvement to an existing product or process (Federal Laboratory Consortium for Technology Transfer 2010).

Prior Reviews and Evaluations

The transfer of technologies resulting from forestry and wood utilization research has received only modest attention in recent years. The reviews and assessments that have been undertaken tend to focus on the forest resource sector generally, on the development of public policies and programs, or on the evaluation of rates of return associated with certain research products. Although far from being a comprehensive listing, the following are example assessments.

"The Relevance and Risk of Government Science in Forestry" by Klenk and Hickey (2010) (evaluation how government-sponsored science informs forest policy development in Canada)

"The Interface of Policy Research and the Policy Development Process: Challenges Posed to the Forestry Community" by Spilsbury and Nasi (2006) (conceptual review of research diffusion and impact on policy development)

"The Incorporation of Research into Attempts to Improve Forest Policy in British Columbia" by Innes (2003) (evaluation of research product influence over forest policy development in Canada)

"The Influence of Research and Publications on Conventional Wisdom and Policies Affecting Forests" by Spilsbury and Kaimowitz (2000) (analysis research publication influence forestry decisions worldwide)

"Integrating Science and Policy Development: Case of the National Research Council and US National Policy Focused on Non-Federal Forests" by Ellefson

(2000) (evaluation of conditions contributing to the utilization of research in the development of forest policies).
“Communicating Research Results to User” by International Union of Forestry Research Organizations (1994) (specification of conditions to strengthen the linkages between researchers and the users of research products).
“Innovation and Productivity Change in the Structural Panel Industry” by Haygreen and others (1985). (evaluation of the role of forest products research in the development of the structural wood panel industry).

The aforementioned are examples of reviews focused on forestry and forest products. In some respects especially insightful are evaluations of technology transfer processes occurring within sectors other than forestry or forest products. For example:

“ The Extent and Determinants of the Utilization of University Research in Government Agencies” by Landry and others (2003)
“The Extent and Organizational Determinants of Research Utilization in Canadian Health Services Organizations” by Belkhodja and others (2007)
“Measuring Knowledge Utilization Process and Outcomes” by Rich (1997)
“The Many Meanings of Research Utilization” by Weiss (1979)
“Closing the Gap Between Research and Practice: An Overview of Systematic Reviews of Interventions to Promote the Implementation of Research Findings” by Bero and others (1998)
“State of the Business Incubator Industry: 2006" by National Business Incubator Association (2010a)
“The Effects of Business-University Alliances on Innovative Output and Financial Performance: A Study of Publically Traded Biotechnology Companies” by George and others (2002)
“The Utilization of Health Research in Policy-making: Concepts, Examples, and Methods of Assessment” by Hanney and others (2003)
“Determinants of Integrated Product Development Diffusion” by Boyle and others (2006)
“Adjusting the Roles of National Laboratories: Some Comparisons between UK, French and Belgian R&D Management” by Smith (1997)
“Federal Laboratories as Research Partners” by Lyden and Link (1999)
“Benchmarking of Business Incubators” by the European Commission (2002).

TECHNOLOGY TRANSFER SYSTEMS AND PROCESSES

The extent to which the products of research are used by individuals and organizations has been subject to increasing conjecture in recent years. The dilemma appears to rest on observations such as “. . . there is not yet an integrated conceptual model of research utilization” and ". . . little is known about the factors that induce professionals and managers to use research in their professional activities" (Landry and others 2003). Implied by these pointed statements are questions such as: To what extent is research actually used by public and private organizations? What conditions determine the extent to which the products of research are used? And are there differences in research utilization between and within various types of organizations? Although intense review is beyond the scope of this review, consideration in a conceptual sense has been given to some of these questions, notably the following.

Frameworks Structuring Utilization

Knowledge utilization has received considerably attention in recent years, if for no other reason than managers are increasingly being pressured to evaluate the extent to which investments in information resources are producing acceptable and appropriate results. Given such an environment, a critical question becomes how does one document the use of information and its impact? The flood of subquestions that emanate from such concerns is endless (Rich 1997):

> What specific uses are information put to in decision-making?
> What types of information are preferred over others?
> What is the rate at which new information is adopted?
> What patterns does information follow as it flows through an organization?
> What types of organizations require what types of information?
> What human personalities are more prone to using new information?
> What organizations are most effective as generators of useful information? Why?
> What can be done to reduce the gap between research and its utilization?
> What types of organizations are most effective at facilitating the application of new information? Why?

Securing answers to these questions is certainly beyond the purview of this review. However, the contextual framework for examining the use of research-generated knowledge and its utilization would seem appropriate to the assessment of processes promoting the utilization of research devoted to wood utilization and product development research.

Evaluating the utilization of knowledge provided by research presumes a conceptual basis for doing so. Commonly accepted over the years have been various linear interpretations of innovation, namely "one does research, research leads to development, development leads to production, and production to marketing," a conceptual framework that many suggest misrepresents innovation processes as a series of smooth, well-behaved linear events, ignorant of the many complex causal factors that are at work (Kline and Rosenberg 1986, Link and Link

2009, Rich 1997, Weiss 1979). Unfortunately, the community of analysts struggling to carry-out evaluations of knowledge utilization continues to be plagued by the reality that conceptual bases for doing so are often woefully inadequate.

> “. . . there is not yet an integrated conceptual model of research utilization . . . little is known about the factors that induce professionals and managers to use research in their professional activities” (Landry and others 2003).

> “. . . Much of the ambiguity in the discussion of research utilization derives from conceptual confusion” (Weiss 1979).

> “. . . Despite several attempts to development conceptual models for explaining the use of research, there is not yet an integrated conceptual model for use by experts in the field of knowledge utilization” (Oh 2000).

Adding to the challenges of evaluating the utilization of research is the often ambiguous nature of phrases suggested as valid measures of utilization. When is “information diffused,” “knowledge utilized,” and “research implemented?” Over the years, many scales and indices have been suggested for measuring these conditions, although most have been (and continue to be) plagued by fuzzy conceptual frameworks. An examination of current thinking on three of the latter is summarized in what follows.

Science-Knowledge Environment

The relationship of research endeavors and the use of products therefrom has been broadly conceptualized in a number of ways, ranging from notions of free-flowing and unbridled research that seeks to expand understanding of human and natural worlds generally, to models asserting the importance of linkages between researchers and the persons and organizations that have a direct and often vested interest in the products of investments in research. Although such diversity is acknowledged, experience suggests four major frameworks for assessing this continuum (Belkhodja et al. 2007, Kline and Rosenberg 1986, Landry et al. 2003, Weiss 1979) (Table 1). First, general *diffusion of scientific knowledge*, where researchers define and conduct research, the results of which are advanced in an uncertain fashion to various users (research is viewed as part of the intellectual enterprise of society). Information transfer is not automatic and is seldom guided by any single entity. Second, *imprecise demand for knowledge* wherein the demand for the products of research is ill-defined and the cultural differences between users and researchers are significant. Operating in such a framework, users have some – but limited – influence over the focus of research and as a result receive research products in forms that are

Table 1. Conceptual frameworks for research and scientific investigations, by key attributes and implications for research utilization and technology transfer.

Research framework	Key attributes	Implications for research utilization
A. Diffusion of scientific knowledge	•Researchers are the source of ideas for research and for conducting research. •Users of research products are poorly defined (if at all). •Research products advance aimlessly from researchers to users (nonlinear).	•Interaction between researchers and users of research products is virtually nonexistent • Transfer of knowledge is not assured and certainly not automatic. •Responsibility for transfer of knowledge is not assigned to an individual or organization. •Raw and unformated knowledge is not always easily used.
B. Imprecise demand for knowledge	•Users of research are sources of ideas for research, although most times in a very limited and indirect manner. •Researchers and users have markedly different cultures which restrict communication. •Research products advance sporadically and inconsistently from researchers to potential users.	• Research focus is often ill-defined and unclear, thus making research products of limited use. •Cultural differences limit interaction between researchers and users of research products. • Limited interaction between researchers and users limits utilization of research products.
C. Facilitated interaction for knowledge	• Interface between researchers and users of research products is limited, although facilitated by third parties. •Problems are identified, defined and made known to researchers by third parties. •Useful products of research are identified, configured and presented in useful forms to users by third parties.	•Researchers and users of research products are neither involved in the selection of researchable problems nor the selection of transferable information. •Third party interlocutors may be limited in ability to bridge the user-researcher interface.
D. Direct user-producer interaction for knowledge	•Interaction between researchers and users of research products exists at all stages of knowledge production. •Researchers actively seek user advice on problem definition, research approach, and ways of facilitating the use of research products.	• Instrumental role of research is focused on at expense of unfettered freedom to research unexplored subjects. •Access to the products of research is limited to few users of the products of research. •Very technical and very narrow products of research limit their broader application. •User organizational interests (limited time for research, change in problem definition, proprietary considerations) can compromise the integrity of research processes and products.

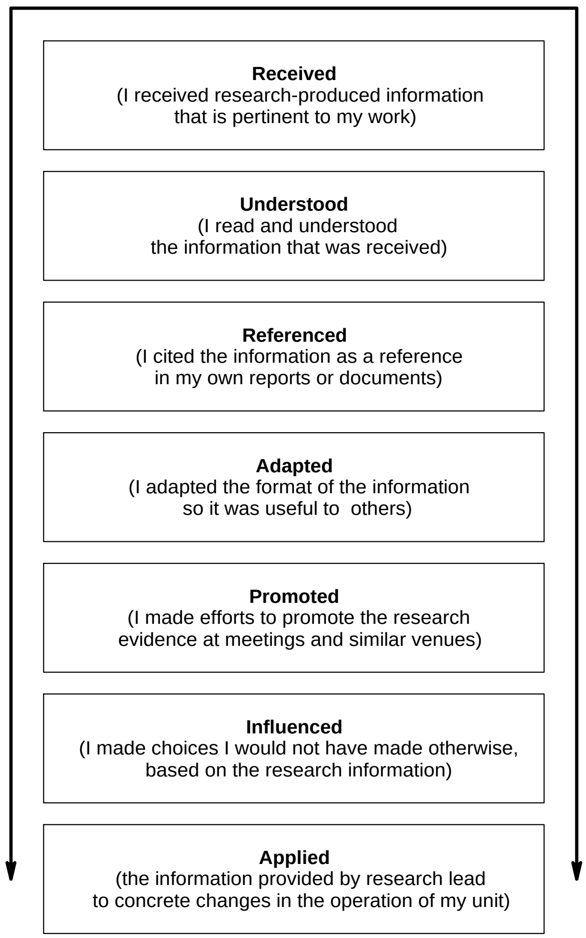
Source: Adapted from Belkhodja et al. 2007.

understood by researchers but foreign to them. Third, *facilitated interaction* as a conceptual framework advances the importance of collaboration and dissemination activities in which third parties become the interface between users and researchers. Their role is one of enabling a better research focus on user-defined problems and on the subsequent use of products produced by researchers. And fourth, suggested as a research utilization framework is *direct user-researcher interaction*, which suggests the importance of personal contacts in defining problems in need of research, ways of conducting research, and avenues for utilizing the findings of research.

The aforementioned frameworks for relating research activities to research clientele have implications for the utilization of knowledge produced by research. For example, unbridled generation of scientific information by researchers is no guarantee that research products will be transferred to potential users nor that the knowledge so generated will be of value to the clients of research. Similarly, poorly defined research objectives can lead to research products that fail to adequately address the important information needs of users or that are delivered to users in ways and forms that make the products unuseable. As for facilitated user-researcher interactions, the imposition of a third party may do little to bring users and researchers together in manners that truly focus on information needs. Poorly informed third-party interlocutor ability can do little to bridge the user-researcher interface. As for direct user-producer interaction, researchers can become captive to the narrow interests of users and thereby lose their freedom to more broadly explore problems and research approaches that may have greater payoffs.

Individual Utilization of Knowledge

The utilization of information produced by research has increasingly focused on the manner in which individual users respond to such information and on whether their response is a single discrete event or a spectrum of decisions that eventually lead to the application of information generated by research. The former suggests that a decision to use a product of research is a discrete event based on a single research report or program. Because research findings may generate many effects, and because decisions do not always depend on a single piece of research, interest has increasingly focused on conceptualizing the use of research as a series of different decisions. As stated elsewhere, ". . . research utilization decisions do not depend on a single piece of research, but on a series of research results converging toward one decision" (Rich 1997). From the perspective of an individual manager or professional, commonly suggested are the following stages of knowledge utilization (Belkhodja et al. 2007, Knott and Wildavsky 1980, Landry et al. 2003, Rick 1997, Weiss 1979).



Organizational Utilization of Knowledge

The ability of organizations to assimilate the products of research has also been of considerable interest in recent years, although the bridge between an individual manager's reliance on the products of research and the innovative character of an organization generally has been subject to much conjecture as stated elsewhere ". . . the relationship between individual and organizational learning [involving the products of research] is far from being clear and well established . . . organizational learning goes beyond the simple accumulation of individual learning [that is] grounded in research" (Belkhodja et al. 2007). The hallmark of an organization that has effective research utilization capabilities is typically one that has made knowledge absorbing processes part of normal organizational routines (for example, training, conferences, internet access). Viewed as a process, suggested is that an organization's capacity to absorb knowledge involves four major steps (Belkhodja et al. 2007, Rich 1997, Zahra and George 2002):

Acquisition: capacity to identify and acquire external knowledge that is critical to an organization's operations.
Assimilation: capacity to analyze, interpret and understand knowledge acquired from external sources.
Transformation: capacity to combine newly acquired knowledge with already assimilated knowledge.
Exploitation: capacity to use and take advantage of new knowledge by developing new capabilities that improve an organization's operations.

Circumstances Influencing Utilization

Range of Factors and Conditions

Conditions that determine whether the products of research will be utilized have been suggested by a number of analyses and by considerable speculation and conjecture. They range from the importance of a close working relationship between researchers and potential users of research, to the necessity for timely introduction of research into decision making processes, and from the significance of sound scientific and analytic footings for research, to the importance of having the results of research presented in understandable and appealing formats. Suggested by some is that these and other conditions can best be appreciated if grouped into five major summary categories as follows (Belkhodja et al. 2007, Spilsbury and Nasi 2006).

Type and Content of Research. Are the products of the research scientifically and analytically sound? Are they presented in formats demonstrating . . .

- quantitative validity ensuing from scientific and analytical rigor.
- qualitative validity based on observance and case studies.
- theoretical or speculative explanation of solutions to problems.
- advancement of science and scholarly knowledge.

Organizational Context. Are the products of the research cognizant of conditions in the managing organization? Are they relevant to conditions faced by managers-administrators . . .

- always concentrated directly on specific (exclusive) information needs.
- timely and pertinent to users and user colleagues.
- understanding of organization's policies and programs.
- able to improve organization's policies and programs.
- focused on a particular level of government (federal versus state managers-administrators).
- focused on a particular size of organization (small versus large organizations).

Culture of Users-Researchers. Are the products of the research reflective of common user-researcher interests? Are they the result of processes where products are . . .

- consistent with the interests and needs of users (for example, easy to understand, appealing in format, operationally specific, clinically verifiable).
- acquired from an environment of close and active user-researcher working relationships.

User-Researcher Linkages. Are the products of the research emanating from healthy consultative activities between users and researchers? Are they the products of processes where . . .

- links between users and researchers at all stages of knowledge utilization are intense (user-researcher interaction at informal meetings, conferences-seminars, electronic mail, common libraries and data sources).

User and Manager Attributes. Are the products of the research the result of engagement of reliable and qualified participants? Are the research products originating from the interests of . . .

- users-managers with high levels of formal education.
- users that are professionals in managerial positions.

The style and background of managers and professionals have also been suggested as major factors determining the extent to research will be favorably received. In this respect, variables likely to explain an organization's ability to absorb the products of research are managerial and professional (1) ability and willingness to learn, (2) past experiences in research leadership positions, (3) allotment of time to research entities and endeavors, (4) level of formal education attained, and (5) perception of how relevant the results of research are to the organization's operations. In addition to such indicators, other measures are attitude toward the products of research (manager's preferred source of information?), intensity of use of research products (manager applied research products in the past?), linkage between users and researchers (manager actively engaged with researchers in the design of research?), access to the results of research (manager attends demonstrations of how to use research results?), and past experiences with research practices and processes (manager having collected research data in the past?). Evidence suggests that an organization's ability to acquire, react to, and incorporate the products of research into decision making processes are heavily dependent of the character of the organization's managers and professionals (Belkhodja et al. 2007).

The context of adoption constraints and certain intrinsic attributes of research products that are sought by users has also been pointed to as conditions affecting the use of research (Rogers 1983, Spilsbury and Nasi 2006). If research is suggesting that "something different needs to be done," managers are likely to ask the following questions: *Relative advantage* – is it better than what it replaces and are additional costs outweighed by the benefits? *Compatibility*–does the innovation fit with current practices, norms, and values? Complexity–is it simple to understand and use? *Trialability*–can the innovation be tested on a trial basis without large investments? *Observability*–are the benefits readily discernable? And, *reversibility*–is it possible to stop using the innovation and to continue as before? Within such a context, impediments to the use of research-provided knowledge have been suggested as follows–various combinations of which make generic solutions for increasing knowledge utilization quite problematic (Spilsbury and Nasi 2006).

Constraint on use of research	*User perspective on cause*
Unaware of new technology or innovation	Poor dissemination of research results, inadequate user involvement in research processes, large supply of competing or contradictory information
Sources of new technology or innovation lack credibility	Lack of influential partners or clients, lack of familiarity with producers of research, uncertain credibility of technology's science, research findings contrary to conventional wisdom
Poor fit for new technology or innovation	Research results address a low-priority problem, technology inflexible or difficult to adapt, inappropriate format-presentation of research results, lack of user involvement in development of new technology
Inadequate understanding of new technology or innovation	Unclear purposes or possible application of new technology, insufficient capacity of user to use new technology, poor format and presentation of new technology
Unaware of problem requiring application of new technology or innovation	Lack of information about a problem requiring new technology, lack of capacity to diagnose a problem in need of new technology, problem disregarded by user
Inappropriate timing for application of new technology or innovation	Technology available but conflicts with conventional wisdom, limited window of opportunity for using new technology
Lack of enabling conditions or incentives to use new technology or innovation	Lack of capacity to implement new technology, inadequate incentives to adopt new technology

Manufacturing establishments can be major users of new technologies brought forth by research. Conditions at play when company decisions are made to use (or not use) research range from how well the products of research advance a company's mission and competitive position, to whether a company has an established process for identifying and examining new technologies, and from the information management systems internally available to a company, to the willingness of company managers to actively and willingly express visible support for suitable technologies (Boyle et al. 2006, Gerwin and Barrowman 2002, Nijssen and Frambach 2000, Poolton and Barclay1998). In a more a focused sense, determinants of research utilization within a manufacturing environment can be summarized as follows (identified from nearly 30 references on research diffusion amassed by Boyle et al. 2006).

Context Oriented Factors (company mission, structure and culture favors research and the products therefrom)–new technology is important to company mission and strategic interests; company has a history of receptivity to new ideas and technologies; adopting new technology poses acceptable risk and liability to company; initial and ongoing financial requirements posed by new technology are acceptable; new technology is applicable and expected to persist for an acceptable period of time; company size and structure complements adoption of new technology (small versus large organization, formalized and centralized versus decentralized and flexible); and programs for training and educating employees about new technology are available to a company.

Process Oriented Factors (company processes for converting products of research into new processes or products are available)–administrative layers between company researchers and managers are few; group sessions to promote creative discussion of visions and barriers to the adoption of new technologies can be readily exercised; opportunity exists to collect pro-con views from disparate entities within a company; technical requirements of existing processes and products can easily be transformed to meet the requirements of the new technology; opportunity exists for many sequential rounds in which company researchers and managers can offer opinions and visions regarding the new technology; prototypes making use of the new technologies can be promptly developed and observed; and ability to target new technology to selected sets of potential adopters exists within a company.

People Focused Factors (company researchers and managers actively engage in research and in the conversion of research products into new products and processes)–company managers are receptive to new technologies and are willing to actively and willingly express visible support for suitable technologies; company researchers-managers are located in one physical location; information management technologies stimulating communication and information sharing occur widely within a company; new product development engages the knowledge of customers, managers, suppliers and researchers; evaluation and reward for new process and product development are focused group-wide within a company; researchers and managers are willing to refine, elaborate and modify products of research; company managers view the new technology as easy to understand and use and view the technology as better than technologies to be superceded (relative advantage); demographics of company employees suggest adoption of the products of research (age, gender, education); and the number of company employees that will be required to changes behavior and work patterns is acceptable.

> *Information Focused Factors* (company information management systems facilitate research and the adoption of products therefrom)–company can offer a single database for storage of information concerning new process and product development; and reliable software exists to simulate the impact of new technologies on company manufacturing processes and new products.

Within the above context, the paraphrased views of company managers are instructive: “you must have good researcher-manager communication to ensure all that all issues are recognized and resolved before they become big issues,” “resistance to research-developed technologies [results from] resistance to change generally and resistance to working openly with other company departments,” “we are poor at integrating the products of research; departments are managed more like silos,” “close working relationships . . . , our eleven researchers/developers by necessity work closely with production units to make production prototypes,” “because many changes involving new processes and products are incrementally small changes, involvement of research disciplines are limited and viewed as being handled by design engineers,” and “products of research can increase costs initially, but they can be offset by production of better products, made more efficiently, and of better quality” (Boyle et al. 2006).

Dissemination of information provided by research programs has also been identified as a factor in the use of research-based information. Huberman (1995) made an extensive review of programs engaged in the dispersal of research, identifying the following conditions to be major players: *intensity of effort* (ample time devoted by lead researcher and staff, access to sufficient human and material resources), *quality of execution* (adherence to a well-developed plan, implementation of appropriate strategies, smooth implementation patterns), *relevant tactical approaches* (interaction of users and researchers, presentation of user-specific products, multiple channels-modes of communication, reinforcement of messages, in-person transmission of messages, follow-through [continuity] with users), and *high quality written documents* (readable, operationally appropriate, focus on important user variables, incorporation of user context, realism of recommendations, attractiveness of research reports).

<u>Critical and Necessary Conditions</u>

As the aforementioned indicates, a wide variety of conditions have been suggested as predictors of whether information provided by research will actually be used. As important as they all may appear, which conditions are especially meaningful? To shed light on the matter, consider an admittedly modest but very discerning number of efforts to define the relative importance of conditions that influence the use of information provided by research. Few of the evaluations selected for review focus on sectors involving the use and management of forests.

Why? Because there is an unusual dearth of rigorous appraisals involving the use of research by organizations (public and private) engaged in the use and management of forests and the manufacture of products therefrom. It is sectors other than natural resources from which some of the more informative assessments of research utilization have come in recent years (for example, health services, educational organizations, pharmaceutical industries, biotechnology companies, semiconductor industries, automobile and related transportation industries, national and state legislative systems).

Table 2. Transfer of research produced information from university researchers to government officials in Canada, by frequency of use and stage of knowledge utilization. 2003.

Information provided by research was . . .	Frequency of occurrence in stage in knowledge utilization (percent)					
	Never	Rarely	Sometimes	Usually	Always	Total
Received	7	36	44	12	1	100
Understood	1	6	29	50	14	100
Referenced	16	28	36	17	3	100
Adapted	33	36	25	6	0	100
Promoted	19	33	33	14	1	100
Influenced	10	35	38	12	1	100
Applied	11	36	43	9	1	100

Note: Decisions from one stage to the next are sequential.
Source: Adapted from Belkhodja et al. 2007, Landry et al. 2003.

The importance of various conditions that promote the use of research has benefitted greatly from recent evaluations undertaken in Canada. In 2003, the utilization of university-produced knowledge by Canadian federal and provincial governments was evaluated, the results of which have proven to be especially instructive (Landry et al. 2003). A major portion of the evaluation focused on the importance of individual manager decisions regarding the use of research (Landry et al. 2003) (Table 2). Concentrating on 833 managers and seven government sectors (including natural resources) in 2003, their sequential decisions regarding the use of research suggest that only a modest portion (13 percent) usually or always receive research provided by university researchers, although once received a large portion (64 percent) took the time to read and understand the information. After receiving, understanding, referencing and adapting the information, very few of the managers promoted the information in meetings with colleagues or similar venues (15 percent)–85 percent never, rarely or sometimes did so. As for actually applying the research to an issue or problem, only 10 percent responded usually or always in the sequential set of steps. Although the managers' responses may be interpreted as less than favorable to the unitization of research, at each stage of the sequence and average of 56 percent of the managers report their decisions to be positive, namely actions were taken sometimes, usually or always. Although the evaluation does not focus directly on wood utilization and product development research, the results would seem to suggest that managers are positively receptive to research in the seven stages of research utilization.

In addition to understanding individual manager decisions regarding the use of research, the above referenced evaluation also provides insight about unitization-promoting factors generally. Regarding the latter, professional managers in Canadian government positions were found to be greatly influenced by at least eight major conditions (Table 3), namely the products of the research demonstrated validity in terms of scientific and analytic rigor, the research results were timely and pertinent to the managers, the research was understanding of the policies and programs being implemented by the manager's organization and appeared capable of improving these policies and programs, the products of the research were easy to understand and operationally possible to implement, managers and researchers had worked together (at various venues) to produce the research, and the managers using the research had high levels of formal education. Not considered good predictors of research utilization was research promoting theoretical or speculative explanations for solving problems, research that is concentrated directly and very specifically on a single information need (to the point of being exclusive), and research that was especially focused to a particular size of government organization or to only processionals in managerial positions (Landry et al. 2003).

The sector or type of agency a manager is affiliated with also has an affect on the utilization of research. Again, the Canadian experience is instructive. Research utilization was lowest among managers in the municipal and public works sector and highest among managers in the education and information sector. When sectors are ranked from high to low utilization of knowledge provided by research, the following positioning occurs: education and information technology; social services, health and social security; agriculture, forest, fishing and environment; economic finance and development; justice, immigration and cultural affairs; job creation and standards of employment; and municipal and public works. Overall, these rankings confirm that policy domains matter and that professionals and managers in certain government sectors make greater use of research than professional managers in other sectors. When focus was directed at research utilization in the agricultural, environmental and natural resource sectors (a sector in which wood utilization and product development was situated), manager reasons for using research differ from manager responses in other sectors. Very significant predictors of research utilization were timeliness and pertinence of research results, consistency of research results with manager interests and needs, and research products that result from focused interaction between manager and researcher. Nine of the 15 factors considered as predictors of research utilization by natural resource and related managers were determined *not* to be significant. Somewhat or very significant as a predictor of research use were research products

Table 3. Predictors of research utilization by professional managers in the fields of Forest Resources, Fisheries, Agriculture and Environmental Management in Canada, by importance of predictor. 2003.

Predictor of the utilization of research products	Forest, Fisheries, Agriculture and Environmental Organizations	All organizations
Type and Content. Research products are presented in a format demonstrating . . .		
• quantitative validity ensuing from scientific and analytic rigor	not significant	highly significant
• qualitative validity based on observance and case studies	not significant	very significant
• theoretical or speculative explanation of solutions to problems	very significant	not significant
• advancement of science and scholarly knowledge	not significant	somewhat significant
Organizational Context. Research products are useful to managers-administrators to the extent they are . . .		
• always concentrated directly on a specific information need	not significant	not significant
• timely and pertinent to users and user colleagues	highly significant	highly significant
• understanding of organization's policies and programs	somewhat significant	highly significant
• able to improve organization's policies and programs	not significant	highly significant
• focused on a particular level of government (federal versus state managers-administrators)	not significant	very significant
• focused on a particular size of organization (small versus large organizations)	not significant	not significant
Culture of Users-Researchers. Common interests of users and researchers are evident and research products are . . .		
• consistent with the interests and needs of users (easy to understand, appealing in format, operationally specific, clinically verifiable)	highly significant	highly significant
• acquired from an environment of close and active user-researcher working relationships	highly significant	highly significant
User-Researcher Linkages. Research products are useful to the extent . . .		
• links between users and researchers regarding knowledge utilization are intense (user-researcher interaction at informal meetings, conferences-seminars, electronic mail, common libraries and data sources)	highly significant	highly significant
Attributes of Users and Managers. Research products are useful to the extent . . .		
• users-managers have high levels of formal education	not significant	highly significant
• users are professionals in managerial positions	not significant	not significant

Note: Organizational domains are(1) municipal, regional, public affairs, public infrastructure; (2) economic development, finance, fiscal; (3) education, information, technology; (4) forest, fisheries, agriculture, environmental; (5) health, social services, social security; (6) language, culture, immigration, justice, native affairs; and job creation, employment standards. Statistical levels of significance are highly, very, somewhat, not significant at 1, 5, 10 and less than 10 percent level, respectively.
Source: Adapted from Landry et al. 2003.

that demonstrate theoretical or analytical rigor and research appreciative of the policies and programs for which a manager is responsible (Table 3) (Landry et al. 2003).

Certain types of technologies developed by research appear to require special conditions in order for them to be effectively disseminated and utilized. Such has been found to be the case regarding the transfer of nanotechnologies to various types of businesses, including manufacturing enterprises (Bozemann et al. 2008). Of interest are nanotechnology-based materials involving coatings, pharmaceuticals, molecular electronics, optical materials, and textiles and displays. Based on information collected from 25 companies located near (within 30 miles) university-based nanotechnology research centers in 2005, the conditions found to have the most positive influence on company utilization of nanotechnologies were direct access to university resources engaged in research related to nanotechnology (especially faculty and physical facilities) and access to early-stage capital resources necessary in order to commercialize the new nanotechnologies. Companies with more experience (more years) with nanotechnologies were more likely to seek out and to commercialize such technologies. Such suggests that a minimum level of company knowledge about a new technology is probably necessary before a company approaches university researchers that are engaged in such research. Also facilitating the utilization of new nanotechnologies was the extent to which company research and development investments are already devoted to some degree to such technologies. Implied is that relevant in-house scientific equipment and personnel makes the importing of new nanotechnologies much easier. And finally, only weak evidence suggests that smaller companies (measured by number of employees and size of revenue) are at a disadvantage in adopting university-developed nanotechnologies. Regardless of company size, access to a broadly based, qualified manufacturing labor force does not appear to be a necessary condition for the effective diffusion of new nanotechnologies.

The utilization of research can also have a geographic and infrastructure orientation. Because the drivers of regional knowledge utilization are numerous and diverse, and often embedded within regional innovative capacity generally, identifying their nature and impact is often challenging. However, in 2007, the following conditions were identified as important indicators of research utilization for current or emerging technologies (Auerswald and Kulkarni 2008) (asterisk indicates variable explains 50 percent or more of innovation-knowledge utilization incidents):

Innovative Infrastructure Conditions
- Venture capital companies*
- Patent lawyers*
- Patent frequency*
- IT software companies*
- Physical research facilities
- Engineering services
- Testing laboratories
- University R&D funding
- Universities and colleges (large size)

Social Capital
- Civic and social associations
- Business associations

Creative and Cultural Conditions
- Management consulting personnel*
- Theaters and orchestras*
- Architectural services*
- Book stores and libraries
- Museums and art galleries
- Religious facilities

Financial Instruments
- Research awards to small businesses*
- Research awards to large businesses*
- Business incubators

At the risk overgeneralizing, regions with an abundance of venture and software companies, plentiful consulting organizations and cultural amenities, and ample opportunities for businesses of all sizes to obtain research grants, appear to be regions in which there is a greater likelihood that knowledge generated by research will be used.

TECHNOLOGY TRANSFER ORGANIZATIONAL LANDSCAPE

Opportunities for moving the products of research from ideas and concepts to commercialization can be fraught with difficulties. The latter can range from inadequate financial resources to uncertainty over marketability of the technology, and from exceptionally high risk of product or process failure to exceptionally long horizons before a financial payout. In such cases, business entrepreneurs often have a broad array of public and private organizations from which to look for support. In some cases, the logical fit may be private entities that can offer the financial resources considered critical to the commercialization of a new technology. Examples are high net-worth individuals that seek healthy returns on their investments or private equity firms that manage investments on behalf of individuals or groups of individuals (pension funds, endowments, foundations). The security offered by various local, state and federal government programs can also be a source of support for start-up companies. Examples are various grants and incentives that are made available to small businesses by agencies such as the U.S. Small Business Administration. In some cases, the advancement of new technologies is promoted by a combination of public and private support, as is often the case with business incubators. Regardless of the source of support, the fledgling enterprise hoping to be a success must plead its case for some sort of financial, managerial or legal protection if its promising–but risky–product of research is to successfully move into a viable place in a market environment.

Private Program Sponsorship

Private organizations often engage in research involving wood utilization and development. Although their number and the focus of their research efforts have been reasonably well documented, comprehensive and publically available information about how they transfer newly developed technologies to clients and, in some cases, the broader public is sketchy (Ellefson et al. 2010). These organizations may have a for-profit orientation (for example, wood–based manufacturing companies, research service organizations) or a nonprofit orientation (for example, trade and business associations).

Information Transfer Programs

Research Service Organizations. Operating as private for-profit businesses, research service organizations respond to the information needs of a variety of individuals and enterprises engaged in the use and manufacture of wood products (Appendix Table 1). Typical of such organizations are literally hundreds of private consulting firms. Although they often only peripherally engaged in rigorous research activities, for-profit research service organizations do investigate (or research) problems posed by clients and do convey the results of such information to their clients. When doing so, they become actively engaged in the transfer of technical knowledge. Noteworthy as examples of service organizations that are actively engaged in research and in technology transfer are the following.

•*Herty Advanced Materials Development Center* (Savannah, GA): *Mission* – Through innovation, unlock commercial opportunities in wood fiber and ensure production into new markets and industrial products. *Major Focus*–Research, testing, pilot-scale production, product commercialization, information dissemination; *Sector Interest*–Pulp, paper, board, and advanced composites.

•*Polymers Center of Excellence* (Charlotte, NC): *Mission*–Assist in the development of emerging polymer technologies and provide timely, cost-effective technical support for such technologies. *Major Focus*–Product design, testing, education; research dissemination; *Sector Focus*–Packaging and consumer product industries.

•*CleanTech Partners* (Middleton, WI): *Mission*–Help businesses implement new and emerging technologies that will reduce energy consumption, create jobs, and protect the environment; *Major Focus*–Equity financing, business counseling, information dissemination; *Sector Focus*–Commercialization of technologies used by forest product companies.

•*Applied Paper Technology, Inc*. (Atlanta, GA): *Mission*–Help customers improve the predictability of their paper, paperboard, or converted product; *Major Focus*–Research, testing, information dissemination; *Sector Focus*–Coated paperboard, and fine paper.

In addition to the aforementioned, there are also many private for-profit organizations that are engaged primarily in the dissemination of information. Although the strength of the link between their performance of research and the transfer of technology therefrom may be tenuous, they do play a role in promoting the utilization of knowledge that originates from a variety of public and privately sponsored research programs. A comprehensive and detailed public understanding of these organizations is wanting. The following examples will have to suffice (Ellefson et al. 2010).

•*ABB, Inc*. (Appleton, WI; Portland, OR)–services involving process control systems, instrumentation and energy systems for the paper and composite industries.
•*Abba Makolin Waldron & Associates, LLC* (Neenah, WI)–services involving development of processes, products and materials for the pulp and paper industry.
•*Buckman Laboratories* (Memphis, TN)–services involving development of speciality chemicals for the pulp and paper, packaging and recycling industries.
•*Chempap, Inc.* (Montgomery Center, VT)–services involving strategic planning, merger and acquisitions, advising buyers and sellers in the forest industry.
•*EnteGreat, Inc.* (Birmingham, AL)–services involving manufacturing designs to help in the leveraging of technology required by in the production of pulp and paper.
•*Intota Corporation* (Minneapolis, MN)–services involving wood adhesives used in laminated wood and oriented strand board, especially selection, application, and failure of adhesives.
•*PERFORX* (Atlanta, GA and Portland, OR)–services involving operational planning and performance of large paper converting, panel product and sawmill enterprises.
•*Wood Machining Institute* (Berkeley, CA)–services involving collection, evaluation and dissemination of information about wood machining equipment and cutting tools as applied to operations such as chipping, sawing, planing, shaping, routing, and sanding.
•*Wood Advisory Services, Inc.* (Millbrook, NY)–services involving engineering and construction, building performance evaluations, process and product evaluation, and statistical analysis and experimental design.
•*Wood Resources International* (Bothell, WA)–services involving global wood price trends and global trade in wood and paper products.

Trade and Business Associations. A myriad of private nonprofit organizations perform an assortment of wood utilization related activities on behalf of their members. For example, they may examine and test materials and processes (for example, APA-The Engineered Wood Association), develop product and process standards (for example, National Association of Home Builders Research Center) and lend financial support required in order to implement the findings of research (for example, CleanTech Partners). In the process of doing so, they often engage in technology transfer activities (for example, publishing technical journals and news letters, sponsoring education and training forums). Trade and business associations may focus their activities directly on wood and woody products (for example, Center for Paper Business and Industry Studies), although for many, wood utilization is but one modest part of their organization's overall interest (for example, Southern Research Institute) (Ellefson et al. 2010).

The number of trade and business associations representing the wood-based interests of individuals and businesses in 2006 exceeded 100 nationwide (Ellefson et al. 2010). Although certainly not comprehensive nor exhaustive, the following are examples of trade and business organizations that undoubtedly engage in the transfer of research-based information to member organizations and the general public: Alliance for Environmental Technology (improve the environmental performance of the pulp and paper industry), National Nanotechnology Manufacturing Center (accelerate the commercialization of nano-enabled materials and devices), American Society for Testing and Materials (ASTM) (voluntary development of technical standards for materials, products, systems, and services), National Institute of Building Science (promote effective cooperation between public and private interests seeking energy efficient and environmentally responsible homes and buildings), American Institute of Timber Construction (development laminated industry design and product standards, including quality assurance, inspection, grading, and laminated timber research), and Composite Panel Association (bring together the complete value chain affiliated with the composite panel industry).

Wood-based Companies. Wood-based manufacturing companies are often actively engaged in wood utilization research and development (in 2008, 26 companies reported an average investment of $30 million per company [$788 million total] in research or about one-third of the industry's total investments for such purposes [$2.4 billion in 2006]) (Appendix Table 2) (Ellefson and Kilgore 2010). Unfortunately, very little is publicly known about company processes used to select problems worthy of research, or how the information resulting from research makes its way to new product development or to improvements in manufacturing and marketing activities. In most cases, company proprietary interests prohibit widespread understanding of these processes.

The research intentions of wood-based companies can provide some insight on company research and how the products of such may be used (Ellefson and Kilgore 2010). As announced in annual reports and filings with the U.S. Securities and Exchange Commission, companies indicate their research programs are important for a number of reasons, including support for the implementation of company business strategies generally, development of new and improved products and processes required in order to remain competitive in the marketplace, reduce the cost of manufacturing products and distributing them to customers, and seek solutions to sensitive environmental problems associated with the manufacture of certain products. Companies also appear to use their research programs as a way of building customer loyalty by providing technical support based on the findings of research activities. Example statements of intent for the research programs of specific companies provide a more focused understanding.

- *Buckeye Technologies, Inc*. "Focus on developing new products, improving existing products, and enhancing process technologies to further reduce costs and respond to environmental needs . . . focus on advanced products and new applications to drive future growth"
- *International Paper Company*. "Direct research and development activities to short and long-term technical assistance needs . . . and to process, equipment and product innovations."
- *Kimball International* ". . . development of manufacturing processes, major process improvements, new product development and design, information technology, and wood related technologies."
- *Nashua Corporation.* "Direct research toward developing new products and processes and improving product performance, often in collaboration with customers."
- *Rayonier, Inc.* "R&D efforts in performance fiber business directed primarily at developing existing core products and technologies."
- *Schweitzer-Mauduit International, Inc*. ". . . dedicated to developing paper product innovations and improvements to meet the needs of customers."
- *Verso Paper Company*. ". . . work with customers in developing and modifying products to accommodate their evolving needs and to identify cost saving opportunities within company operations."
- *Weyerhaeuser Company.* "Research is a strategic business investment to help company and its customers achieve sustainable competitive advantage by creating and preserving options in the face of uncertainty about the future competitive environment."

Wood-based manufacturing companies are but a part of the nation's overall manufacturing sector. So too are their research activities part of a more widespread corporate interest in research. From a research utilization perspective, trends in other sectors of the economy can be instructive. Recent assessments suggest that companies are expanding their network of innovation entrepreneurs beyond the traditional models of company-based research and development (Radjou 2006) . . . [1]

> "[It is] becoming increasingly apparent to many leading businesses that the traditional model of research and development–where companies single-handedly finance, invent and commercialize their innovations–is increasingly ill disposed to meeting company [needs for innovation] . . . the typical R&D organization, with all its insular and unresponsive culture, is now hampering firms' ability to deliver research that can be converted into profitable innovations."

Emerging company research and development models point to the need for a seamless weave of internally and externally available research and innovation services. By establishing such networks, companies are better able to co-innovate with customers (market feedback, service needs, innovative solutions to problems), expand research productivity (internal and external partnerships among scientists and engineers), spread the risk of disruptive innovations (joint ventures, equity partnerships) and access innovative talent across sector and national boundaries. Exactly how this evidence might influence conditions within the wood-based industry is subject for conjecture.

The importance of broadening company research and development networks has been carefully documented for collaborations involving companies and universities, especially in the field of advanced materials (for example, coated materials, anti-bacterial materials). Recent evaluations indicate that companies report substantial rewards from more intense collaborations with universities, especially with "star scientists" that are subsequently involved throughout all stages of knowledge utilization–from discovery of science, to university and industry collaboration, to innovation and piloting, and to commercialization of products (Baba et al. 2009). Broad-scale interest in collaboration is supported by surveys in which companies report a strong and growing interest in partnering with universities (research consortia, grants and contracts), cooperating with federal laboratories (research and development contracts) and participating in formal alliances and joint ventures with other companies (Cosner 2010).

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[1] The importance of forming alliances, partnerships and joint ventures to the growth and innovation of 71,000 U.S. companies (respondents) was as follows: great importance–29 percent of companies, moderate importance–46 percent and little importance–25 percent. Of companies reporting less than $10 million annual revenue, 31 percent indicated venture capital to be of great importance (National Science Foundation 2004).

Venture Capital Programs

Venture Capital Firms. Venture capital can be an important means by which the products of research are transferred into commercially useful products and processes.[2] Venture capital is a broad subcategory of private equity that refers to equity investments typically made in less mature companies for the launch, early development, or expansion of a business (potentially high growth companies with accompanying high risk). Venture capital typically comes from institutional investors and high net-worth individuals which is pooled together by investment firms. Often the results of research, entrepreneurs may possess products and processes that require large up-front capital requirements which cannot be financed by cheaper alternatives such as debt. That is most commonly the case for intangible assets such as software and other intellectual property, whose value is unproven. In turn this explains why venture capital is most prevalent in the fast-growing technology and life sciences or biotechnology fields. Venture investment is most often found in the application of new technology, new marketing concepts and new products that have yet to be proven. Although most closely associated with fast-growing technology and biotechnology fields, venture funding has been used for other more traditional businesses. The need for high returns makes venture funding an expensive capital source for most companies seeking to commercialize newly developed technologies.

Venture capitalists typically assist during four stages in a company's development, namely idea generation, start-up, ramp up, and exit. Roughly corresponding to these stages, six phases of venture capital are usually offered, namely seed money (low level financing needed to prove a new idea), start-up money (early stage financing needed to fund expenses associated with marketing and product development), first-round money (funds for early sales and manufacturing), second-round money (working capital for early stage companies that are selling products, but not yet turning a profit), third-round (mezzanine financing) (expansion money for a newly profitable company), and fourth-round money (bridge financing) (money to finance ongoing processes). Because there are no public exchanges listing their securities, private companies meet venture capital firms and other private equity investors in several ways, including warm referrals from an investor’s trusted business sources, investor conferences and symposia, and summits where companies pitch directly to investor groups in face-to-face meetings. Fewer than one in 10 entrepreneurs seeking funding from a venture capital fund are successful (National Capital Venture Association 2010). To engage in venture capital

[2] In 2001, venture capital’s importance to the growth and innovation of 71,000 U.S. companies (respondents) was as follows: great importance–15 percent of companies, moderate importance–28 percent and little importance–57 percent. Of companies reporting less than $10 million annual revenue, 31 percent indicated venture capital to be of great importance (National Science Foundation 2004).

investment, an investor must be an accredited investor as defined by the U.S. Securities and Exchange Commission.[3] Venture capital funds that invest in fledgling companies hoping to commercialize a new wood product or processing technologies have not been identified or assessed in any comprehensive sense. As such, the following examples of literally thousands of private venture capital funds must suffice.

•*Global Star Capital Fund* (Ohio) – financing for equipment, commercial mortgages, equity funding, operational financing and staffing-recruiting; investment range of $1 million to $10 million; sector focus: technology, health care, energy, nanotechnology.
•*GreenHills Venture Fund* (California) – financing for equity investments and operational financing; investment range of $1 million to $10 million; sector focus: technology, health care, energy, nanotechnology, chemicals, transportation.
•*Cynergy Partners Fund* (Texas) – financing for equity investments, staffing-recruiting, operational financing; investment range of $1 million to $10 million; sector focus: technology, health care, sector focus: technology, health care, automotive.
•*Meritus Capital Funds* (California) – financing for debt consolidation, operational requirements and secured-unsecured loans; investment range of $10 thousand to $10 million; sector focus: technology, software, pharmaceuticals and software development.
•*Matrice Finance Group Fund* (Wisconsin) – financing for equipment, commercial mortgages, equity funding, operational financing and staffing-recruiting; investment range of $1 million to $10 million; sector focus: technology, health care, energy, nanotechnology and chemicals.
•*Celtex Investment Fund* (Texas) – Financing for operations and equity investments; investment range above $10 million; sector focus: technology, health care, energy, nanotechnology and chemicals.
•*Capital Structure LLC Fund* – Financing for equipment, loans, equity investment; investment range above $10 million; sector focus: technology, health care, energy, nanotechnology and chemicals.

The aforementioned funds are by most standards quite modest in size. Examples of very large venture capital funds (manage in excess of $2 billion) are Sequoia Capital Fund ($4 billion; computer systems and software), Insight Venture Partners Fund ($3 billion; software and internet), Atlas Venture Fund ($2 billion; technology and life sciences) and New Enterprise Associates Fund ($6 billion; health care and information technology).

[3] As defined by the U.S. Securities and Exchange Commission (2010), only accredited investors are permitted to invest in certain venture capital investments, limited partnerships, hedge funds and angel investment opportunities. They must have a net worth of at least $1 million, have earned at least $200,000 the past two years, and expect to earn at least that amount in the current year.

Venture capital firms are diverse in the criterion they use to select opportunities for investment of their monies. Consider the following (Shane 2008):

> •*Start-up or Established*. Venture capital firms want evidence that entrepreneur has successfully taken on some risk. Some will prefer significant progress in the commercialization of research and prefer making a small venture investment to move commercialization to the next level. Others firms will be more willing to invest in the initial stages of the commercialization process.
> •*Services or Manufacturing*. Venture capital firms specialize in certain sectors (for example, software development, electronics-instrumentation, telecommunications). Solicitation of funds should be made to firms that are consistent with an entrepreneur's proposed business.
> •*Low Funding or High Funding*. Venture capital firms vary in the amount of funding they are willing to expend on a proposed business. As with sectors, request for funds should be made to firms consistent with a firm's resource capabilities.
> •*Local, National or Global*. While some venture capital firms have global operations, many have a regional focus. Preference is to have entrepreneurs connect locally and then branch out geographically.
> •*Investment Rate of Return*. Venture capital investors have differing expectations on the return of their investment. Some seek safer investments and are willing to accept lower returns, while others are looking for large returns on monies invested. Entrepreneurs should look for firms with the risk-reward philosophies that match the entrepreneur's business.
> •*Hands on or Laissez Faire*. The nature of equity necessitates the involvement of another party and entrepreneur's business. Some venture capital investors want more or less control for the same capital. It is important for entrepreneurs to understand the role the venture capital firm plays in the decision-making process of each investment.

Venture capital deals in 2009 totaled 2,766 (2008–3,985, 2007–4,027), with the average dollar amount per deal totaling $6.34 million. Ranked by percent of venture capital deals, the following sectors were leaders in 2009: software–22.3 percent (17.5 percent of funds), biotechnology–14.6 percent (20.1 percent of funds), medical devices and equipment–11.0 percent (14.1 percent of funds), media and entertainment–9.0 percent (6.6 percent of funds), and industrial-energy–8.3 percent (13.1 percent of funds) (National Capital Venture Association 2010). Although the industries are not individually identified, the industrial-energy sector contains industries that may include wood-based manufacturing enterprises (for example, packaging products, polymer-fiber materials, packaging products, building products)(National Capital Venture Association 2010).

Angel Investors. Affluent individuals can also be a source of financing required to successfully launch the results of research into commercially viable products and processes. Angel investors are affluent individuals who provide capital from their own funds (usually in exchange for convertible debt or ownership equity) to a private business owned and operated by someone else who is neither a friend nor a family member. Although a small but increasing number of angel investors have organized into groups or networks to share research and pool their investment capital, most are single independent investors (55 percent)(unlike venture capital investors who manage the pooled assets of others). Because they are typically interested in seed-startup or early-stage investing, angel investors bear extremely high risk and therefore usually require a very high return on investment–often at least 10 or more times their original investment within five years. Because of such expectations, entrepreneurs interested in commercializing a technology developed through research often avoid expensive angel financing for commercialization of a new business (Shane 2008).

Angel investors are often retired executives or business owners interested in angel investing for reasons that go beyond pure monetary return, including keeping abreast of current developments in a particular business arena, mentoring another generation of entrepreneurs, and offering valuable management advice and important contacts. As with investors of venture capital, there are no public exchanges listing angel investors. As such, private companies must meet angel investors via referrals from trusted sources, at investor conferences and symposia, and at meetings organized by groups of angels where entrepreneurs' companies speak directly to a potential angel investor. In some cases, the more advanced groups of active angel investors (about 300 composed of 12,000 investors in 2008) have full time, professional staffs, associated investment funds, sophisticated web-based platforms for processing funding applications, and annual operating budgets of well over US$250,000 (Shane 2008).

Angel investors operating in the United States numbered more than 260,500 in 2008 (2007–258,000) and provided $19.2 billion in start-up funding to 55,480 entrepreneurial ventures. The healthcare industry (health care services, medical devices and equipment) was the focus of the largest share of these investments (16 percent), followed by software (13 percent), retail (12 percent), biotech (11 percent), industrial-energy (8 percent) (major focus on green technologies) and media (7 percent). Seed and start-up capital are a significant focus of angel investors, namely (Center for Venture Research 2009):

Seed and start-up stage investments – 45 percent of total
Operational stage investments – 40 percent
Expansion stage investments – 15 percent

From 2001 through 2003, the median angel investment was $10,000, while the average dollar value invested (in 2006) per angel in an angel group deal was $31,457 (range from $600 to $500,000) (Shane 2008) Although rates of return are quite variable, they averaged 22 percent in 2008. Only a small number of companies who apply get angel investor funding. In 2009, of all submissions received (20,915) only 6.2 percent succeeded first screening, 4.8 percent were chosen for presentation, 2.8 percent for due diligence, and 2.6 percent received funding (AngelSoft 2010).

As with venture capital funds and investors, a systematic review of angel investors promoting companies seeking to commercialize new products and processes resulting from wood utilization research has not been comprehensively assessed. However, in 2008, the National Governor's Association identified 144 angel groups by name, the following of which are examples (leading states–CA with 19, PA with 9, MA with 8) (National Governor's Association 2008).

Huntsville Angel Network (AL)
Desert Angels (AZ)
Golden Gate Angels (CA)
Life Science Angels (CA)
Angel Investor Forum (CT)
Active Angel Investors (DC)
Springboard Capital Angels (FL)

Atlanta Technology Angels (GA)
Boise Angel Alliance (ID)
Heartland Angels (IL)
Southern Illinois Angels (IL)
Mid-America Angels (KS)
Bluegrass Angels (KY)
LA Angel Network (LA)

Bay Angels-Boston (MA)
River Valley Investors (MA)
Maryland Angels Council (MD)
Maine Angels (ME)
Great Lakes Angels (MI)
Bridger Private Capital Network (MT)
Piedmont Angel Network (NC)
Granite State Angels (NH)

New York Angels (NY)
Ohio Tech Angels Funs (OH)
Women's Investment Network (OR)
Minority Angel Investment Network (PA)
Technology Tree Group (TX)
North Country Angels (VT)
Delta Angel Group (WA)
Wisconsin Investment Partners (WI)

The characteristics of angel investments provide some insight about the criterion that such investors consider when making and investment in a high-risk new company venture. Consider the following (Shane 2008):

•*Investment Size* – Median angel investment made between 2001 and 2003 was $10,000, the mean was $77,000 and the range was $600 to $500,000.
•*Debit Financing* – Although angel investing involves the provision of debt as well as equity, debt financing accounts for 40.2 percent of the money that angels provide to startups.

•*Investment Instruments* – Equity investments made by business angels are often straight common stock purchases. By some estimates, common stock was used in 40 percent of investment rounds that involved only angels.
•*Follow-on Investments* – Angel investments occur primarily in a single round; a minority of business angels follow on initial investments. By some estimates, angels provide follow-on money only 25 percent of the time.
•*Investment with Venture Capitalists* – Very seldom do angel investors and venture capitalists invest in the same companies. Even among the most sophisticated accredited angel investors, backing the highest potential businesses, venture capitalist co-investment by angels occurs in only a small portion of funding rounds.
•*Valuation* – very few companies that receive angel investments have a multimillion-dollar net worth when they receive angel money. By some estimates, only 36 percent of angel investments were made in companies worth more than $1 million at the time of investment.
•*Ownership Share* – Business angels rarely obtain majority ownership of their portfolio companies. By some estimates, most angel investors who invest in the initial financing round of a startup company collectively acquire between 20 and 35 percent of the company in which they are investing.
•*Exits and Returns* – Only a small portion of angel investments have a positive exit. The best financial returns for investors in startup companies tend to come from investments in companies that go public. Few angel investments exit through acquisition.

Business Incubator Programs

Business incubation is a support process that is designed to accelerate the successful development of start-up companies that seek to commercialize the products of research. The fundamental intent of business incubators is to produce firms that are viable and freestanding in competitive markets. Depending on the business model that is chosen, business incubators can be used to accomplish a variety of objectives. For example, they can be used as a means of commercializing new technologies, building or accelerating growth of local industries, enhancing the technological and competitive position of a company, diversifying local economies and promoting regional economic development, nurturing a community's entrepreneurial spirit and encouraging entrepreneurship among certain groups within society (for example, women and minorities) (Knopp 2007). Even though their objectives may be diverse and the manner in which they seek to accomplish them wide in range, the common ingredient for all business incubators is “. . . the opportunity for new ventures to take shelter for, say, two years, from fierce competitive market forces that might otherwise destroy the infant enterprise before it gained size and strength sufficient to compete. This is inherent in the term ‘incubator’ itself”(Maital and others 2008). As is the situation with venture capital firms and angel investors,

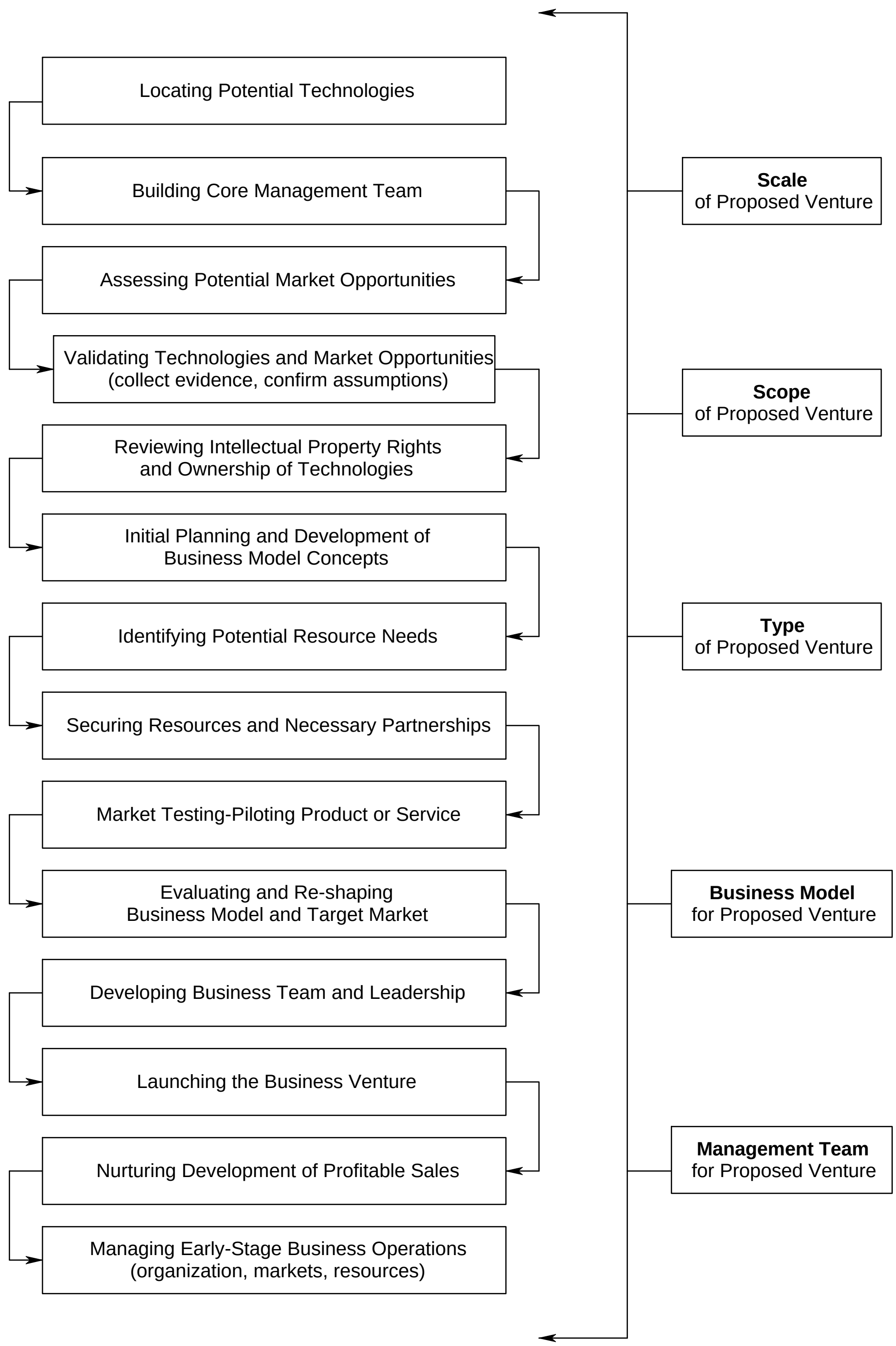

Figure 1. Major stages in the development and implementation of research-supported start-up companies.

little is known about the number or interests of business incubators that nurture companies focused on wood-based technologies developed by research. Examples of business incubators generally must suffice (Appendix Table 3).

A start-up company hoping to enter a market with a new technology must successfully address a variety of challenges (Figure 1) (Churchill and Lewis 1983, Haims and Levine 2001, Hannon 2003). For example, exactly what new technologies are available and how marketable are they? How can the ownership of these technologies be properly secured over the life of the business? What type of managerial talent will the new business require and how will the risk of company ownership be allocated between the company's owners and managers? Where should the company be physically located and how does it gain access to important business services? Who might sponsor the new company and what type of partnerships should it seek out? And from whom can financial resources be obtained, especially if the company requires an extended period of time to develop prototype processes and engage in market testing?

Business incubators can provide start-up companies with answers to many of the aforementioned questions. They can provide a wide variety of services and resources, including management guidance, technical assistance, office and manufacturing space, basic business services and equipment, and assistance in obtaining the financial resources considered so necessary to the growth of a new company. Within these broad categories, incubators have been known to sponsor business training programs (accounting-financial management), assist in the development of product marketing plans, provide for linkages to research conducted by institutions of higher education, identify potential advisory board members and management staff, guide fledgling companies through complex regulatory compliance processes, assist in the management of intellectual property, offer access to high-speed internet resources, and inform companies about loans, angel investors and venture capital. Although most incubators provide office space and shared administrative services to their clients, the ". . . heart of a true business incubation program is the services it provides to start-up companies" (Knopp 2007).

Incubation programs come in many shapes and sizes and serve a variety of interests and communities (Gassmann 2006)(Figure 2). In 2002, an estimated 3,400 incubators were active worldwide; 1,400 incubators were active in 2006 in North America.[4] In the latter region,

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[4] In 2002, incubation programs operating worldwide were distributed as follows: North America–1,400 (2006), Western Europe–900, Far East–600, South America–200, Eastern Europe–150, and Middle East and Africa–150. Focusing on Western Europe, key sponsors were the European Union–13 percent, individual country public agencies–25 percent, companies and banks–21 percent, universities and similar R&D organizations–16 percent, community organizations–12 percent, and others–13 percent. Legal status of incubators: public entity–24 percent, private company–38 percent, semipublic–28 percent, and other unknown–10 percent. Primary objective of incubators (rank

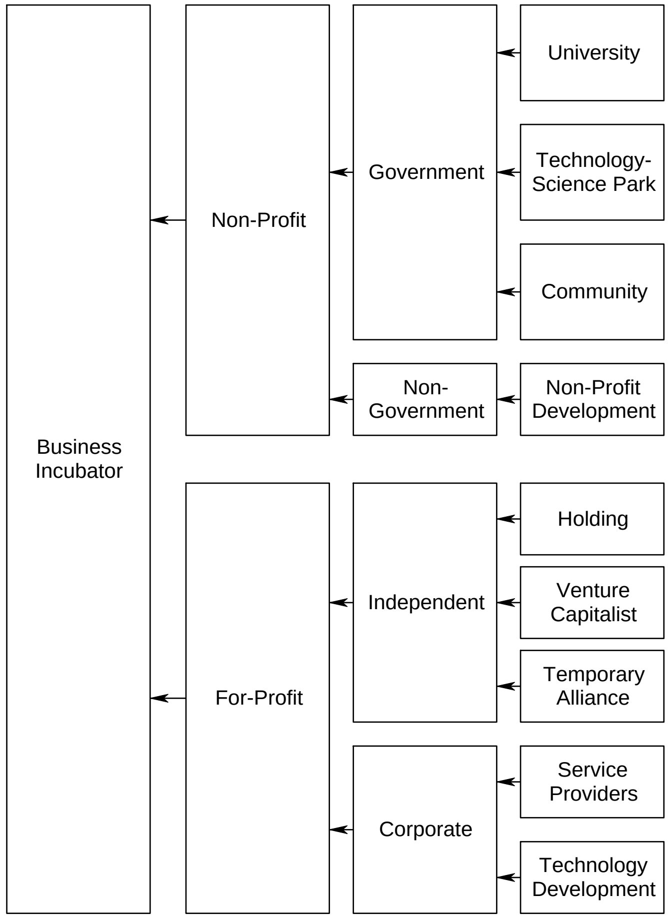

Figure 2. Classification and sponsorship of for-profit and nonprofit business incubators.

incubators reportedly assisted 27,000 companies, provided employment for more than 100,000 workers and generated annual revenues of $17 billion (European Commission 2002, National Business Incubator Association 2010a). Most business incubators in the United States are nonprofit organizations (about 94 percent), although a modest number (6 percent) are set up to obtain returns on shareholder investments. More than half of all business incubation programs involve "mixed-use" projects, namely they work with clients from a variety of industries. For example, in 2010 the San Diego Technology Incubator, Inc. facilitated the business interests of seven fledgling companies including, Flouortronics, Inc. (chemical detection technology), GPS

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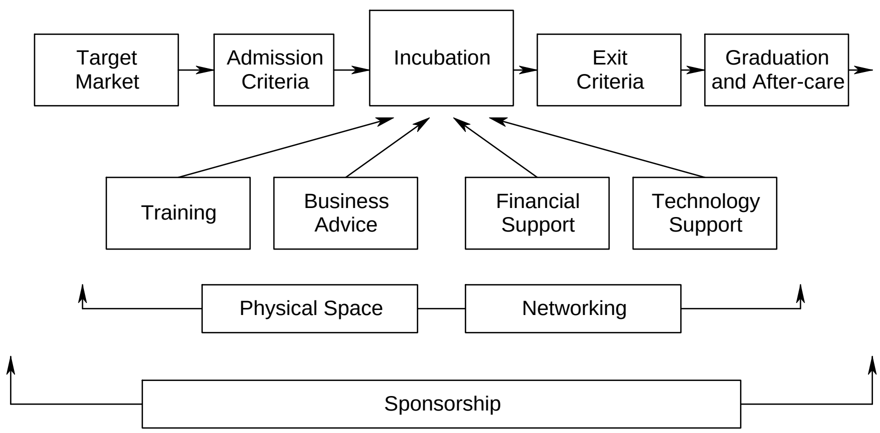
order): contribute to competitiveness and job creation, help R&D centers commercialize new technologies, help companies generate spin-off businesses, and help disadvantaged communities. Importance to company performance: critical–22 percent (without support, would not be successful), important–61 percent (support helpful but not critical to success), not important–17 percent (would succeed without incubator support) (Appendix Table 4) (European Commission 2002).

International Technologies, Inc. (wireless cellular technology), and Onmaterials, LLC (metal application of nanotechnologies). As a group, technology incubators dominant in number, namely 39 percent of incubation programs in 2006 (only 3 percent were manufacturing firms). Among the many industry sectors supported by incubation programs are computer software services, bioscience-life sciences, electronics-microelectronics, telecommunications, medical devices and healthcare technology, advanced materials and composites, energy and clean technologies, and aerospace technologies (Knopp 2007).



The average annual coat of operating a business incubator is in the range of $175,000 to $350,000. Technology incubators tend toward the high end of this range, while service or mixed use incubators are at the other extreme. Most of the cost of operating a business incubator involves rent and client fees (59 percent), followed by service contracts (18 percent) and cash operating subsidies (15 percent). Incubators employ an average of 2.8 full-time persons (Knopp 2007). The operational dimensions of a business incubator are summarized as follows.

Incubation programs are sponsored by a variety of individuals and organizations. In some cases, sponsors may serve as an incubator's parent or host organization (university) or may simply make financial contributions to the incubator (angel investor). In some cases, incubation programs take equity in client companies, although most do not (in 2006, only 25 percent of incubation programs reported taking equity in some or all of their clients). In 2006, 31 percent of business incubators in the U.S. were sponsored by economic development organizations (for example, York County Economic Development Corporation [Pennsylvania]) with the remaining incubators sponsored by organizations such as state or local governments (21 percent) (for example, Greenville Wood Composites Incubator [Maine]), academic and educational institutions (20 percent) (for example, Boston University Incubator [Massachusetts]), hybrid incubators with more than one sponsor (8 percent) (for example, Mississippi Enterprise for

Technology [Mississippi]), venture capital and for-profit entities (4 percent) (for example, Northern Arizona Center for Emerging Technologies [Arizona]), and a variety of other sponsors (or no sponsor) (16 percent) (National Business Incubator Association 2010a). As a means of promoting their collective interest in communication and funding, incubators have seen fit to organize and participate in state and national associations, examples of which are the National Business Incubator Association (representing more than 300 incubators), Colorado Business Incubator Association (seven members), Maryland Business Incubator Association (15 members) and Wisconsin Business Incubator Association (40 members).

Business incubators do not serve any and all companies. Entrepreneurs who wish to enter a business incubation program must apply for admission. Acceptance criteria vary from program to program, but in general only those with feasible business ideas and a workable business plan are admitted. In nearly all cases, incubator developers must first invest time and money in a feasibility study which will help determine whether the proposed project has a solid market, a sound financial base, strong community support, and represent a dynamic model of a sustainable, efficient business operation. Once established, business incubation programs are encouraged to commit to industry-established best practices, wherein the management and boards of incubators encouraged to strive to (National Business Incubation Association 2010b):

•*Mission* – Obtain consensus on a mission that defines the incubator's role in the community and develop a strategic plan containing quantifiable objectives to achieve the program mission.
•*Finances* – Structure for financial sustainability by developing and implementing a realistic business plan.
•*Management* – Recruit and appropriately compensate management capable of achieving the mission of the incubator and having the ability to help companies grow.
•*Governance* – Build an effective board of directors committed to the incubator's mission and to maximizing management's role in developing successful companies.
•*Client Assistance* – Prioritize management time to place the greatest emphasis on client assistance, including proactive advising and guidance that results in company success and wealth creation.
•*Facilities and Resources* – Develop an incubator facility, resources, methods and tools that contribute to the effective delivery of business assistance to client firms and that address the developmental needs of each company.
•*Community Focus* – Seek to integrate the incubator program and activities into the fabric of the community and its broader economic development goals and strategies.

•*Stakeholder Support* – Develop stakeholder support, including a resource network, that helps the incubation program's client companies and supports the incubator's mission and operations.
•*Information Management* – Maintain a management information system and collect statistics and other information necessary for ongoing program evaluation, thus improving a program’s effectiveness and allowing it to evolve with client needs.

The amount of time a company spends in an incubation program can vary widely depending on a number of factors, including the type of business and the entrepreneur's level of business expertise. Life science and other firms with long research and development cycles require more time in an incubation program than manufacturing or service companies that can immediately produce and bring a product or service to market. On average, members of business incubators spend 33 months in an incubator program. Many incubation programs set graduation requirements by development benchmarks, such as company revenues or staffing levels, rather than time in an incubator program (Knopp 2007).

Successful completion of a business incubation program increases the likelihood that a start-up company will stay in business for the long term (historically, 87 percent of incubator graduates stay in business) (Knopp 2007, National Business Incubator Association 2010a). Suggested is that in order for a business incubator to promote success among start-up companies, it should: offer clients below-market-rate space on flexible terms, eliminate building maintenance requirements, allow tenets to share equipment and services that would be otherwise unavailable or unaffordable, increase entrepreneurs’ awareness of and access to various types of financial, managerial and technical assistance, provide an environment where small businesses are not alone (reduce anxiety, tenets give each other business), and increase the entrepreneur’s visibility. In 2007, an analysis of public and private incubators ranked financial support, links to financial sources and marketing as especially important to public incubators while financial support, networking with strategic partners and protection of intellectual property rights as most important to a successful private business incubators (Frenkel and others 2008) (Table 4) (1=highest importance, 17=lowest importance).

Although somewhat dated (1988), an earlier evaluation of critical factors for the success of business incubators suggests the following (factors ranked only within each major group) (Lumpkin and Ireland 1988): *experience of management team* – management skills, marketing skills, technical skills, experience, financial skills, growth rate projection; *financial strength* – profitability, liquidity; *price-earnings* – debit, asset utilization, personal investment of management team, current size of firm; and *market-personal factors* – written business plan, references from others, aggressiveness-persistence, marketability of product, creativity, uniqueness of products, age of management team.

Table 4. Factors influencing the success of public and private business incubators, by ranked importance of factor. 2007.

Factors	Public incubators	Private incubators
Financial support	1	1
Links to financial resources	2	6
Marketing	3	5
Networking with strategic partners	4	2
International collaborators	5	4
Intellectual property rights protection	6	3
Legal counseling	7	7
Strategic counseling	8	7
Market information	9	8
Access to labor pool	10	13
Management support	11	11
Networking of facilities	12	9
Source of technological information	13	14
Professional network	14	10
Advanced training and studies	14	15
Connections with suppliers	15	16
Available suitable space	16	12
Access to inputs	17	16

Source: Frenkel and others 2008.

Public Program Sponsorship

A variety of state and federal government organizations engage in the transfer of research-produced knowledge.[5] Income cases, technology transfer may be their primary mission (for example, Cooperative Extension Service) while in other cases the commercialization of

[5] A number of federal laws promote technology transfer, of which the following are examples: Smith-Lever Act in 1914 (directs development of practical applications of research knowledge in agriculture, including wood utilization); Renewable Resources Extension Act of 1978 (authorizes the educational delivery of a wide variety of forest resource information); Stevenson-Wydler Technology Innovation Act of 1980 (requires improved utilization of federally funded technology developments—including inventions, software, and training technologies—by state and local governments and the private sector); Patent and Trademark Law Amendments Act of 1980 (Bayh-Dole Act (allows universities, not-for-profit corporations, and small businesses to patent and commercialize their federally funded inventions); Federal Technology Transfer Act of 1986 (enables federal government-owned laboratories to enter into cooperative research and development agreements and to negotiate licensing agreements for inventions created by the laboratories); Technology Transfer Commercialization Act of 2000 (enables federal laboratories to grant licenses to federally owned inventions); Cooperative Forestry Assistance Act of 1978 (directs Forest Service to introduce new technology and research findings to owners and managers of forests and to wood processors and forest operators); and Executive Order Facilitating Access to Science and Technology (Executive Order 12591) (directs federal agencies to encourage and facilitate collaboration among federal laboratories, state/local governments, universities, and the private sector—particularly small business—in order to assist in the transfer of technology to the marketplace) (U.S. Government Accountability Office 2002).

research-produced technology may be an integral part of their research mission (for example, USDA Forest Service) or a core program focusing on an interest in promoting the success of certain groups of clients (for example, U.S. Small Business Administration). Consider the following as examples of these diverse types of organizations and programs.

Information Transfer Programs

Cooperative Extension Service. Part of the National Institute of Food and Agriculture, the Cooperative Extension Service (CES) has historically engaged in the extending of research results through partnerships with land grant universities (about 2,900 extension offices nationwide). Among the six major areas focused on by the Cooperative Extension Service, three are especially relevant to the extension of new research-produced technologies, namely, natural resources, leadership development, and community and economic development. Within theses areas, the Cooperative Extension Service advances a mission of advancing knowledge by putting ". . . research-based management practices into action through extension activities." It does so by implementing a variety of education and research focused laws. Stemming in a major way from authorities granted by the Renewable Resources Extension Act of 1978 (proposed 2010 funding of $4.1 million), in 2007 nearly 50-university extension faculties reported wood utilization and wood products as a focus of their technology transfer efforts (forest-wood products generally–38 persons, harvesting-engineering–11 persons) (Cassidy 2007). In 2009, reporting land-grant universities conducted 3,196 educational events involving more than 171,000 forestry, rangelands, and natural resource stakeholders. More than 2.22 million indirect contacts were made via newsletters or websites, and more than 22,036 landowners or managers implemented at least one new resource management practice on 32 million acres of forest. Renewable forest resource extension activities reportedly lead to the creation or expansion of nearly 950 income-generating businesses in 2009. Unknown is how many of these accomplishments involved the transfer of new research-based technology focused on the utilization of wood (Cooperative State Research, Education and Extension Service 2009).

Fiscal and Tax Incentive Programs

A variety of state and federal government organizations provide financial or similar assistance to fledgling companies seeking to commercialize a new technology that has been developed through research. Although commercializing new technologies is not always the primary objective of such programs, by implication they do engage in research utilization and commercialization activities. Consider the following as examples.

Small Business Administration (SBA). Charged with assisting and protecting the interests of small businesses, the Small Business Administration (U.S. Department of Commerce) is responsible for programs that range from business planning to marketing and advertising, and from financial support to the business needs of special audiences. Although little is publically known about their focus and direct impact on promoting the commercialization of research involving wood utilization, the following are SBA programs that offer potential to do so.

Venture Capital Program – SBA's Small Business Investment Companies Program (SBIC) seeks to provide small businesses with the venture capital that cannot be accessed for reasons of business size, limited assets or early-stage development. Focus is on young potential high-growth companies that are viewed as high risks with longer investment horizons than usual. SBICs are privately owned and managed investment funds, licensed and guaranteed by the SBA, that use their own capital to make equity and debt investments in qualifying small business. SBICs provide hands-on involvement in their portfolio companies, including board participation, corporate governance, strategic planning and marketing, management recruitment, financial support, capital raising, and company exit support. In 2010, there were more than 400 licensed SBICs nationwide. Nearly $1.9 billion of venture capital was invested in 2009 (72 percent for operating capital), 44 percent of which went to small start-up firms (less than five years old). Leading sector recipients of SBIC venture capital were manufacturing (24 percent); transportation (14 percent); professional, scientific and technical services (13 percent) and information systems (12 percent). Examples of companies that have benefitted from SBIC program in the past are Federal Express, Apple Computer, Domain Furniture Company and Performance Polymers, Inc. (U.S. Small Business Administration 2010).

Small Business Innovative Research Program. The Small Business Innovation Research (SBIR) program is designed to encourage small businesses to explore new technologies and to pursue the commercialization of such technologies. The program is an acknowledgment of the risks and expenses that are often faced by small business when engaged in research and when seeking to implement the products of research. Eleven federal departments and agencies are required to use a portion of their research and development funds (2.5 percent each) for awards to small businesses (departments of agriculture, commerce, defense, education, energy, health and human services, homeland security, transportation, Environmental Protection Agency, NASA, and the National Science Foundation). To qualify for the program, the small business must be a for-profit business, American-owned, have 500 or fewer employees and employ the project's principal researcher. In addition, the SBA encourages the awarding of grants to projects that demonstrate a high degree of innovation, have substantial technical merit and show a good possibility of succeeding in future marketplaces. In 2006, participating agencies invested $1.9 billion in nearly 5,900 projects (U.S. Small Business Administration 2007).

As a 2009 participant in the SBIR Program, the U.S. Department of Agriculture sponsored 18 projects involving wood utilization and development. Support for the projects ranged from $75,000 to Custom Materials, Inc. (Elliot City, MD) for purposes of investigating wood-based advanced ceramic materials, to $350,000 to Restoration Technologies, LLC (Silver City, NM) for purposes of evaluating engineered wood chip composite erosion control material. The average SBIR grant focused on wood utilization was about $223,000, with half the grants in the range of $295,000 to $350,000; the remainder in the range of $75,000 to $80,000. Except for one, all grants involved only applied research. As for the subjects of investigation, the following are examples: assess formation of structural core material from wood residuals and recycled fiber (West Mountain View International, LLC; Vancouver, WA); evaluate paper conservation by new mass de-acidification techniques (IFT, Inc., Richmond, CA); and investigate nano-biocides for wood-based construction materials (Nanodynamic Life Sciences, Inc. Pittsburgh, PA) (Ellefson et al. 2010).

Small Business Technology Transfer Program. SBA's Small Business Technology Transfer Program (STTR) promotes partnerships between small businesses and premier nonprofit research institutions, the intent of which is to transfer high-tech innovations to the marketplace. The major difference between the SBIR Program and the STTR Program is that the latter requires substantial (at least 30 percent) cooperative collaboration between a small business and a nonprofit research institution (for example, federal national laboratory, college or university). Five federal departments are required to participate in the program, doing so by setting aside a portion (0.3 percent each) of their research and development funds (departments of defense, energy, health and human services, NASA, National Science Foundation). As examples of projects, past National Science Foundation partnerships have involved the development and marketing of composites from recycled carbon fiber (with Materials Innovation Technologies, LLP. Fletcher, NC), development of industrial scale alcohol production from renewable feedstocks (with ELCRITON, Inc. Newark, DL), and the matching of renewable energy production with patterns of electrical demand (with HOMER Energy, LLC. Boulder, CO).

In addition to the three aforementioned programs, the Small Business Administration is also responsible for the following programs, each of which has implications for technology transfer. *Guaranteed Loan Program:* loans (debit financing) made available to small businesses by commercial lenders and various types of community development organizations. *Bonding*

Program: bonds (surety bonds guaranteed by SBA) made available to small businesses as a means of strengthening their ability to access new business opportunities.

Economic Development Administration. The Research and National Technical Assistance Program of the Economic Development Administration (EDA) (U.S. Department of Commerce) supports information dissemination efforts which focus on regional economic development and entrepreneurship. One of the more significant ways in which such goals are accomplished is via regional innovative clusters and associated business incubators ($100 million in 2010). For example, the EDA has supported business incubators in an around federal national laboratories (facilities for technology and science-based companies, technology commercialization incubation space, and prototype manufacturing facilities.). Often unclear is the extent to which EDA supported clusters and incubators involve the transfer of technology produced by research, especially technologies involving wood-based products and processes. The EDA also has a history of supporting university-based centers for economic development (42 centers) which can play an important economic development role by promoting the use of various technical resources associated with universities (Economic Development Administration 2008, 2010).

State Government Incentive Programs. State governments sponsor a wide variety of fiscal and tax incentives programs that have implications for the commercialization of research-produced technologies. Although the majority of these programs are focused on state interests in economic development generally, some are designed to directly enhance the investment climate for the commercialization of new technologies resulting from research. State tax credits focused on angel investors are an example. The purpose of such credits is to reduce the risk and cost of angel investing in order to encourage more entrepreneurial activity in high-growth small businesses. The theory is that if successful, these programs can attract investment dollars, create jobs, and contribute to the economic growth of a state. Tax credits represent a dollar-for-dollar reduction of the investor's tax liability and can be structured as refundable or nonrefundable credits. Again, very little is known about the use of such tax credits as a way of promoting the commercialization of new wood-based technologies by start-up companies. Some insight can be provided by the following states that have income tax programs (July 2008) favoring angel investors (National Governors Association 2008,Williams 2008).[6]

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[6] As a more detailed example, the Minnesota Angel Tax Credit program provides for a 25 percent tax credit for investments in small emerging businesses, a maximum credit of $125,000 per person per year, and funding of $11 million in credits in 2010 and $12 million annually for 2011 through 2014. Types of businesses qualifying for the tax credit are businesses that are (a) using propriety technology to add value to a product, process or service in a qualified high-technology field, (b) engaging in research and development of a propriety product, process or service in a qualified high-technology field, and (c) researching, developing or producing a new propriety technology for use in agriculture, forestry,

Arizona Angel Investment Tax Credit – 30 Percent
Hawaii High Tech Investment Tax Credit – 100 Percent
Indiana Venture Capital Investment Tax Credit – 20 Percent
Iowa Qualified Business Investment Tax Credit – 20 Percent
Kansas Angel Investor Tax Credit – 50 Percent
Louisiana Angel Investor Tax Credit – 50 Percent
Maine Seed Capital Tax Credit – 40 Percent
Minnesota Angel Tax Credit – 25 percent
New Jersey High Tech Investment Tax Credit – 10 Percent
New Mexico Angel Investment Credit – 25 Percent
North Carolina Investment Tax Credit – 25 Percent
North Dakota Seed Capital Investment Tax Credit – 45 Percent
Ohio Tech Investment Tax Credit – 25 Percent
Oklahoma Small Business Capital Credit – 20 Percent
Oregon University Venture Capital Funds – 60 Percent
Vermont Seed Capital Fund – 10 Percent
Virginia Qualified Business Investment Credit – 50 Percent
West Virginia High Growth Business Investment Tax Credit – 50 Percent
Wisconsin Angel Investor Tax Credit – 25 Percent
Kentucky Investment Fund Act – 40 Percent
Michigan Angel Investor Incentive – N/A

A modest few states also offer centralized incubator funding (for example, the state of Michigan's Pre-Seed Capital Fund supports high-tech start-up companies as they near commercial viability by providing access to early-stage capital investment or micro loans to accelerate company development). Venture capital funds can also be government supported. In 2008, 30 state governments sponsored 47 state-supported venture capital funds, including the Maine Venture Capital Investing Program, South Carolina Venture Capital Fund and the Louisiana Venture Capital Match Program (National Association of Seed and Venture Capital Funds 2008)

mining, manufacturing or transportation. Qualified high-technology fields include, aerospace, agricultural processing, renewable energy, energy efficiency and conservation, environmental engineering, food technology, cellulosic ethanol, information technology, materials science technology, nanotechnology, telecommunications, biotechnology, medical devices, pharmaceuticals, diagnostics, biologicals, chemistry, and veterinary science. Qualifying businesses must be headquartered in Minnesota and operating for no more than 10 years, have fewer than 25 employees with 51 percent of total payroll in state, and not have received more than $2 million in previous equity investments. Certain service-type business are excluded from the program (for example, banking, accounting, real estate) (Minnesota Department of Employment and Economic Development 2010).

Research and Development Programs

The research programs of universities and of federal and state governments are actively engaged in efforts to transfer the products of their research to various users. Although not focused specifically on the wood utilization research and its commercialization, some indication of public entity involvement in this respect is provided by the technology transfer activities of U.S. agencies with federal research laboratories. For example, in 2007 the U.S. Department of Agriculture reported 126 invention disclosures, 151 patent applications filed or issued and 339 licensing arrangements, while the U.S. Department of Energy reported 1,575 invention disclosures, 1,134 patent applications filed or issued, and 5,842 licensing arrangements. The total for six federal agencies with research laboratories (the aforementioned two plus the departments defense, commerce, health and human services, and National Aeronautics and Space Administration) was 4,486, 3,230 and 10,347, respectively in 2007 (National Science Foundation 2009). A more focused discussion of government agency technology transfer activities involving wood utilization follows.

Forest Service. The Forest Service's (U.S. Department of Agriculture) State and Private Forestry organization is charged with providing technical and financial assistance to forest landowners and resource managers (employed nine technology transfer specialists in 2006). Within the organization, the Forest Product Laboratory's Technology Marketing Unit has the agency's most pointed responsibility for the transfer of research-produced technology involving wood utilization and marketing (employed four technology transfer specialists in 2010). The Unit's mission is to promote the efficient, sustainable use of wood by transferring technologies developed by the Laboratory and certain other research entities (universities, federal national laboratories, Forest Service research stations). It supports the Forest Service's forest products utilization interests by facilitating the adoption of forest-based material technologies to many small, rural forest product businesses. The breadth of the Unit's work includes forest products conservation, processing, manufacturing efficiency, marketing, recycling, and bioenergy. Technical assistance is provided in various forms, including publications, technical assistance visits, conferences, workshops, meetings, demonstration projects and face-to-face advice to potential users of new wood product and process technologies (U.S. Government Accountability Office 2006, Williamson and others 2009).

Federal National Laboratories. The U.S. Department of Energy (Office of Science) is the steward of 17 national laboratories that perform research and development on a wide array of problems. Special features of these laboratories are the wide scope of their research, the massive infrastructure established to undertake such research, and the extensive multidisplinary teams of scientists that are gathered together to research important national problems. Problematic, however, is at which national laboratories is research involving wood utilization and development actually being conducted. Research and development involving wood utilization appears to be most relevant at nine of 17 national laboratories operated by the U.S. Department of Energy.[7] Within these nine national laboratories, 21 organizational entities (divisions, programs, centers) appear to have research initiatives that are especially relevant to understanding the science and potential uses of wood and woody materials (Ellefson et al. 2010).[8]

National Laboratories have very active technology transfer programs that engage a variety of mechanisms, depending on the objectives of the organizations involved (Appendix Table 5).[9] Among the mechanisms employed by Laboratories are:

> *Cooperative Research and Development Agreements* – Legal agreements in which participants agree to collaborate by providing personnel, services, facilities or equipment. Rights to intellectual property are negotiated and certain data that are generated may be protected for up to five years.
> *Licensing Agreements* – Transfer of less than ownership rights in intellectual property to permit its use by a licensee. Potential licensees must present plans for commercialization and when awarded are granted a license for a specific field of use.
> *Personnel Exchange Programs* – Arrangements allowing laboratory staff to work in industry facilities and industry staff to work in government facilities. Costs are borne by organization sending the personnel. Intent of exchanges is to enhance the technical capabilities in specific areas.
> *Research and Development Consortia* – Arrangements wherein multiple federal and nonfederal organizations work together for a common research and development objective. Funds are not usually exchanged between participants.

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[7] Ames Laboratory, (Ames, Iowa), Argonne National Laboratory (Argonne, IL), Brookhaven National Laboratory (Long Island, NY), Idaho National Laboratory (Idaho Falls, ID), Lawrence-Berkeley National Laboratory (Berkeley, CA), Oak Ridge National Laboratory (Oak Ridge, TN), National Renewable Energy Laboratory (Golden, CO), Pacific Northwest National Laboratory (Richland, WA) and Sandia National Laboratory (Albuquerque, NM).

[8] Examples (2009) of new laboratory facilities to house research programs of relevance to wood utilization research and the transfer of technology from such research are the Center for Functional Nanomaterials (Brookhaven National Laboratory), Center for Nanophase Materials Sciences (Oak Ridge National Laboratory), Center for Integrated Nanotechnologies (Sandia National Laboratory) and Molecular Foundry (Lawrence Berkeley National Laboratory)

[9] In 2006, National Laboratories and facilitates negotiated and executed 12,437 technology transfer-related transactions. The latter included 631 cooperative research and development agreements, 2,416 work-for-others agreements involving nonfederal entities, 5,916 licenses of intellectual property, and 3,474 user facilities agreements (U.S. Department of Energy 2007). Among the technologies successfully transferred to the private sector in 2006 was a "multiport dryer paper design to improve paper drying processes."

Technical Assistance to Small Businesses – Laboratory personnel respond to inquiries of small businesses, providing information to solve a particular problem or to improve a process or product.
User Facility Agreements – Arrangements permitting private organizations to conduct research and development using unique laboratory facilities or equipment. The user pays the full cost of laboratory use.

National Laboratories also seek to reduce private sector risk and enable industrial investment in the adoption new technologies. They do so by engaging in partnerships that are consistent with the following principles (National Renewable Energy Laboratory 2010):

Balance Public and Private Interest – Demonstrate stewardship of publicly funded assets, yielding national benefits. Provide value to the commercial partner.
Focus on Outcomes – Develop mutually beneficial collaborations through processes, which are timely, flexible, efficient, and compliant with requirements. Align actions with business outcomes.
Reflect Core Values – Conduct technology partnership processes through professional practices, action, and a respect for duty. Align with the fundamental values of honesty, integrity, fairness, stewardship, and quality.
Create Transparency – Make goals, processes, and the availability of intellectual assets transparent. Keep partners informed of decisions and the status of actions as agreements are developed.
Ensure Confidentiality – Maintain deep respect for proprietary business information and data.
Seek Continuous Improvement – Measure, monitor, and seek feedback about processes and outcomes. Use this information to improve processes and practices.

The technology transfer programs of National Laboratories are clearly focused on moving newly developed technologies to advanced stages of commercialization and ultimately to the operation of businesses that can successfully compete in the marketplace. Mission statements place a clear priority on doing so, for example . . . "committed to developing and transferring technologies, " "move technologies to the marketplace to benefit society," "foster commercialization of inventions," "dedicated to starting new technology-based companies," and "actively pursue business opportunities for new inventions." To accomplish their mission and objectives, technology transfer entities within National Laboratories, offer a wide array of partnership arrangements to prospective business partners, including intellectual property protection (licensing and patenting arrangements), access to facilities and professional expertise (laboratories and equipment), sponsorship of education and training programs, development of business incubators and business parks, incentives for small business development, and carrying out research for companies that lack specialized equipment or unique professional talent. In addition, Laboratories aggressively publicize information about newly developed technologies (actually list types of new technologies) and encourage prospective business to directly contact the scientists that are responsible for such technologies.

The entities within National Laboratories that administer technology transfer programs are clearly labeled as such. For example, Office of Technology Transfer, Office of Technology Transfer and Commercialization, Office of Technology Deployment and Industry Partnerships and Office of Technology Commercialization and Partnerships (Appendix Table 5). The staffing of such entities varies considerably, although 10 to 12 persons per entity is common. In all cases, offices of technology transfer report directly to the director of a National Laboratory and are equal in rank to a Laboratory's scientific divisions. The Directorate of Partnerships at the Oak Ridge National Laboratory is an example of how one such entity is organized and the type of staff expertise that is available to organizations seeking to benefit from the technologies developed by the Laboratory (Figure 3).

As a means of promoting their collective interest in communication and funding, National Laboratories participate in the Federal Laboratory Consortium for Technology Transfer (FLC). Organized in 1974 and formally chartered in 1986 (Federal Technology Transfer Act), the Consortium is a nationwide network of 250 federal laboratories and centers that promotes technology transfer by fostering linkages between laboratory developed technologies and the expertise of prospective users in the marketplace. Ten to 15 laboratories having an interest in wood utilization research are affiliated with the Consortium (for example, Forest Products Laboratory, Forest Service, U.S. Department of Agriculture). As a means of facilitating the transfer of technologies developed by member laboratories, the Consortium sponsors the Technology Locator Program which works to match user technical requests for expertise and facilities with appropriate federal laboratory capabilities (Federal Laboratory Consortium for Technology Transfer 2010).

Universities and Colleges. Universities are major sponsors of technology transfer programs. Their motivation to do so is an extension of their basic mission, namely to teach, generate new knowledge, and be of service to society. University technology transfer offices are relied upon to identify and manage new discoveries in the best interest of the public. Specifically, they seek to preserve intellectual property rights, facilitate partnerships, generate revenue and institutional recognition, and protect academic research enterprises as a source of future innovations. Although the priority given to each of these factors may vary from university to university, the technology transfer they promote enables the public to enjoy a broad array of new products and processes. Although the technology transfer programs of universities are important,

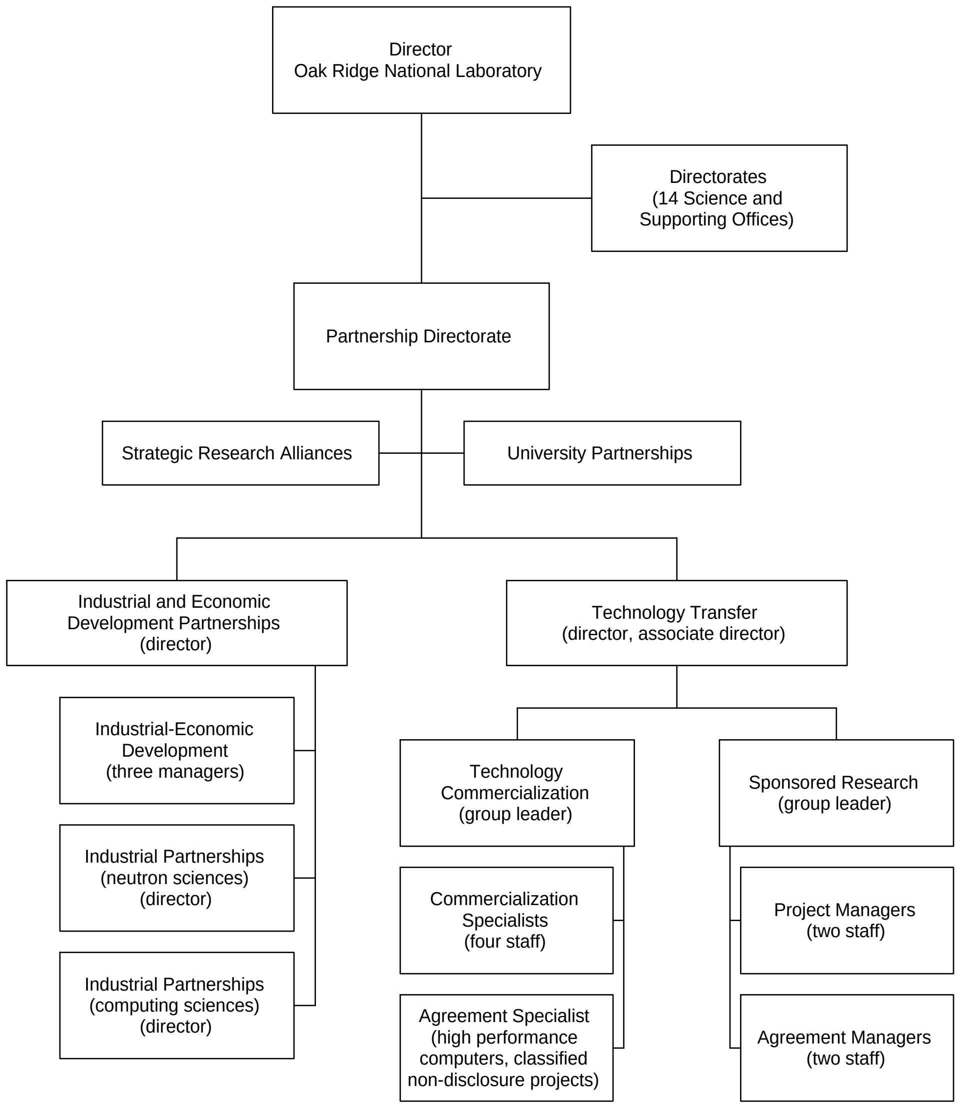
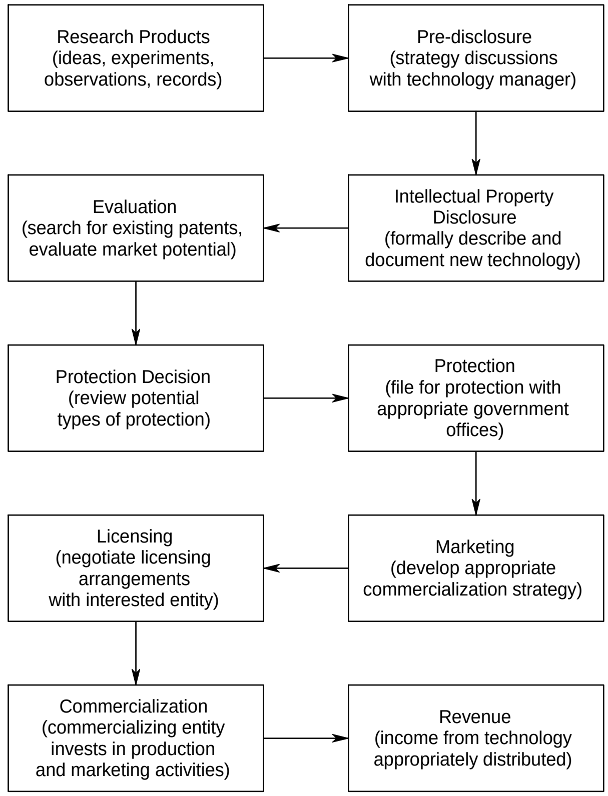


Figure 3. Technology transfer partnerships of the Partnerships Directorate, Oak Ridge National Laboratory, U.S. Department of Energy. 2010.

not to be ignored is the most common form of university technology transfer, namely the teaching of students and the reporting of research results through various media. Although in brief summary form, major steps in a university implemented process for technology transfer are as follows.



The enactment of the Patent and Trademark Law Amendments Act of 1980 (Bayh-Dole Act) enabled universities, nonprofit corporations, and small businesses to patent and commercialize their federally funded inventions. As such, universities are able to garner substantial income from the licensing and patenting of university developed technologies. An example is the University of California which in 2008 reported $128 million of income from licenses and patents (systemwide). The largest portion of this income was invested in University programs generally (university general and operating fund–60 percent, researchers and inventors–38 percent, research program equipment and infrastructure–2 percent) (University of California 2009). Although certainly not exhaustive, examples of some of the more widely known university technology transfer programs are the Cornell Center for Technology, Enterprise and Commercialization; Harvard Office University, Office of Technology Development; Mayo Clinic, Office of Intellectual Property; Office of Intellectual Property Administration, University of California (Los Angles); Office of Technology Transfer, George Mason University; Office of Technology Transfer, Johns Hopkins University; and the Technology Licensing Office, Massachusetts Institute of Technology.

Table 5. Technology transfer entities at universities with Wood Science and Technology Programs, by university and staff. 2010.

University	Technology Transfer-Commercialization Office
Auburn University	Office of Technology Transfer (9)
Clemson University	Office of Technology Transfer and Business Innovation (4)
Iowa State University:	Office of Intellectual Property and Technology Transfer (15)
Louisiana State University	Office of Intellectual Property, Commercialization and Development (NA)
Michigan State University	MSU Technologies (18)
Michigan Technological University	Technology and Economic Development (8)
Mississippi State University	Office of Technology Commercialization (5)
North Carolina State University	Office of Technology Transfer (14)
Oregon State University	Office of Technology Transfer (five)
Pennsylvania State University	Intellectual Property Office (12)
Purdue University	Office of Technology Commercialization (8)
Southern Illinois University	Technology Transfer Program (2)
State University of New York at Syracuse	Office of Technology Transfer (6)
University of Georgia	Technology Commercialization Office (10)
University of Idaho	Office of Technology Transfer (5)
University of Kentucky	Office of Commercialization and Economic Development (28)
University of Maine	Office of Research and Economic Development (6)
University of Massachusetts	Office of Commercial Ventures and Intellectual Property (6)
University of Minnesota	Office of Technology Commercialization (36)
University of Tennessee	UT Research Foundation (9)
University of Washington	Center for Commercialization (47)
University of Wisconsin - Madison	Wisconsin Alumni Research Foundation, Inc. (NA)
University of Wisconsin - Stevens Point	WiSystem Technology Foundation, Inc. (5)
Virginia Polytechnic Institute & State University	VA Tech Intellectual Property (8)
Washington State University	WSU Research Foundation (9)
West Virginia University	Office of Technology Transfer (7)

Note: Number in parentheses is number of staff persons in a technology transfer unit.
Source: Society of Wood Science and Technology 2010; and individual university web sites.

A comprehensive accounting of wood utilization technologies that have been commercialized by universities is not available. However, all 26 universities that have wood science and technology programs accredited by the Society of Wood Science and Technology (2010) have university-wide technology transfer centers, offices or foundations (Table 5). The faculty and researchers engaged in wood science and technology (more than 300) at these universities have ample opportunity to access the offerings of these programs. The latter each have an average of 11 staff (professional and support) that provide various types of support for technology transfer. As for a core staff, most entities have a director, licensing and patenting specialists, and a variety of managers responsible for specified areas of technology (for example, engineering, life sciences, health sciences). Examples of staff arrangements at six universities follows.

MSU Technologies, Michigan State University (18 staff): Management staff (executive director, support staff), technology managers (agriculture, engineering, life sciences), agreement and patent staff (license coordinator, patent coordinator), professional support staff (account, legal secretary, others).

Office of Technology Transfer, North Carolina State University (14 staff): Management staff (director, support staff), licensing and compliance staff, business and accounting managers.

Technology Commercialization Office, University of Georgia (10 staff): Management staff (director, support staff), licensing managers.

Office of Technology Commercialization, University of Minnesota (35 staff): Management staff (director, support staff), technology strategy managers, technology marketing managers, contacts and compliance managers, CEOs-in-residence, professional advisors.

UT Research Foundation, University of Tennessee (nine staff): Management staff (president, support staff), marketing and business development staff, incubator coordinator, licensing and patents staff, staff attorneys.

Center for Commercialization, University of Washington (47 staff): Management staff (vice provost, support staff), finance and business staff, technology licensing staff (engineering, health sciences, life sciences, computer-software), strategic initiatives staff, new ventures staff, intellectual property staff.

University technology transfer offices have common themes to their mission statement, notably an interest in protecting the intellectual property rights of the university, promoting the availability of university-developed technologies to business communities, and sponsoring educational opportunities to researchers and companies interested in university innovations. Examples of mission statements are as follows.

> “. . . protect and promote the discoveries of researchers at NCSU . . . doing so by protecting university intellectual property . . . commercializing new technologies . . . supporting startup companies . . . providing training and education . . . and ensuring business compliance.” Office of Technology Transfer, North Carolina State University.

> “. . . protect intellectual property, identify its commercial potential, and stimulate economic development through the transfer of technologies to the marketplace . . . doing do by screening university discoveries and inventions . . . provide training and education on patent and copyright procedures . . . marketing intellectual property to companies . . . negotiate licensing and patenting agreements”

Intellectual Property Office, Pennsylvania State University.

> ". . . promote the timely transfer of commercially valuable knowledge and information developed by the University to the businesses most capable of reducing them to practice . . . doing so by . . . assisting researchers to protect innovations . . . promote and foster entrepreneurism based on new technologies . . . execute licensing arrangements with business partners . . . in lieu of royalties, provide small amounts of equity to startup companies." Office of Technology Transfer, University of Idaho.
>
> "Support the commercialization of University research . . . doing so through intellectual property protection, technology transfer, entrepreneurship training, new venture formation, business incubation, and economic development activities." Office of Research and Economic Development, University of Maine.
>
> "Evaluate, protect and commercialize inventions and discoveries created by University academic researchers . . . doing so by transforming ideas, inventions and creative works into commercially viable products, processes and services that have economic payback to the inventors, the sponsors and the University." Office of Commercial Ventures and Intellectual Property, University of Massachusetts.

University technology transfer programs are organizationally most often situated within a university's hierarchal structure (for example, Office of Technology Transfer within a larger Office of University Research). However, there are universities that have chosen a different organizational model. For example, Virginia Polytechnic Institute and State University (VPI) promote technology transfer thorough a separate foundation, namely Virginia Tech Intellectual Properties which is a university affiliated corporation that seeks to protect, market and commercialize technologies and innovations developed by the university. A major goal of the corporation is to help translate scientific findings into tangible products, while returning income to the inventor and VPI to support further research and education. Such is accomplished by facilitating the licensing of technology to companies, encouraging new faculty startup ventures, working with publishers and distributors of software, and supporting the transfer of research and knowledge to other universities, research institutes and companies. Similar arrangements have been established and implemented at other universities. For example, the University of Wisconsin's WiSys Technoloy Foundation, Inc. has as a primary mission the managing of the intellectual property of the University of Wisconsin system generally(the Foundation is a subsidiary of the WI Alumni Research Foundation which focuses on intellectual property management of the University of Wisconsin-Madison).

Universities are often very active participants in the development of commercial business ventures based on technologies developed by university researchers. For example, the Oregon

State University Venture Capital Fund provides financial support to startup companies that seek to commercialize innovations developed by university researchers (for example, commercializing the application of a new wood adhesive made from renewable materials). A similar funding arrangement is the University of Washington's Technology Gap Innovation Fund which seeks to enhance the commercial potential of promising early-stage discoveries made by the university's research programs. The expected outcomes from the Fund are the formation of new companies and increased licensing activity. The University of Idaho also expresses an interest in startup companies by offering to take a small equity stake in start-up companies in lieu of up-front fees and for the deferral of patent reimbursements. Doing so enables the start-up company to preserve capital, a critical aspect of early business success. On a somewhat different track, a number of universities (for example, Auburn University) provide startup companies with heavily subsidized facilities at university-owned research parks.

TECHNOLOGY TRANSFER PROGRAM DESIGN

The efficiency and effectiveness of technology transfer programs is in large measure determined by how well they are designed and administered. Important sources from which to draw ideas for improvement in this respect are the experiences of seasoned administrators and previous evaluations and assessments that have focused on technology transfer programs generally. When combined with an understanding of programs focused on the transfer of wood technologies, these information sources can provide important insights regarding better ways of designing and implementing technology transfer programs. Although the following is far from comprehensive in these respects, it does offer a perspective on potential frameworks for doing so.

Managerial Perspectives

The executives and management staff of wood utilization research and development organizations are often in a position to provide especially noteworthy insight about technology transfer and knowledge utilization. As administrators, they oftentimes are persons that have been faced with the challenge of designing and implementing programs that seek to accomplish such ends. With such in mind, the directors (or their deputies) of various public and private research organizations in the United States and in other countries were contacted. In some cases they were new contacts and were specifically asked about technology transfer conditions, while in other cases the views about such conditions were gleaned from earlier (2006 and 2009) responses about research administration and research performance generally (including technology transfer) (Ellefson et al. 2007, 2010). In either case, a similarly formatted question was posed: “If they are to be used, the products of wood utilization research often requires a well-organized, skillfully managed and carefully monitored set of technology transfer activities. What organizational, managerial and performance assessing features of your organization enable it to effectively convey newly developed technologies to users?” The common threads of thought that flows through the administrators responses are summarized as follows (complete paraphrased listing Appendix Table 6).

> *Organization and Governance* (does structure facilitate technology transfer?): mission emphasizes and promotes technology transfer, governance structures (boards, advisory committees) are actively guiding research direction, clients to be served are clearly identified, processes exist for periodic external review of technology transfer activities, and the organizational linkages between researchers and user groups are clear.
>
> *Administration and Management* (is technology transfer well managed?): managers promote technology transfer, talented researchers are actively engaged with clients and vice-versa, blend of researchers and technology-transfer specialists is appropriate, research objectives are made clear and rid of much uncertainty, blend of research and technology transfer is seamless, research services emphasize commercialization-utilization activities, commitments are made to long-lasting relationships with clients, prompt and well-timed research is provided to users, potential worth of research products is assessed in advance, confidentiality of certain client-provided information is respected, organization partners to promote effective technology transfer, communication between research enterprise and user groups is large and wide-ranging, new technology is adequately explained to clients, and talented and resourceful people are assigned to entities assigned technology transfer responsibilities.
>
> *Performance and Success* (is technology transfer working?): clients make repeat requests for research services (products are innovative and workable), substance of client response is positive (new products, more efficient processes, more profit), products of research are presented in a user friendly fashions, client needs are understood and are sympathized with, and technology transfer activities are an important element making the research enterprise financially healthy and relevant to clients.

<u>Assessment Perspectives</u>

The structure and administration of technology transfer programs ought be consistent with attributes that are commonly suggested for organizations in general. For example, mission and goals should be meaningful and worthy of pursuit, structure is simple and straightforward, responsibility and accountability are clearly assigned, structural flexibility enables redirection of resources as necessary, accurate and timely information is widely communicated, sustainable flow of human and financial resources is promoted, and capacity exists to resolve ongoing disagreements over mission and objectives. Focusing on research programs, among attributes suggested for technology transfer special sensitivities to the needs of clients groups, assertively diffusing newly developed technologies, and extensive linkages with other researchers and other research organizations (Ellefson et al. 2007).

A number of conditions promoting (or deterring from) technology transfer were set forth earlier in this review. Among these conditions were many that are relevant to the design of technology transfer programs. For example, programs should transfer products of research that are: scientifically and analytically sound and come from credible and reliable research organizations, relevant to conditions faced by managers-administrators (focused, timely, pertinent), consistent with the interests and needs of users (easy to understand, appealing in format, operationally specific, clinically verifiable), and acquired from an environment of close and active user-researcher working relationships.

Transfer of technologies to (and within) private companies poses special considerations for knowledge utilization. Special conditions at play when decisions are made to use (or not use) research range from how well the products of research advance a company's mission and competitive position to whether or not a company has an established process for identifying and examining new technologies, and from the information management systems internally available to a company to the willingness of company managers to actively and willingly express visible support for suitable technologies. This range of conditions relevant to the design of technology transfer initiatives can be categorized as context oriented conditions (company mission, structure and culture favors research and the products therefrom), process oriented conditions (company processes for converting products of research into new processes or products are available) and information focused conditions (company information management systems facilitate research and the adoption of products therefrom).

Business incubators are often especially important to the transfer of new technologies, especially where business risks involving new technologies are large as in the early states of business development. Among many recommendations for business incubators, the European Union (2002) recommends that business incubators should be . . .

> • *Designed to support and be part of a broader strategic framework*. They should not be stand-alone entities but rather should work along side other organizations so as to promote broader strategic interests.

• *Promoted by an inclusive partnership of public and private sector stakeholders*. They should reflect overall regional, technology and business strategies typically promoted by a wide range of organizations from the public and private sectors, including local authorities, universities, companies, and financial institutions. Public authorities have an important catalytic and leadership function, and can provide crucial pump-priming investment during the development phase of incubators.

• *Grounded in a well-developed and realistic business plan.* The business plan should set out the rationale for the new business, the type and size of target markets, a detailed operating and managerial framework, estimated capital investment and operational running costs.

•*Cognizant of the importance of public sources of support*. Public assistance in the form of financial support and access to physical facilities should be an integral part of a business incubator's early stage development, although dependence on such support should be properly limited in amount and in time.

• *Discerning in their adoption and upholding of admission and exit criteria*. They should not have an undue focus on the need for income that can come from high occupancy rates, rather they should balance the importance of income with the importance of the flexibility required to admit occupants with interests more consistent with an incubator's strategic direction. Similarly, incubators should limit the length of time companies can remain as tenants, although such must be respectful of the nature of the startup business.

• *Managed by a high quality experienced team of administrators*. The quality of the management team, and adoption of businesslike approaches to running and incubator and monitoring clients, is crucial to performance. Management teams should be composed of senior personnel preferably coming from a business background.

• *Periodically evaluated against relevant benchmarks of performance*. They should be judged in terms of long-term impacts achieved rather than short-term measures such as occupancy rates or failure rates. Feedback from companies operating under the umbrella of an incubator should be made part of the evaluation process.

Partnerships between and within public and private organizations are frequently advocated as important ways of promoting the transfer of research-produced technologies. Properly constructed, operated and evaluated, partnerships can provide an effective means of accelerating the progress of technology from the laboratory to the market. Successful partnerships are characterized by ". . . clear objectives, cost-sharing, industry leadership, limited (well-defined) public commitments, measurable outcomes, and learning through sustained evaluations" (Link and Link 2009). Although partnerships are an important tool, they are not a guarantee of successful technology transfer – acknowledging the riskiness of some new technologies is important. Also, the reality that partnerships are usually temporary entities often embodying sunset provisions tends to ensure early recourse to private investments and more rapid commercialization of new technologies (Link and Bauer 1989, Link and Link 2009, National Research Council 2003).

Strategic factors important to the successful transfer of environmental technologies involving the Montreal Protocol were carefully assessed in 1995 (Strelneck and Linquiyi 1995). The lessons learned included that technology transfer programs should . . .

•*Address critical information needs of potential users* (who are the users and what information do they need?)
•*Accommodate the competencies of potential users* (do potential users have the expertise to understand the new technology and, if not, how might they be made appreciative of it?)
•*Respect uncertainties and risk aversion of potential users* (do potential users consider the new technology a sizeable risk and, if so, how might riskiness be reduced or users made more adventuresome?)
•*Respect motives of potential users* (do potential users face financial hardship if new technology is adopted and, if so, how might financial and market-driven constraints be eased?)
•*Utilize information formats well situated to potential users* (do potential users dislike [don't understand] certain technology transfer formats [academic journals] and, if so, how might information be reformatted?)
•*Recognize time horizons needed for adoption by potential users* (do potential users understand the often long time periods for successful adoption of new technologies and, if not, how might planning horizons be made more accommodating to longer term payoffs?)
•*Favor flexible and opportunistic schedules consistent with the agendas of potential users* (do potential users fear standardized schedules for utilizing new technologies and, if so, how might adoption schedules be made more flexible?)
•*Make use of a broad set of implementation tools* (do potential users respond better to a broad range of technology transfer approaches [pilot projects, scientists on-sight]?).

The National Aeronautics and Space Administration Factors considers the following factors when managing the transfer of new technologies to private companies (National Aeronautic and Space Administration 2010).

•*Technical factors*: Does the company . . . understand the new technology, have access to necessary facilities and equipment, have access to technical and engineering skills, and capable of making design changes in the new technology that are necessary to achieve commercialization?
•*Business factors*: Does the company . . . have a mission and goals that are consistent with the new technology, demonstrate strength in the area of the new

technology, have a clearly defined set of existing and potential customers, properly characterize the market size and chances of successful access, have a competitive advantage in the marketplace, have a well-developed roadmap to commercialization, demonstrate manufacturing and marketing capabilities, and have appropriate financial and personnel resources?
•*Management factors*: Does the company . . . have commitment of leadership and management to new technology, well-defined project management and scheduling skills, demonstrate reasonableness of proposed time lines and required resources, exhibit past management team strengths and capabilities, and have a record of successful commercialization of new technologies?
•*Economic impact*: Does company . . . have technology commercialization plans that lead to financial and organizational benefits to the company, new high-quality jobs, positive impact on consumers and taxpayers, commercialization impacts in reasonable time periods, potential export of new processes and products, and positive impacts on company's local community?

The International Center for Environmental Technology Transfer has established a lengthy history of defining key attributes of effective technology transfer programs (International Center for Environmental Technology Transfer 2001). Among the Center's findings are that technology transfer activities should . . . acknowledge technology transfer as a complex process that can involve many different stakeholders, view the leveraging of private investment as a legitimate outcome of technology transfer, complement other public and private programs engaged in technology transfer, seek to fully integrate new technologies with the mission and objectives of private concerns, be flexible and capable of adapting to specific and often-changing private sector technology needs, and acknowledge that both the transferring organizations and the recipients of new knowledge have much to learn during the process of transferring knowledge.

SUMMARY AND OBSERVATIONS

Public and private research focused on wood utilization and product development in the United States is an important source of innovation required for sustaining the worldwide competitive position of the wood-based industry. However, there continues to be an interest in how the research community might better organize and manage its efforts to improve the use of research-produced technologies. With such in mind, a review was undertaken to gain a better understanding of the conceptual frameworks explaining technology transfer, the public and private organizations that sponsor technology transfer initiatives, and the conditions necessary for the effective transfer of technologies provided by research.

The review provided substantial insight about technology transfer involving wood utilization research. However, it also highlighted a number of important information voids. For example, properly focused and rigorously applied evaluations of why and in what manner the products of wood utilization research are used, or not used, are seriously lacking in number and relevance to today's circumstances. Likewise, technology transfer programs in other sectors of the economy, and their potential application to wood utilization research, have not been seriously examined. And lastly, the role of many potentially promising tools for promoting the commercialization of wood utilization research has not been adequately explored, especially venture capital and business incubators.

Conceptual Framework

The transfer of research-developed technologies to various users involves processes that are poorly understood, a condition that is exasperated by the lack of consistent conceptual frameworks for guiding analyses of knowledge utilization generally. Increasingly suspect are suggestions that innovation processes are a series of smooth, well-behaved linear events, suggestions that ignore the many complex causal factors that are at work. Current thinking points to three ways of explaining knowledge utilization, namely science-knowledge interplay (for example, researchers and users proceed in an aimless fashion, researchers and users connect by way of facilitators, researchers and users actively link to define problems and research directions), personal assimilation of knowledge (for example, individuals identify, reformat, promote and apply the products of research), and organizational assimilation of knowledge (organizations acquire, assimilate, transform and exploit the products of research).

Conceptual frameworks provide the structure for understanding knowledge utilization. The conditions that actually determine whether the products of research will be utilized are wide ranging and are based on modest analysis and considerable speculation and conjecture. They range from the importance of a close working relationship between researchers and potential users of research to the necessity for timely introduction of research into decision making processes, and from the significance of sound scientific and analytic footings for research to the importance to research presented in understandable and appealing formats. Suggested by some is that these and other conditions can best be appreciated if grouped into five major categories, namely type and content of research (for example, does the research product have validity ensuing from scientific and analytic rigor?), organizational context (for example, is the research product directed to a specific need for information by a specific user group?), culture of users-researchers (for example, is the product of research presented in an appealing format and easy to understand?), user-researcher linkages (for example, did the research product result from processes involving extensive user-researcher interaction?), and user and manager attributes (for example, what is the occupational and educational occupational level of users?). Within any of these categories are literally hundreds of more exact conditions important to the use of, or detraction from, knowledge produced by research.

Empirical evidence of conditions considered especially important to the use of information produced by wood utilization research is wanting. In most cases, evidence comes from other natural resource sectors (for example, environmental sciences, natural resources generally) or–more instructively–from other service and technical sectors (for example, medicine, aeronautics, education). As for research used within the natural resource sector generally, the most important conditions favoring the use of research appear to be the timeliness and pertinence of the research, consistency with user interests and needs, appreciation of user policy and program environment, and evidence that the research product resulted from vigorous interaction between researchers and users. Such conditions are not markedly different from conditions occurring in other sectors, except for the importance of scientific rigor, ability to improve an organization's policies and programs, and the educational level of users–all of which appear to be more important conditions than occur in the natural resources sector. Regardless of the aforementioned conditions, the reality is that there exists very modest understanding of the circumstances that determine when the products of research will–or will not–be used. The use of wood utilization research is no different in this respect.

Organizational Landscape

Private Program Sponsorship. New technologies resulting from research are transferred to users by a wide variety of private organizations. Operating with a for-profit orientation, some are independent "transfer technology enterprises" that conduct research–or synthesize research from other sources and market the products thereof to established enterprises or fledgling business concerns. Appropriately known as research service organizations, their number and the exact nature of their business interests have not been determined in a comprehensive sense (probably in the range of 50 to 100 businesses nationwide). Examples are the Herty Advanced Materials Development Center (Savannah, GA), Polymers Center of Excellence (Charlotte, NC) and the Intota Corporation (Minneapolis, MN). If they have a common element, it's their interest in transferring technology for a profit. Contrasting with such an interest are enterprises that have similar technology transfer interests but operate as nonprofit entities (trade and business associations). In most cases they function as intermediaries between research users and research organizations, transferring wood utilization technologies to users (usually association members) via the sponsorship of conferences and training forums and the publication of newsletters and technical journals. In 2006, more than 100 wood-based trade and business associations were so engaged, examples of which are the National Nanotechnology Manufacturing Center, National Institute of Building Science, Composite Panel Association, and the National Association of Home Builders.

Wood-based manufacturing companies are also active participants in technology transfer, doing so by providing corporate managers with product and process information that will enable them to remain competitive in the marketplace. Companies may scan the research landscape for new technologies that have been developed and made known by an array of public research organizations, or they may operate their own research programs that can provide technologies more attuned with company operations. In 2008, 26 wood-based manufacturing companies invested $788 million in research and development, a significant portion of which probably involved wood utilization technologies. Often because of propriety interests, very little is publicly known about company processes involving the selection of problems worthy of company sponsored research, or how the information resulting from research makes its way into new products or improvements in existing manufacturing and marketing processes.

Technology transfer can also be facilitated by privately sponsored venture capital and angel investments. These sources of support are most often geared toward the launching of less mature businesses that hope to be successful with newly reported technologies that have been produced by research. Such businesses are often considered to be high risk but demonstrate a potential for substantial growth and lucrative financial rewards in the future. Although venture capital firms are interested in providing seed and startup money for the commercialization of high risk technologies, they are very selective in who will receive funds (fewer than one in 10 entrepreneurs seeking funds are successful) and often desire evidence that a potential entrepreneur is willing to assume some of the new business's risk. Angel investors are also willing to provide seed and startup money, although their tolerance for risk is much higher – but expect lucrative rates of return that are commensurate with the higher risks involved. Nationwide, venture capital deals in 2009 totaled nearly 2,800, with the average investment being about $6 million, while in 2008 there were more than 260,000 angel investors that provided more than $19 billion to 55,000 entrepreneurial ventures. Unfortunately, very little is publically known about venture capital and angel investments as they relate to the transfer of technologies involving the utilization of wood.

Business incubators are also important arrangements for promoting the transfer of research produced technologies. Whether publicly or privately sponsored, their fundamental intent is to develop companies that are viable and freestanding in competitive markets, doing so by accelerating the development of start-up companies that work to commercialize the products of research. Successful completion of a business incubation program substantially increases the likelihood that a start-up company will stay in business for the long-term (nearly 9 of 10 incubator graduates stay in business). The heart of a business incubation program is the services it provides, including management guidance, technical assistance, office and manufacturing space, basic business services and equipment, and assistance in obtaining the financial resources. Successful business incubators have characteristics such as clarity of mission, financial stability, quality facilities, competent management staff and a good understanding of the market conditions their member companies hope to access. In North America, more than 27,000 companies were assisted by more than 1,400 incubators in 2006. As a group, technology incubators are very common (for example, computer software services, medical devices and health care, advanced materials and composites, energy and clean technologies), although most incubators work with a variety of technologies and industries. As with venture capital and angel investors, not very well understood is the number and operation of business incubators that focus on wood utilization technologies.

Public Program Sponsorship. Technologies resulting from research are also transferred to users by an assortment of publically sponsored programs. Among the latter are programs of the Cooperative Extension Service, whose mission is to put research-based management practices into action through extension activities implemented by about 2,900 extension offices nationwide. While cooperative extension may focus on educational activities, state and federal governments also offer a variety of fiscal and tax incentive programs that promote the utilization of research findings. For example, the U.S. Small Business Administration sponsors three very important programs that are designed to promote innovations by small business, namely the Small Business Investment Companies Program (SBIC), Small Business Innovation Research Program (SBIR) and the Small Business Technology Transfer Program (STTR). The common intent of these programs is to encourage small businesses to explore new technologies and to pursue the commercialization of such technologies, with the SBIC acting as a source of venture capital while the SBIR and the STTR requiring federal research agencies to allocate a portion of their research monies to innovative activities undertaken by small businesses. The transfer of new technologies developed by wood utilization research has benefitted from all three of these programs.

State governments also sponsor a wide variety of fiscal and tax incentives programs that have implications for the commercialization of research-produced technologies. Although the majority of these programs are focused on state interests in economic development generally, some are designed to directly enhance the investment climate for the commercialization of new technologies resulting from research. Examples are tax credits focused on angel investors (18 states, including Louisiana's Angel Investor Tax Credits program and VT Seed Capital Fund), special funding for business incubators (Michigan's Pre-Seed Capital Fund), and venture capital (30 states, including Maine's Venture Capital Fund, South Carolina's Venture Capital Fund). Again, very little is commonly known about the use of such tax credits as a way of promoting the commercialization of new wood-based technologies by start-up companies.

Public research organizations also sponsor programs to transfer new technologies resulting from their research initiatives. An example is the Technology Marketing Unit of the Forest Service's (U.S. Department of Agriculture) Forest Products Laboratory. Engaging the talents of four technology transfer specialists, the unit's mission is to promote the efficient, sustainable use of wood by transferring technologies developed by the Laboratory and certain other research entities (universities, federal national laboratories, Forest Service research stations). The U.S. Department of Energy's Federal Laboratories also have significant technology transfer capabilities, sometimes involving the transfer of research findings concerning wood utilization and development. The technology transfer activities of nine of the nation's 17 federal laboratories are especially relevant to the latter, activities that are carried out in a variety of ways, including cooperative research and development agreements, licensing agreements, personnel exchange programs, research and development consortia, technical assistance to small businesses, and user facility agreements.

Universities and colleges engaging in research also have seen fit to focus attention on the transfer of technologies arising from their research. University technology transfer offices seek to preserve intellectual property rights, facilitate partnerships, generate revenue and institutional recognition, and protect academic research enterprises as a source of future innovations. All 26 universities that have wood science and technology programs accredited (2010) by the Society of Wood Science and Technology have university-wide technology transfer centers, offices or foundations (for example, Office of Technology Transfer, North Carolina State University; Center for Commercialization, University of Washington). The latter entities each have an average of 11 staffs (professional and support) that provide various types of assistance for technology transfer. The faculty and researchers engaged in wood science and technology (more than 300) at these universities have opportunity to access the offerings of these programs. Universities are also very active participants in the development of commercial business ventures based on technologies developed by university researchers. For example, the Oregon State University Venture Capital Fund provides financial support to startup companies that seek to commercialize innovations developed by university researchers. Although examples are available, the extent to which university-wide technology transfer programs focus on the commercialization of new wood-based technologies has not been comprehensively assessed.

Program Design

The success of technology transfer programs is in large measure determined by how well such programs are organized and administered. Important sources from which to draw ideas for improvement in this respect is the experience of seasoned administrators and prior evaluations of technology transfer programs. Drawn from such sources, especially important considerations for effective transfer of research-produced technologies are that an organization's . . .

> *Purpose and structure emphasizes technology transfer*. Mission emphasizes the transfer of knowledge to user groups, organizational structure clearly reflects the concerns and interests of user groups, governance structures actively promote the use of research, knowledge transfer initiatives complement those of other organizations, and cooperative structures (partnerships) are in place for facilitating the use of new technologies.
>
> *Administration and management emphasize technology transfer.* Experienced managers emphasize and promote technology transfer, commitments are made to long-lasting relationships with clients, communication between research enterprise and user groups is large and wide-ranging, broad range of technology transfer approaches are used, talented researchers are actively engaged with clients and vice-versa, prompt and well-timed research is provided to users, confidentiality of certain client-provided information is respected, new technology is clearly explained to clients, blend of researchers and technology-transfer specialists is appropriate, and able and talented people are assigned to entities responsible for technology transfer.
>
> *Performance and evaluation procedures emphasize technology transfer.* Processes for reviewing the effectiveness of technology transfer activities are in place and are active, standards for measuring program success are relevant and measurable, researchers and clients understand and are sympathetic to evaluation and review processes, and management changes are made in response to instructive reviews.

The ability to effectively use the products of research also depends on the interests and positioning of users. For example, managers actively and willingly express support for new technologies generally, established processes for identifying and examining the potential of new technologies, equipment and engineering skills necessary commercializing new technologies, markets of appropriate size and chances of successful access, record of successful commercialization of new technologies, and opportunity for achieving respectable financial and organizational benefits.

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Appendix Table 1. Private Organizations Engaged in Wood Utilization Research and Technology Transfer in the United States, by Organization Characteristics. 2009.

Organization	Research Mission-Objectives	Major Focus	Wood Utilization Research and Development Interest	Resources
Applied Paper Technology, Inc. (Atlanta, GA)	Help customers improve the predictability of their paper, paperboard, or converted product	Research, testing, information dissemination	Coated paperboard, and fine paper	Seven staff
APA-The Engineered Wood Association (Tacoma, WA)	Develop and maintain markets through excellence in product promotion, quality assurance, and technical support.	Research, testing, information dissemination	Engineered wood product manufacturing.	---
Center for International Trade in Forest Products (CINTRAFOR) (Seattle, WA)	Undertake and apply research on technical, environmental, economic, social and resource problems that impede international trade in forest products.	Research, information dissemination, education	International trade in forest products.	10 staff
Center for Paper Business and Industry Studies (Atlanta, GA)	Identify, develop, and support research on business, management, and social science issues that are of critical interest to the global forest products industry.	Research, information dissemination, education	Pulp and paper industry.	Six staff
CleanTech Partners (Middleton, WI)	Help businesses implement new and emerging technologies that will reduce energy consumption, create jobs, and protect the environment	Equity financing, business counseling	Commercialization of technologies used by forest product companies.	Seven staff
Consortium of Universities for Research in Earthquake Engineering (CUREE) (Richmond, CA)	Advance research, education and technologies involving earthquake engineering	Research, information dissemination, education, collaboration	CUREE-Caltech Woodframe Project.	27 staff (research-advisory)
Herty Advanced Materials Development Center (Savannah, GA)	Through innovation, unlock commercial opportunities in wood fiber and ensure production into new markets and industrial products.	Research, testing, pilot-scale production, product commercialization	Pulp, paper, board, and advanced composites.	---

Source: Company web sites and company annual reports.

Appendix Table 1 (continued).

Organization	Research Mission-Objectives	Major Focus	Wood Utilization Research and Development Interest	Resources
Institute of Paper Science and Technology (IPST) (Atlanta, GA)	Provide new knowledge and technology through research and transfer technology considered important to the technical needs and competitive position of industry.	Research, information dissemination, education, collaboration	Global pulp, paper, and related industries.	10 staff
Integrated Paper Services (Appleton, WI)	Provide timely research, test data, and interpretive analysis.	Testing, research	Pulp, paper, and allied industries.	11 staff
National Association of Home Builders Research Center (Upper Marlboro, MD)	Source for reliable, objective information and research on housing construction and development issues.	Research, testing, information dissemination, education, collaboration	Residential construction and housing industry.	Four mgt. staff and others
Polymers Center of Excellence (Charlotte, NC)	Assist in the development of emerging polymer technologies and provide timely, cost-effective technical support for such technologies.	Product design, testing, education	Packaging and consumer product industries.	20 staff
Resource Information Systems, Inc. (Bedford, MA)	Create high quality information about the global forest products industry.	Research, information dissemination	Pulp, paper, and timber industries	---
Sardo Pallet and Container Research Laboratory (Center for Unit Load Design)	Provide research, technical assistance, and continuing education programs directly applicable to the pallet and container industries.	Research, information dissemination, education	Pallet and container industry	Eight staff
Southern Research Institute (Birmingham, AL)	Innovative solutions to industry problems involving life sciences, engineering, energy, and the environment.	Research, information dissemination, education	Wood materials and mechanics, chemistry and physics of materials, biomass energy technologies	---

Appendix Table 2. Research and Development Expenditures by Public Wood-based Manufacturing Companies in the United States, by Company. 2003-2008.

Company	Year (million dollars)					
	2008	2007	2006	2005	2004	2003
Advanced Environmental Recycling Technologies, Inc.	0.3 [*]	0.3 [*]	0.3	0.1	-	-
Avery Dennison Corporation	94.0 [1.4]	95.5 [1.5]	87.9	85.4	81.8	74.3
Bemis Company	25.9 [0.7]	26.0 [0.1]	25.0	24.0	21.0	21.4
Buckeye Technologies, Inc.	8.2 [1.1]	8.2 [0.1]	8.3	9.2	9.4	9.3
Flexsteel Industries, Inc.	3.1 [0.8]	3.3 [0.8]	3.3	3.0	2.9	2.7
Furniture Brands International, Inc.	88.1[2.9]	80.7 [3.8]	72.7	65.9	-	-
Georgia-Pacific (Koch Industries)	-	-	-	-	61.0	64.0
Graphic Packaging Holding Company	8.0 [0.2]	9.2 [*]	11.4	9.9	9.6	7.4
Herman Miller, Inc.	38.8[2.4]	38.8 [2.0]	42.1	36.7	-	-
IFCO Systems North America, Inc.	5.6[0.8]	4.8 [0.7]	-	-	-	-
International Paper Company	22.0[0.1]	24.0 [0.1]	45.0	63.0	67.0	71.0
Kimball International, Inc.	16.0[1.3]	16.0 [1.4]	17.0	15.0	16.7	17.6
Kimberley-Clark Corporation	297.0[1.6]	276.8 [1.5]	301.2	319.5	279.7	-
Koppers, Inc.	2.8[0.2]	2.8 [0.1]	2.5	2.8	2.2	-
MeadWestvaco Corporation	61.0[0.9]	62.0 [0.9]	65.0	50.0	74.0	80.0
Nashua Corporation	0.7[0.3]	0.8 [0.3]	0.6	0.6	2.1	2.5
Neenah Paper, Inc.	6.5[0.1]	6.4 [0.6]	3.5	2.2	1.5	2.1
Packaging Corporation of America	6.9[0.3]	7.6 [0.3]	6.9	6.8	6.1	6.1
Rayonier, Inc.	5.0[0.4]	5.0 [0.4]	6.0	6.0	7.0	9.0
Rock-Tenn Company	0.3[*]	0.7 [*]	0.8	-	-	-
Schweitzer-Mauduit International, Inc.	8.3[1.1]	8.0 [0.1]	7.3	9.0	9.3	8.3
Smurfit-Stone Container Corporation	3.0[*]	3.0 [*]	4.0	9.0	8.0	5.0
Sonoco Products Company	15.9[0.4]	15.6 [0.3]	12.7	14.7	15.4	14.2
Universal Forest Products	3.7[0.2]	3.2 [0.1]	4.1	-	-	-
Wausau Paper Company	2.5[0.2]	2.6 [0.2]	2.1	1.9	1.9	2.2
Weyerhaeuser Company	64.0[0.8]	71.0 [0.4]	69.0	61.0	55.0	51.0

Note: No entry indicates information not available or company not part of wood-based industry. Number in brackets indicate research and development expenditures as a percent of company sales. An asterisk indicates less than 0.1 percent.

Source: Company annual reports and filings with U. S. Securities and Exchange Commission.

Appendix Table 3. Technology-focused Business Incubators (examples) in the United States, by Business Characteristic. 2010.

Name	Mission	Sectors and Focus	Governance	Examples of Funding	Services
North Woodward Tech Incubator (Michigan)	To facilitate the development of high-growth, technology oriented businesses	Climate technologies, transportation equipment, automated publishing systems	Board of Directors, Advisory Board	Sponsors and contributors, returns from participating companies	Office space, mentoring, administrative support, telecommunications, processional services
Center for Emerging Technologies (Vermont)	Foster the success of high opportunity technology firms by providing substantive business mentoring	Medical devices, high performance computing, advanced materials, energy technologies	Board of Directors, Advisory Board, President	Angel investors, venture capital, state government, federal government (Small Business Administration)	Office space, shared resources, capital, networking, training
Research Valley Innovation Center (Texas)	Combine science, engineering, technology, and innovative business practices with fast growing high impact companies	Medical devices, digital advertising, biotechnology products, electro-optical navigation systems	Advisory Council, General Manager	Energy venture capital, U.S. Small Business Administration, university research consortiums	Business advisory services, funding access programs, investment networking physical space and support services
Venture Center (Michigan)	Create environments that advance innovation and commercialization of life science products and technologies	Medical devices	Advisory board, executive director	State government capital fund, loan fund, emerging technologies fund, economic development fund, angel investors, business self-funding	Physical space and support services, business planning, marketing and advertising, communication and public relations, consulting and legal advice
EcoComplex Incubator (New Jersey)	Serve as a catalyst for new high-tech environmental businesses	Home energy saving software, recycling materials, carbon dioxide separation, ethanol technologies	Advisory Council, Director	Venture capital, angel investors, foundations, state and federal government agencies	Business plan development, office space and laboratories, research assistance, general business services
Greenville Wood Composites Incubator (Maine)	Encourage businesses to grow in the rapidly-expanding field of composites	Custom veneer panels, delta strand, extruded wood-plastic composites, oriented strand board	Advisory council, Director	State rural development grants, business self-funding	Business plan development, office space, testing services, internet service

Source: National Business Incubator Association 2010a and 2010b, and websites of example business incubators.

Appendix Table 3 (continued).

Name	Mission	Sectors and Focus	Governance	Examples of Funding	Services
Center for Advanced Technology (Connecticut)	Stimulate innovation and improve workforce development with special focus technology competitiveness	Business efficiency improvement, workforce development, commercialization of technologies	Board of Directors, President and Chief Executive Officer	State government Small Business Incubator Program, venture capital, angel investors	physical space, training, funding, grant development, networking, mentors, laboratory facilities
Colorado Springs Technology Incubator (Colorado)	Provide resources and services to innovative entrepreneurs, enabling creation and grow of technology companies into major employers	New plant technologies, marketing automation software, green energy and electrical grids, cryptographic security technologies	Board of Directors, Chief Executive Officer and President	Venture capital, angel investors, foundations, U.S. Small Business Administration	Market research, competitor analysis, technical feasibility, financial forecasting, business planning, investor relations executive mentoring
North Carolina State University Technology Incubator (North Carolina)	Support and stimulate entrepreneurship involving new technologies	Advanced composite materials, software design, toxic gas detection, wireless device engineering, application of nanotechnologies	Manager	Venture capital, angel investors, foundations, state and federal government agencies	Business planning, financial and legal advice, physical space and support services, commercialization support, funding networks, access to university resources
Dartmouth Regional Technology Center (New Hampshire)	Foster the development of high-growth technology startup companies	Medical device technologies, cognitive electronics, database management technologies	Board of Trustees, Executive Director	Venture capital, angel investors, foundations, state and federal government agencies	Office and laboratory space, financial and intellectual property management, accounting, planning, legal and financial services
Ohio University Innovation Center (Ohio)	Provide carefully designed environment for growth of new and fragile technology-oriented businesses	Alternative energy technologies, medical diagnostic technologies, computer and communication services, multimedia technologies	Vice President Research	Regional development commissions, chambers of commerce, state department of economic development, federal agencies	Office space, laboratories, shared business services, coaching, training, networking

Appendix Table 4. Organizational Structure and Management Practices of Business Incubators in the European Union, by Structure and Management Characteristic. 2002.

Country and Number of Business Incubators: Austria 63, Italy 45, Belgium 13, Luxembourg 2, Denmark 7, Netherlands 6, France 192, Portugal 23, Finland 26, Sweden 39, Germany 300, Spain 38, Greece 7, United Kingdom 144, Ireland 6 (911 total).

Business Activities of Business Incubators (Percent)
Sales, marketing and distribution – 0.4
Business and financial services – 0.6
Advanced/ High-tech manufacturing – 18.6
Information & Communication Technologies – 18.2
Research & Development – 12.2
Biotechnology/ Pharmaceuticals – 14.2
Knowledge-based industries/ new economy companies -- 11.5
Other Manufacturing Activities – 6.1
Other Service Activities -- 8.8
A combination of some/ all of these activities -- 9.5

Partners (Board Members and other Partners) of Business incubators (Percent)
EU and/or other international agencies – 13.4
National authorities and public agencies – 25.3
Companies, banks and other private sector organizations – 20.8
Universities and other R&D organizations – 16.4
Community and voluntary organizations – 11.5

Legal Status of Business Incubator (Percent)
Public Entity – 24.0; private company – 37.6; semi-public or other – 28.0; do not know – 10.4

Objectives of Business Incubator Ranking (1 = most important, 0 = least important)
Contribute to competitiveness and job creation – 1.3
Help R&D centers commercialize know-how – 2.8
Help companies generate spin-off activities – 2.9
Help disadvantaged communities/individuals – 2.8
Other roles – 2.9

Tenants in Business Incubator
Minimum of one too maximum of 120; average of 32; mean of 18.

Business Activities of Tenants in Business Incubator (Percent)
Sales, marketing and distribution – 7.4
Business and financial services – 14.3
Advanced/ high-tech manufacturing – 8.5
Information & Communication Technologies – 33.8
Research & Development – 4.8
Other manufacturing activities – 6.8
Other service activities – 15.5
A combination of these activities – 9.0

Note: Total number of business incubators surveyed – 911. Response rates vary between characteristics.
Source: European Commission 2002.

Appendix Table 4 (continued).

Type of Business Incubator (Percent): For profit – 21.8, Not for profit -- 76.9, Unknown – 1.3

Source of Funding for Set Up of Business Incubator (Percent)
Subsidies - European Union and other international agencies – 22
Subsidies - national authorities and public agencies – 46
Payments from banks and other private sector organizations – 13
Payments from universities and other R&D organizations – 5
Other sources – 13

Operating Costs of Business Incubator (Percent)
Total payroll/benefits – 41.0
Building costs(e.g., maintenance) – 22.1
Services to tenants – 24.6
Other costs (e.g., utilities, equipment, supplies) – 13.3

Time Period for Business Incubator to Break Even (Percent)
Less than one year – 7.4; 1-2 years – 14.8; 2-3 years – 29.6; 3-4 years – 3.7; 4-5 years – 3.7; over five years – 40.7

Core Business Support Services Provided by Business Incubator (Percent) (multiple responses possible)
Pre-incubation services – 11.7
Business planning and forming a company 11.0
Training to develop business skills – 6.4
Accounting, legal and other related services – 2.8
Market research, sales and marketing – 5.5
Help with exporting and/or partner search abroad – 5.0
Help with e-business and other aspects of internet technology – 6.9
Advice on development of new products and services – 7.7
Help with raising bank finance, grants, venture capital – 12.1
Incubator venture capital fund, business angel network – 5.5
Advice on recruitment of staff and personnel management – 5.7
Networking (e.g., other entrepreneurs, customers) – 11.4
Mentors, board members and other senior advisers – 6.8
Other services – 1.4

Business Incubator Pricing Policy for Core Services (Percent)
Services are mostly free to clients – 30.8
Clients charges partly cover the cost of services – 46.2
Client charges cover the entire cost of services – 20.5
Do not know – 2.6

Criteria used to Screen Projects for Admission to a Business Incubator (Percent)
A business plan must be ready: Quite Important – 25.6, Very Important – 62.8, Not Important --11.6
Financing must be in place: 34.6, 33.3, 32.1
Firm must have innovative project: 29.5, 47.4, 23.1
Firm must have high growth: 40.1, 33.8, 26.1
Other criteria: 7.7, 25.6, 66.7

Appendix Table 4 (continued).

Criteria Used to Decide When Tenants Should Leave a Business Incubator (Percent)
Firms only rent units for a fixed time: Quite Important – 29.5, Very Important – 42.3, Not Important – 28.2
Firms leave to get more space: 29.5, 47.4, 23.1
Firms leave when objectives achieved: 21.8, 10.3, 67.9
Firms leave when aims not achieved: 12.8, 17.9, 69.2
Firms leave to get other services: 14.1, 10.3, 75.6
No particular exit criteria: 2.6, 10.3, 87.2
Other criteria: 3.8, 2.6, 93.6

Maximum Length of Time Tenants can Occupy a Business Incubator Units (Percent)
No maximum tenancy – 7.7; less than one year – 6.4; 1- 2 years – 12.8; 2-3 years – 28.2; 3-4 years – 16.7; 4-5 years – 11.5; over five years – 9.0; do not know – 21.8

Average Number of Personnel in a Business Incubator
Managers and professional – 2.3; secretarial – 1.4; other personnel – 1.9
Average staff per incubator – 5.6

Qualifications of Incubator Manager (Percent)
Accounting, banking, finance – 25.6
Real estate, property management – 6.8
Personnel management, education/training – 17.6
Legal qualification – 11.9
Sales, trade, marketing – 19.3
IT or Telecommunication – 5.1
Other – 13.6

Criteria Used by Management to Monitor Incubator Performance
Incubator occupancy rates: Very Important – 18.8, Quite Important – 23.2, Not Important
Number of firms graduating from incubator: 17.7, 21.3, 8.3
Jobs created by tenant/ graduate companies: 25.4, 14.8, 5.7
Turnover of tenant / graduate companies: 12.2, 21.3, 21.0
Financial performance of incubator: 15.5, 16.8, 15.3
Other criteria: 10.5, 2.6, 35.0

Appendix Table 5. Technology Transfer Programs of the U.S. Department of Energy's National Laboratories, by Laboratory, Mission and Services Provided. 2010.

National Laboratory	Technology Transfer Mission-Objective	Example Activities and Services
Ames Laboratory, Office of Sponsored Research Administration (Ames, IA)	. . . committed to developing and transferring technologies . . . through collaborations, help industry and Laboratory meet common technical objectives, while reducing development costs and risks.	Business plan development, intellectual property protection, cooperative research and development agreements, personal exchange program, access to unique research laboratories and engineering services.
Argonne National Laboratory, Office of Technology Transfer (Argonne, IL)	. . . pro actively deliver advanced technology and unique technical services to industry by targeting strategic emerging high-impact technologies and forming market-driven alliances . . . and to expand benefits to users of technology, enhance market impact, and contribute to solution of important domestic problems.	Cooperative research and development agreements, access to Laboratory technologies and licencing opportunities, provide unique technical services and facilities, conduct research for industries lacking special facilities, offer educational-training opportunities. Staff of 15 persons.
Brookhaven National Laboratory, Office of Technology Commercialization and Partnerships (Long Island, NY)	. . . foster commercial development of inventions and discoveries made at the Laboratory . . . committed to utilization of Laboratory developed technology and technical capabilities to the benefit of industry and government.	Exchange of personnel between industry and Laboratory, cost-shared research agreements and partnerships, licensing of and patenting of technologies, access to unique facilities and expertise. Staff of nine persons.
Idaho National Laboratory (Idaho Falls, ID)	. . . make capabilities and technologies available to federal agencies, state and local governments, and to universities and industry . . . disclose new inventions and creations to ensure that intellectual property can be captured, protected and made available.	Licencing of intellectual property, participation in industry research and development partnerships, use of unique laboratories, access to technical expertise.
Lawrence Berkeley National Laboratory, Department of Technology Transfer and Intellectual Property Management (Berkeley, CA)	. . . move technologies from the Laboratory to the marketplace to benefit society . . . doing so by developing and managing an array of partnerships with private and public sectors.	Manage lab-industry research partnerships, ensure appropriate patent or copyright protection, license technology to start-up companies, distribute royalties to inventors, provide opportunity to access laboratories and expertise, incentives for small businesses

Source: Website of each National Laboratory. 2010.
Note: Staff numbers refer to staff in technology transfer unit.

Appendix Table 5 (continued).

National Laboratory	Technology Transfer Mission-Objective	Example Activities and Services
Oak Ridge National Laboratory, Department of Technology Transfer, Department of Industrial and Economic Development Partnerships (Oak Ridge, TN)	. . . dedicated to starting new technology-based companies using technologies developed by the Laboratory.	Collaborative research, licensing technologies, access to research facilities, opportunity to locate at Laboratory-sponsored research park. Staff of 18 persons.
National Renewable Energy Laboratory, Department of Commercialization and Technology Transfer, Department of Deployment and Industry Partnerships (Golden, CO)	. . . reduce private sector investment risk in new technologies and enable industry investment in the adoption of renewable energy and energy efficiency technologies.	Research partnership agreements, technology licensing opportunities, access to laboratories and testing facilities, expert advice and guidance, business incubator development, connect investors with financial opportunities. Staff of seven persons.
Pacific Northwest National Laboratory, Office of Technology Deployment and Outreach (Richland, WA)	. . . develop technologies that successfully translate into industrial products, services, and consumer goods . . . actively pursue business opportunities for inventions with the greatest potential to positively impact people's lives . . . match expertise with unique business needs—so all can be successful.	Research partnership agreements, access to licensing and intellectual property protection, education and training opportunities, collaborative research opportunities, access to Laboratory facilities and expertise, economic development consultation.
Sandia National Laboratory (Albuquerque, NM)	. . . bring new technologies to the market place . . . leverage the resources and technologies of the Laboratory with special focus on external partners . . . make it possible for partners to access science and technology, people, and infrastructure.	Cooperative research and development agreements, commercial licensing agreements, user facility agreements, small business technology opportunities, community education and training opportunities.

Appendix Table 6. Administrator Perspectives on the Structure and Management of Entities Engaged in the Transfer and Commercialization of Research-Produced Wood-based Technologies. 2010.

Perspectives of Administrators in the United States

Advice and Guidance

. . . meeting twice a year, our advisory board identifies key issues for our involvement and then sets clear objectives – including technology transfer – that are to be achieved before the next meeting.
. . . our for-profit research organization is well-governed by a five-member board of trustees appointed by the governor for five year terms. It understands and is very much in tune with our mission of accelerating commercialization processes.

Mission and Direction

. . . all research is conducted to be supportive of our mission of creating economic development opportunities through commercialization of new technologies and products.
. . . technology transfer must be a tangible contributor to our mission and our goals (economic development, job creation, and environmental solutions).
. . . successful research implementation rests on staying relevant which for our organization requires periodically reviewing our research agenda.

Clients and Patrons

. . . meeting the information needs of clients is very important to technology transfer efforts. If a public or private organization does not find information useful or profitable, strategic research directions should be re-evaluated.
. . . to be effective, a research enterprise must meet the needs of industry, looking for research opportunities that add value to industry and, subsequently, being able to assemble the resources required to address these research opportunities.

Organization and Administration

. . . research projects have become much more targeted, making research utilization and commercializing of new technologies more successful.
. . . talented researchers, well-qualified support staff, good communication, and decentralized decision-making are conditions important to the successful implementation of research.
. . . frequent communication about our research enterprise, including the commercialization of our research products, is critical to the success of our organization.
. . . feedback on client satisfaction with the information produced by our research programs is periodically sought and evaluated. It's a measure of how successful we are at transferring new technologies.
. . . technology transfer can be facilitated by a variety of measures, including special technology transfer entities for new businesses, company propriety interest in a public research enterprise, scientist temporary employment with private enterprises, jointly operated public-private pilot plants, scientists starting businesses utilizing their research, government temporary equity positions in startup companies, and collaborating with venture capital companies to create new businesses using newly-developed technologies.

Source: Ellefson and others 2007, 2010, and contacts with a variety of research program managers.

Appendix Table 6 (continued).

Measures of Success

. . . how well technologies are transferred can be judged by the number of manufacturers assisted in creating new materials-based products, extent of new innovative capital expenditures made by industry without help, and new jobs created as a result of our for-profit commercialization ventures.
. . . in the final analysis, the bottom line is whether research-generated products and processes are made available to a company and contribute to its bottom line.
. . . important performance measures for technology transfer are whether scientific outcomes are valued by clients as measured by repeated service requests and by client enterprise expansion.
. . . success of technology transfer efforts depends upon whether the industry sees research results as value-added contributions. To the point, research must be relevant to industry and communicated to it.
. . . as a private center, the focus of technology transfer is on customer communication, making sure that customers get the research and testing they expected. If customers return for more work, it is a great sign that they were satisfied and that technologies have been properly transferred.
. . commercialization of research depends a lot on senior management. They must hold the scientific staff accountable for being entrepreneurial and for taking the necessary measures to deploy the results of research.

Perspectives of Administrators in other Countries

Advice and Guidance

•We operate on the basis of a program established periodically by an advisory committee composed of representatives of our shareholders. The committee identifies current research needs of industry and assists in the implementation of research results.
•Engaged representatives from our owners-members ensure that the organization is dealing with the right (demand driven) topics in need of research.
•Our private research association, composed of [more than 100] member companies, gives close contact to industry, and facilitates industry participation in all our research and development projects. Such is a real plus for technology transfer.
•As a privately owned organization, of greatest importance for management of the institute are committed owners who set clear objectives for and expectations of the organization.
•As a private organization, our organization's overall governance is by a board of directors, with the structure for managing research involving advisory committees and external reviews of our programs — including technology transfer. This governance has proven quite effective.

Mission and Direction

•Our organization is expected to contribute to real economic growth . . . so attention to user needs is critical. Our program is a careful blend of research and commercialization-utilization activities that are focused on clients.
•[Our national research plan] firmly links the attributes that are demanded by clients in the marketplace to processing technologies and the characteristics of the wood resource.
• We have changed what we offer our members - making our membership offerings much more commercially focused. This also helps when we sell our commercial services.

Appendix Table 6 (continued).

Clients and Patrons

•Clients and customers needs and their satisfaction must always be focused on and given high priority. A research result is of little value until it is known and applied. Hence, significant efforts and measures must be taken to communicate new findings and relevant knowledge to different target/customer groups.
•The importance of a research organization's relationship with client groups (customers, patrons, sponsors) cannot be underestimated, irrespective of whether an organization is chartered as public or private. Without such, technology transfer is unlikely.
• Focus is on the linkage between our members and the project centers which [conduct] the forest research activities. Being a member driven organization, decision-making is very democratic and stems directly from the members' needs and expectations for the products of research.
•Our primary focus is on industry and client needs, including government agencies. In today's markets, relevance is crucial. Market trends and our client needs drive not only the way in which we deliver service and solutions, but also our science planning, research investments and technology transfer activities.
•Committed to a long-lasting relationship with clients by offering top-quality services . . . first link in chain of collaboration: listen to clients and their research needs. Meet expectations of clients with efficiency and respect for contractual commitments. Effective technology transfer will follow.

Organization and Structure

•We have become structured over the years to allow for individual sponsorships with allied industry companies on individual research projects. This allows companies to participate, not in a controlling fashion, in the research program, and potentially to become the commercialization partners for the [research] results that are produced. These partnerships give us a way to take technology right through to final commercial products.
•Our organization has a very well developed member company partnership system in which individual member company employees participate as observers and short term guides for the actual research program at the detail level. This gives direct member company input into each research project, and lays the groundwork for efficient technology transfer as research results become available.
•Individual member companies of our organization may act as project liaisons for specific projects, doing so in order to provide guidance to ongoing research and to implement research results in their businesses as soon as results are available.

Administration

•Small [research] companies like us have a short way to go from ideas to decisions. As such, we are not burdened with highly bureaucratic processes. Our governing board is an active board and is a competent part of our technology transfer decision-making processes.
•To ensure research relevance and effective technology transfer, we assess potential value return from a piece of research up-front, at the planning stage.
•A major challenge to the transfer of our new technologies is the care with which we manage highly confidential information from our member companies, making sure not to divulge information as we work with one member company or another.

Appendix Table 6 (continued).

•We have very close cooperation and networks with relevant industry associations and instruments (promotion body, schools, universities, research and development institutes). All work together with different roles, but with a common main goal of conducting and implementing quality research products.
• Our governance processes ensure that we work on member company priorities, and that we actually deliver the results of our research program to our members.
•A very important factor for our organization is balance of research and application (technology transfer). We often say that without research we have no product to sell, and without application, we have no customers to pay for the research. We work hard as a management team to keep these two in balance.
•Companies that are members of our institute also have significant in-house research operations. As such, there is movement of staff from institutions like ours to the companies and back again. In many cases, this has facilitated the transfer of new technologies from our researchers to our client groups.
•Research is conducted in consortia with the best suited partners – for each project, the best partners are looked for. Our organization plays a key role in identifying defining this network and bringing partners together to address problems and to quickly implement the results of the research that has been focused on such problems.

Communication

•Communication of research results is very important. Approximately 20 percent of total budget is allocated to communication of the knowledge that has been generated by our research activities.
•Special emphasis is placed on the dissemination of research results to various clients and target groups. Publications and seminars are viewed as an integral and important part of research activities.
•Great emphasis is placed on communication with our member companies, including development of web accessible research reports, ongoing review of research project plans and interim results, dissemination of research conference reports, and acting on behalf of our members as the watchdog for research results from many research areas.

Measures of Success

• Satisfied clients are the most important measurement of how we carry out our mission and whether our research products have been successfully used.
•Carrying out orders commissioned by particular clients and achieving profits from those activities is a bottom line measure of success. It means we are successful in the transfer of our research-developed technologies.
•Client relations are built around each client's needs . . . tailor-made information is a powerful tool and one of the cornerstones of [our] business success and our success in commercializing new technologies. Close contacts with clients' production plants are a key element of [our] work.
•Characteristics that enable [our organization] to effectively carry out its mission: client-focused, talented and committed staff, multi-disciplinary approach to problem solving, effective communication of research results, and demonstration of valuable return on research investments.
•Emphasis is on client-oriented user-friendliness, namely providing information in user-friendly databases; publishing reports, especially reports aimed at decision makers.

Appendix Table 6 (continued).

•It is extremely important to deliver expected research results to our clients, especially when it comes to quality products and meeting client time schedules.
•A key performance indicator is delivery of successful research products that produce the economic impacts predicted for a client. Satisfied industry partners are a very important indicator of our success.
•Most important performance criterion is client satisfaction (member-owner-customer). To enable this, products and services have to be numerous, of high quality, and well adapted to customer needs.
•Successful work of our institute is to be found in satisfaction of our clients. Was the new technology adequately explained to our clients? Did the technology work and bring the financial success that was expected? Did the institute provide the service in a timely and cost-effective manner?
•To carry out our mission, we are dependent to a large degree on our own earnings. Therefore, we are more focused on concrete results than on international publishing with referees, etc., etc., etc. We simply have to be effective at technology transfer if our organization is to survive financially.
•Did we help grow and maintain markets for timber through our research and information programs? This is the most important performance measure for us.
•Our organization is profitable – a condition for our very existence. We have to prove our competitiveness by showing positive results with the research that we produce. If it doesn't meet the needs of the marketplace, we have to rethink our approach.
•Very important to contribute to visible results such as new innovative products, new processes, and new market opportunities. This is of interest to media and helps create pride and self-confidence in industry and in our institute.
•A large percentage of our total budget is provided by external sources. Such is a measure of our success in accessing and selling (commercializing) the products of research in the marketplace.

Employees and Financing

•Talented research and supporting staff are a must. People make the difference – it's true, and as simple as that. To have researchers who are also able to market and sell research the products of their research is absolutely necessary, but they are not so easily found.
•Financing of projects for particular clients is provided directly by the clients themselves. From a research commercialization perspective, clients get exactly what they want in the way of information.
•A world-class research staff is critical to success. The quality of our research staff gives us both breadth of coverage over many technologies of relevance to our members, and depth for individual technical areas. The combination gives us a systems capability when it comes to the transfer and the application of new technologies.

•Nearly all our research and development projects are dependent on industry participation (and often leadership), and at least 50 percent [of our] finances are from industry. Therefore we have to understand and identify with the research and development needs of the industry. This is crucial to the effective transfer of technologies developed by our organization.
•Our organization is financed almost entirely from subscriptions. Therefore, we only have one type of stakeholder to service, making it easier to be focused and to implement the results of our research.