Chapter 2

An Assessment of Technology Transfer in the Logging Industry: End-users' Perceptions of Portable Timber Bridge Technology

(ABSTRACT)

Perceptions of portable timber bridge technology by loggers were investigated within four geographic regions of the United States. Loggers received most technology information by personal contact with other loggers, followed by personal contact with industry foresters, logger education or training programs, trade shows, and trade magazine articles. However, this study identified that loggers in different regions do have different preferred sources for receiving new technology information. Utilizing different sources (e.g., personal contact, logger education programs, or trade shows) for different regions will be necessary to successfully transfer not only portable timber bridge technology, but also other logging-related technologies to the industry.

Loggers indicated that the best method for transferring technology was by word-of-mouth (logger to logger), followed by field demonstrations. It is essential that word-of-mouth and personal contact communication (personal selling methods) are applied as marketing strategies for transferring new technology to the logging industry. Loggers, who have utilized portable timber bridge technology, indicated that the most important factor in the decision to use a portable timber bridge was ease of operation, followed by environmental considerations. Promoters of portable timber bridges should emphasize these two factors as central themes for product promotion, that is user-friendly and environmentally-sound stream crossing alternatives.

Analytical Hierarchy Process (AHP) analysis indicates that respondents received most new technology information from companies producing the new technology, followed by trade shows, industry foresters, trade associations, state agencies (foresters), extension personnel, and the Wood In Transpiration (WIT) Program. Portable timber bridge promoters need to utilize or cooperate with these channels, especially companies, industry foresters, and trade associations, to effectively transfer portable timber bridge technology to users. However, results of the study identified that loggers in different regions have different preferred channels for receiving new technology information. Portable timber bridge promoters need to recognize the regional differences and utilize different channels (in different regions) to increase the utilization of the technology.

This study indicated that loggers have become aware of the benefits of utilizing portable timber bridges. However, loggers indicated that initial cost, availability of product information, and promotion efforts were the major reasons for the low utilization rate of engineered portable timber bridges. This indicates that initial cost and lack of marketing efforts were the major barriers for the adoption of portable timber bridges. To overcome these barriers, a strategic marketing plan is needed, marketing activities must address and utilize different sources and channels for different geographical regions. Traditional methods, such as word-of-mouth (logger to logger) and field demonstrations are still effective for transferring new technology to loggers. However, new communication methods, like the Internet or videos are playing an increasingly important role in technology transfer as the next century approaches.

Introduction

The use of timber in bridge construction has received increased interest in recent years due to the efforts of the Wood In Transportation Program (WIT), USDA Forest Service. New technologies and designs allow a variety of wood materials to be utilized in the construction of highway bridges. Over 300 timber bridges have been funded for highway use since the start of the program (USDA 1995). Pedestrian bridges for recreation purposes have also been sponsored.

However, most of the WIT's research emphasis has been placed on permanent bridge structures. There appears to be a large potential market existing for timber bridges and this market has not been explored. This market is portable timber bridges that are utilized as temporary stream crossing structures during forest management or timber harvesting operations. These bridges can be removed after initial use and be reused at another location. Little is known about important sources for receiving new information regarding logging operations; what are the important materials in the selection of a stream crossing bridge, and what are the factors influencing users' (loggers) decisions to use or not to use portable timber bridges in their operations.

Cooper (1979) indicated that there are three major facilitators in the adoption of new products: marketing and management synergy; strength of marketing communication and launch efforts; and market need, growth, and size. However, in the forest industry, the development of many new wood-related products has been driven by resource availability, cost, and technology – not by users needs (Rosenburg et al. 1990).

Only by having a thorough understanding of the market and customer needs can new products be successfully introduced. This study provides needed information for portable timber bridge technology developers, manufacturers, and promoters to understand potential markets for their products.

Background of the Study

Logging is the backbone of the forest industry. Approximately 16 billion cubic feet of timber are removed from U.S. forests annually. Over 50 percent of the removals are from Southern forests. The demand for wood products continues to increase along with population increases. At the same time, the industry is being asked to maintain forests for multiple uses; such as recreation, wildlife, clean water, and fresh air. Therefore, as the world struggles to meet its growing demand for wood products, it also has to do it in an environmental-friendly manner (USDA 1997).

Logging operations are being placed under increased scrutiny for their effects on water quality. To address these concerns and meet new regulations, logging operations must develop and use stream crossing methods that minimize or eliminate their impact on waterways. Research has been conducted to document the impacts of harvesting activities, roads and road construction, and site preparation on forest stream water quality. Researchers have found that roads and road construction create more pollution, in the form of sediment, than harvesting activities, and that road crossings at streams are the most frequent source of sediment and erosion (Russell 1997). Swift (1985) reported the cumulative amount of soil placed in a stream at road-stream crossings during construction was over 10 times greater than the sedimentation during logging operations.

In recent years, Best Management Practices (BMP) have been developed and implemented by many states to comply with the Environmental Protection Agency's (EPA) guidelines for preventing or reducing pollution generated by non-point sources in forestry activities. Originally, compliance with BMP was voluntary. However, in many states BMP implementation has become mandatory.

Improved stream or river crossings are needed to reduce the environmental impacts of logging operations. Currently there are two types of crossings for low-volume forest roads: temporary or permanent. Common temporary crossings are log stringers, fords, and culverts. Log stringers, if not installed or removed properly, can have an impact upon the watershed. In recent years, the use of log stringers has declined considerably due to material availability and for liability reasons (Taylor et al. 1995). Fords are gravel crossings which may be used to allow vehicles to transverse the water on the river bed. However, fords can introduce sediment into the streams as vehicles drive across. Concrete or corrugated metal culverts have been common stream crossing structures for years. However, sediment loads can be introduced into the stream during excavation and fill work that accompanies culvert installation. Permanent bridges are designed to last 40 to 50 years. For limited and low-volume use of forest roads, it is not economically feasible to build permanent bridges that require expensive initial cost and expensive maintenance for continued service (Taylor et al. 1995).

One practical solution for forestry operations on low-volume forest roads would be portable timber bridges. They can be easily transported, installed, and removed for reuse at different sites. The ability to be reused makes portable timber bridges more economically feasible than other stream crossings and their use may reduce potential water quality problems. Taylor et al. (1995) made cost comparisons between culverts and portable timber bridges. The cost of one culvert installation was $2,700, which was approximately the cost of a portable timber bridge that can be reused many times, therefore, making portable timber bridges more cost effective. In Taylor's study the cost of installation and removal of the portable timber bridge was $2,500. This cost included the initial cost of the bridge, cost of bridge transportation to and from the site, equipment operations, and labor costs distributed over 10 installations. Taylor and Murphy (1992) reported that glulam or stress-laminated portable timber bridges cost an average of $41/sq.ft., while portable steel bridges were $43/sq.ft. The advantages of portable timber bridges are that they can use locally available materials, labor, have a long service life, are relatively light weight, are easy to fabricate and transport, and can be handled by most logging equipment. According to Taylor et al. (1995), the most promising designs, for spans up to 40 feet, consist of longitudinal glulam or stress-laminated decks that are placed across the stream.

Loggers can expect a minimum of eight to ten years of service from a properly constructed, maintained, and treated bridge. When compared to culverts and logging mats, portable timber bridges are more quickly installed and environmentally friendly. Culverts require that soil be backfilled over and against them. Sedimentation, stream turbidity, and erosion can occur at installation and during stream crossing. Also oil, grease, and logging debris can potentially enter the stream with the use of mats (Alderman 1996).

Most material used to construct portable timber bridges is available locally and can provide an economic stimulus to the area. Timber is a renewable resource and bridge fabricators can use their own lumber to significantly reduce bridge costs. It is economically and environmentally feasible to manufacture and use portable timber bridges for temporary stream crossings. Proper installation and use of portable timber bridges allows full compliance with BMP.

Problem Statement

Logging today is a high-technology operation. Most forest disturbances can be minimized by careful logging practices. The forest-based industry has continuously improved the technology of forestry practices throughout the 20th Century. However, the forces that lead to use of technological innovations are not always from inside the firm itself. Often a company receives technology transfer proposals (technology push) from outside sources. Developers of technology often have a difficult time reaching their target users.

Public sector research represents an important source of technology. In the major Western industrial countries, government and university research organizations account for over 40 percent of the national research and development (R&D) expenditures (Large and Barclay 1992). However, many technology transfer efforts between public (federal government) and private sectors have been disappointing (Piper and Naghshpour 1996).

Given the importance of technology for corporate profitability and growth, and for national economies and international competitiveness, it is not surprising that there is strong and active interest in this subject (Irwin and Moore 1991). In the past, transferring technology was viewed as a unilateral flow process (i.e., good technologies sell themselves). More recently, the subject has been heavily emphasized for economic and marketing considerations. But there are problems with a purely market-driven or a purely technologically-driven approach to the successful transfer of technological innovation. It has been suggested that the combination of the two, technology innovation with appropriate marketing, is necessary for real success and needs further investigation (Irwin and Moore 1991).

While this method may be recognized as a strategically sound way of approaching innovation transfer, the actual mechanism of how to achieve this approach is not quite so clear. Recently, researchers have been exploring the issue of culture and communication. Such an approach might help overcome many of the associated problems involved, particularly the communication difficulties occurring among technology developers, message senders, and technology users where different organizational cultures clash (Irwin and Moore 1991). Therefore, it is important to pay close attention to communication and information flow through different cultures involved in the technology transfer process. The marketing of technology requires new skills, styles, techniques, and methods of thinking. Communication competence and effective information flow in transfer technology need to be recognized as a cornerstone (Irwin and Moore 1991).

To date, little research has been conducted by the USDA Forest Service on how to facilitate technology transfer through a communication system to the target users. Smith and Cesa (1998) examined the effectiveness of "technology push" by one of the programs under the USDA Forest Service supervision, the WIT Program. A questionnaire was mailed to over 90 firms identified as suppliers of material for modern timber bridges. Overall, respondents rated the program's "technology push" as moderately effective in expanding markets for wood utilization.

Smith's research only measured manufacturers' response of technology push. It did not evaluate the information flow between the push side of government agencies and consumers. However, to date, technology transfer efforts have been focused upon permanent bridge structures for highways or pedestrian use. The market for portable timber bridges for use in forestry and logging operations has not been evaluated.

The main goal of this study was to evaluate information flow through the logging system. A network concept is applied to the study of communication and information flow among different groups and cultures (Figure 2.1). The first step of this study was to study the information receivers (loggers). Little is known about the sources where loggers receive new technology information in logging operations, what channels (intermediaries) can help to facilitate diffusion of new technology information, what materials are important in the selection of a portable bridge, and what reasons loggers choose to use, or not to use, portable timber bridges.

Objectives of the Study

The methods and channels needed to reach loggers and other forest practitioners in an effective way remain challenging. To ensure that technology reaches loggers at the appropriate time, the objectives of this study were to:

1) identify which sources are important for loggers in receiving new technology information,

2) identify which materials are important in the selection of a portable bridge,

3) evaluate the important factors regarding the process of adopting portable timber bridge technology, and

4) identify which intermediaries are the most effective communication channel(s) in transferring technology information to loggers.

Research Methods

Sample Frame

The sample frame for this research was loggers within the Eastern half of the United States. To determine if differences existed between demographic areas, four distinct demographic regions were identified. They were: East, South, Mid-Atlantic, and Midwest. These four regions accounted for a major portion of timber bridge studies which have been funded by the WIT Program (Cesa 1997).

Questionnaire Development and Data Collection

A questionnaire was used for primary data collection. Data were collected utilizing the “mall intercept” interview method. Although on-site visits or door-to-door interviews are considered the best survey method, they are expensive and time consuming (Aarker et al. 1998). In reality, it is very difficult to visit loggers while harvesting operations are being conducted at various locations (due to budget and time constraints). Mail surveys have long been considered a cost effective way to collect data from a wide geographic area, but historical data indicated that the response rate for a mail survey of loggers has been low. An alternative method was employed. “Mall intercept” interviews are a popular solution when funds are limited and researchers still can have person-to-person interaction and contact (Aarker et al. 1998). The interviews were conducted at venues that have a similar function as shopping malls; logging equipment trade shows. Trade shows offer researchers a valuable marketing option, especially when considering today’s cost of research.

Several trade shows were attended. They are as follows: 1) “Expo Richmond ’98, The 26th East Coast Sawmill & Logging Equipment Exposition” (May 8-9, 1998) in Richmond, Virginia, 2) “West Virginia Timber and Wood Products Show” (June 13-14, 1998) at the Barbour County Fairground, West Virginia, 3) “Logging Congress” (September 11-12, 1998) in Green Bay, Wisconsin, and 4) the “Kentucky Wood Expo” (September 19-20, 1998) at the Laurel County Fairground, Kentucky. “Expo Richmond ’98” was the largest logging related trade show in the Eastern United States, with the largest number of exhibitors and attendees nationwide.

At “Expo Richmond ’98” a trade show display was provided by the Center for Forest Products Marketing and Management at Virginia Tech. In addition, this display was stationed at all attended trade shows. Researchers randomly approached attendees, identified themselves as researchers from Virginia Tech, and explained the purpose and importance of the study for the logging industry. When the attendee identified him/herself as a logger and agreed to participate in the study, he/she was invited to fill out the questionnaire. In order to gain more attention from loggers, posters regarding the study were displayed throughout the show.

During the same time period, questionnaires were sent to the Alabama Forestry Association and selected Cooperative Extension personnel in the New England states (New York, New Hampshire, and Maine). These organizations agreed to request participation from loggers at logger training/education classes. Then the organizations returned the questionnaires to Virginia Tech. Demographically, the study covered the Mid-Atlantic, Mid-West, East, and Southern regions of the United States.

The questionnaire consisted of four sections. Section one collected categorical data concerning what type of timber loggers harvested (e.g., hardwood, softwood, or both), where were they located (state) and in which geographical region (e.g., mountain, piedmont, coastal plain, or other), the technologies currently used in their operations, type of portable timber bridges currently utilized, and educational background. Section two of the questionnaire utilized rating scales to collect data regarding important sources for receiving new information concerning logging operations, materials utilized to select a portable bridge, types of portable timber bridges currently utilized, and factors in the decision process as to whether to use or not to use a portable timber bridge. Section three of the questionnaire utilized the Analytic Hierarchy Process (AHP) model's pairwise comparison technique to identify how loggers prefer certain channel(s) of communication in terms of diffusion information. The final section utilized open-ended questions to ascertain the best method(s) to transfer new technology information to loggers and the concern(s) regarding the use of the new logging technology. Two pages illustrating the different types of portable timber bridges were attached (Appendix A).

The questionnaire was reviewed by a former industrial and consulting forester, and knowledgeable faculty and forestry extension personnel at Virginia Tech to test its clarity and to ensure what important intermediaries in technology transfer were included. A pretest was then conducted with loggers and industry foresters in Virginia and North Carolina. Responses from the pretest were used to clarify question wording, revise the set of intermediaries, and factors in the technology transfer process.

Data Analysis

Data analysis began with one-way and cross tabulations to examine, categorize, and tabulate data. Multivariate Analysis of Variance (MANOVA) was utilized to test for significant differences (overall effect) between demographic groups, geographical groups, and significant differences between data collection locations. Once relationships had been determined using MANOVA, multivariate contrast analysis was followed up to further compare groups and variables simultaneously (e.g., group 1 vs. group 2, group 1 vs. group 3, and group 1 vs. group 4). In MANOVA, the linear combination of dependent variables that best separated the levels comprising the independent variables was determined. The MANOVA test statistic for comparing groups is Wilks' lambda, which can be transformed to an F-statistic to obtain a probability level (p-value) (Grimm and Yarnold 1995). Wilks' lambda expresses the proportion of unexplained variance in the dependent measures (Johnson and Wichern 1992). The range of Wilks' lambda is from zero to infinity. Lower values indicate larger mean differences, therefore indicating stronger group separation (Grimm and Yarnold 1995). Follow up multivariate contrast analysis allowed the researcher to discern subsets of variables that might constitute some underlying constructs on which the groups differ (Grimm and Yarnold 1995). The multivariate contrast produces a test statistic (in this case the multivariate version of a t-test, Hotelling's T^2-Test) that compares two groups with a critical value (p-value) to obtain a significance level (Grimm and Yarnold 1995). A significance level of 0.05 was used throughout the study. The SPSS™ 8.0 for Windows™ (1997) software package was utilized to examine, categorize, and tabulate data. The SAS™ System for Windows™ Release 6.12 (1996) software was utilized to perform MANOVA and multivariate contrast analysis.

This research recognized an unbalanced sample size in the MANOVA test groups (Table 2.1, Table 2.7) and some variables did not appear to meet multivariate normal distribution assumptions (relatively small sample size). Although multivariate statistics are robust enough to withstand minor violations of basic assumptions, it was necessary to perform nonparametic statistical tests to analyze data under these circumstance (SPSS

1998). Nonparametric tests are known as distribution-free tests because they make no assumptions about the underlying distribution of the data and these tests are also utilized to analyze unbalanced data sets. The Kruskal-Wallis test was used to further analyze data under nonparametric statistic assumptions. The Kruskal-Wallis test is a nonparametric analogue to one-way analysis of variance (ANOVA) and it was performed by using the SPSS™ software package.

Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) model's pairwise comparison technique was employed in this study to identify which channels respondents received the majority of technology information from. The AHP model, developed by Saaty (1980), is a multi-criteria decision analysis techique. Typically, the AHP model has three levels of hierarchy, which includes the overall goal (top level), the elements that affect the goal (second level), and the lowest level (comprises the options). At each level, elements are compared pairwise with respect to their importance in the decision making process (Figure 2.2).

This research utilized two levels of hierarchy; level one, with the goal of identifying the importance of communication channels regarding the transfer of information in the logging industry, and level two, seven pre-identified elements (intermediaries) that affect the goal. The respondent could express his/her preference between each set of two elements. For example, verbal transfer can be expressed as equally important, moderately important, strongly important, very strongly important, or extremely strongly important. The descriptive preference is then transformed into absolute numbers 1, 3, 5, 7, and 9, respectively, with 2, 4, 6, 8 as intermediate values for comparison between two successive qualitative judgements. After forming the comparison matrix, relative or priority weights for the elements are derived (Saaty 1980). Priority weights are the components of the eigenvector of the matrix. The significance of these numbers are that they represent the conversion of the pairwise comparisons of the criteria into a ratio scale. This new scale is called a derived scale (Saaty 1988). Priority weights are important for this scale and the sum of these numbers (within the matrix) are always one.

It is important to determine priority weights in pairwise comparison. Several methods have been utilized in research to calculate priority weights, including normalized eigenvalues, logarithmic least squares, and least squares methods (Yang and Lee 1997). However, the three methods mentioned above have been proven to receive the identical results in terms of consistency, and the normalized eigenvalues are suggested when the data are not entirely consistent (Saaty and Vargas 1984). Approximation of the eigenvector can also be used, such as using a geometic mean (Saaty 1988).

Unlike conventional rating scale measurements, the AHP model provides more actual and statistical indicators for researchers. In this research, paired comparisons were made between seven pre-identified information transfer intermediaries. They were extension specialists, state agencies (foresters), WIT technology developers, trade shows, trade associations, procurement foresters, and companies producing and promoting portable bridges. There were 21 pairs for respondents to express their preference [n/2 (n-

1), n=7] (Saaty 1988). Individual results were geometrically averaged to form a composite matrix. Expert Choice™ (1994), a computer program based on the Analytic Hierarchy Process, helped to form the questions, data entry, and analyzed the results for the researcher.

Non-Response Bias

A common concern in survey research is non-response bias. To test for non-response bias, data obtained from non-respondents (via phone calls) were compared to data obtained from the original survey using student t-tests. Respondents were compared in several key areas, which include: important sources for receiving new technology information, important materials in the choice of a portable bridge, and important factors in the decision to utilize portable timber bridges in logging operations. No significant differences (α=0.05 level) were found between the two sets of data, which indicated that non-response bias does not appear to be a problem in this case.

Results and Discussion

One hundred and fifty eight useable questionnaires were returned, which included the classroom survey. Respondents were sorted by different demographic regions and data collection locations. Eighty-nine respondents were from the Mid-Atlantic region, Mid-West region (30), South region (23), and 15 from East region of the United States (Table 2.1). Trade shows resulted in 131 useable questionnaires. There were 27 useable questionnaires returned from different logger education or training classes.

Section one of the questionnaire asked respondents to identify which region (state) they operated in, their primary operation, primary timber species harvested, have they used portable timber bridges in their operation, and education level. Figure 2.3 and Figure 2.4 illustrates the different types of portable timber bridges discussed in this section. Approximately 59 percent harvested both hardwoods and softwoods, 35 percent of the respondents harvested hardwood, and 6.4 percent harvested softwood (Table 2.2). For the geographical operation regions, 40 percent operated in the mountains, 22 percent operated in the piedmont, 15 percent operated in the coastal plain, and 22 percent operated in the plains or similar topography (Table 2.3). Nearly 43 percent of respondents did utilize portable timber bridges in their logging operations (Table 2.4). Fifty-seven percent of the respondents were high school educated, 20 percent attended a four-year college, 14 percent attended a two-year college, and 9 percent attended graduate school (Table 2.5). Interestingly, respondents from the East region had the highest education level among respondents. Fifty percent of the respondents from the East region held at least a four-year college degree. They also had the highest utilization rate for portable timber bridges (80 percent). It could indicate that, according to Assael (1992), consumers with a higher education level (college or above) adopted new products more often and faster then other consumers with average education levels (high school or less).

When respondents were asked about current technologies used in their logging operations, the most frequently used technology was wireless communication, followed by personal computers, and mechanical delimbers (Table 2.6). This indicates that cellular phones or radios could be a preferred method to reach loggers. When personal computers become more popular, related products such as software packages for increasing productivity, maintenance, automation systems, or the Internet could affect the logging industry's operations. In addition, if loggers use the Internet, portable timber bridge manufacturers or promoters could advertise or promote their products on the Internet.

Respondents were asked to rate which sources [on the scale of one (below average importance) to seven (above average importance)] were important in receiving new information regarding logging operations. The number one source was personal contact with other loggers, followed by personal contact with industry foresters, logger education or training programs, trade shows, and trade magazine articles (Table 2.7, Figure 2.5). The least important sources in receiving new information regarding logging operations were extension personnel, state agencies (foresters), and the WIT Program. To determine if differences existed in demographic regions in terms of important sources in receiving new information regarding logging operations, the MANOVA analysis was used. The multivariate null hypothesis tested in the MANOVA test was "*There are no differences between demographic regions by loggers in terms of important sources for receiving new technology information*". This analysis resulted in a Wilk's lambda value of 0.60 and produced a multivariate F of 2.27 with corresponding 33 and 404 degrees of freedom ($F_{33, 404} = 2.27$). The obtained probability (p-value) was < 0.01, therefore, we reject the null hypothesis and conclude that there is a significant multivariate effect for loggers in different regions (in terms of important sources for receiving new technology information). Multivariate contrast analysis was utilized to discern the group differences (e.g., Mid-Atlantic vs. Mid-West, Mid-Atlantic vs. South, Mid-Atlantic vs. East). There were four regions in this analysis and this produced six pairs of comparison groups (Table 2.8). This analysis revealed significant differences between the Mid-Atlantic region vs. East region (p < 0.01), Mid-West region vs. East region (p < 0.01), and Mid-West region vs. South region (p = 0.01) (Table 2.8). The variables which maximized group separation were sales people from companies, state agencies (foresters), trade magazine articles, and the WIT Program (all with p-value < 0.05). Rating means for sales people from companies at each region were: Mid-Atlantic (5.2), East (4.4), Mid-West (5.0), and South (4.3). This may indicate that sales force from companies could be effective in disseminating new technology information for loggers in the Mid-Atlantic and Mid-West regions, but may not be as effective in the East and South regions. Rating means for state agencies (foresters) at each region were: Mid-Atlantic (4.8), East (3.0), Mid-West (4.9), and South (3.6). This indicates that, in terms of sources for receiving new technology information, state agencies (foresters) in the East and South regions were less preferred by respondents. Rating means for trade magazine articles for each region were: Mid-Atlantic (5.2), East (4.1), Mid-West (5.1), and South (5.5). This indicates that respondents from the East region did not prefer to receive information from articles published by trade magazines than respondents from other regions. Rating means for the WIT Program at each region were: Mid-Atlantic (3.9), East (2.4), Mid-West (4.1), and South (3.9). This indicates that the awareness level of the WIT Program was lowest in the East region of the United States.

As mentioned, this research recognized an unbalanced sample size between testing groups and some variables appeared to have minor violations of multivariate normal distribution assumptions (relatively small sample size), therefore the Kruskal-Wallis test was performed to further analyze data under nonparametic statistical assumptions. This analysis revealed significant differences between demographic regions. The variables which maximized group separation were state agencies (foresters), trade magazine articles, sales people from companies, and the WIT Program (Table 2.7). These results correspond to the results of the MANOVA test. The results indicate that the MANOVA test was robust enough to withstand minor violations of normality assumptions.

To determine if differences existed in geographical operation regions (e.g., mountain, piedmont, and coastal plain) in terms of important sources in receiving new information regarding logging operations, the MANOVA analysis was used. Since only in Mid-Atlantic region has the variety of different geographical operation regions, the MANOVA test did not include other demographic regions (Mid-West, South, and East).

The multivariate null hypothesis tested in the MANOVA test was "*There are no differences between geographical operation regions by loggers in terms of important sources for receiving new technology information*". No differences were found between geographical operation regions (Wilk's lambda = 0.72, $F_{33, 218} = 0.78$; p-value = 0.79). The results indicate that differing geographical operation regions did not result in respondents having different preferences in terms of important sources for receiving new technology information. A Kruskal-Wallis test was performed to further analyze data under nonparametric statistical assumptions. This analysis revealed no significant differences were found between geographical operation regions.

To determine if differences existed between variables in this question, Figure 2.6 illustrates the mean and mean range (lower limit to upper limit) at 95 percent confidence interval (C.I.) for each variable. Except the variables of personal contact with other loggers and the WIT Program, other variables did not show the differences (means for these variables fell in each other's mean ranges). This indicates that some lower ranked variables (e.g., extension publications, ads in trade magazine, and state agencies) still have certain role in the important sources for loggers to receiving new technology information.

When asked how important materials were in the selection of a portable timber bridge, respondents reported that timber was the most important, followed by steel, then aluminum, and concrete (Table 2.9). To determine if differences existed between demographic regions, the multivariate null hypothesis tested here was "*There are no differences between demographic regions by loggers in terms of important materials in* *the selection of a portable bridge*". No differences were found between demographic groups (Wilk's lambda = 0.82, $F_{12, 169} = 1.08$; p-value = 0.37) (Table 2.10). One reason for this is that respondents preferred timber as the best material for a portable bridge. A Kruskal-Wallis test was performed to further analyze data under nonparametric statistical assumptions. These analysis revealed no significant differences were found between demographic regions (Table 2.9). This indicates that the results of nonparametric test correspond to the results of the MANOVA.

To determine if differences existed in geographical operation regions (e.g., mountain, piedmont, and coastal plain) in terms of important material in the selection of a portable bridge, the MANOVA analysis was used. The multivariate null hypothesis tested here was "*There are no differences between geographical operation regions by loggers in terms of important materials in the selection of a portable bridge*". No differences were found between geographical operation regions (Wilk's lambda = 0.83, $F_{12, 211} = 1.24$; p-value = 0.25). A Kruskal-Wallis test was performed to further analyze data under nonparametric statistical assumptions. This analysis revealed no significant differences were found between geographical operation regions. To determine if differences existed between variables in this question, Figure 2.7 illustrates that the variable of timber is different from other variables. This indicates that timber could be the best material for the selection of a portable bridge.

For respondents who have used portable timber bridges in their logging operations, the most important factor in the decision to use a portable timber bridge was ease of operation, followed by environmental considerations (Table 2.11). To determine if differences existed between demographic regions, the multivariate null hypothesis tested here was "*There are no differences between demographic regions by loggers in terms of important factors in the decision to use portable timber bridges*". No significant differences were found between demographic groups (Wilk's lambda = 0.68, $F_{18, 156}$ = 1.23; p-value = 0.24) (Table 2.12). The results indicate that differing demographic regions did not result in respondents having different factors influencing their decisions to use portable timber bridges. The results could also indicate that loggers have become aware of the benefits of utilizing portable timber bridges. A nonparametric test (Kruskal-Wallis test) was performed to further analyze data. This analysis revealed no significant differences between demographic regions (Table 2.11). This indicates that the results of nonparametric test correspond to the results of the MANOVA.

To determine if differences existed in geographical operation regions (e.g., mountain, piedmont, and coastal plain) in terms of important factors in the decision to use portable timber bridges, the MANOVA analysis was used. The multivariate null hypothesis tested here was "*There are no differences between geographical operation regions by loggers in terms of important factors in the decision to use portable timber bridges*". No significant differences were found between demographic groups (Wilk's lambda = 0.42, $F_{18, 79}$ = 1.55; p-value = 0.09). A Kruskal-Wallis test was performed to further analyze data under nonparametric statistical assumptions. This analysis revealed no significant differences were found between geographical operation regions.

To determine if differences existed between variables in this question, Figure 2.8 illustrates the mean and mean range (lower limit to upper limit) at 95 percent confidence interval (C.I.) for each variable. The variables of ease of operation, environmental considerations, regulations, and initial cost did not show any differences (means for these variables fell in each other's mean ranges). This indicates that these variables are treated importantly by loggers in their decision to use a portable timber bridge in their operations.

Portable timber bridge users were asked what type of portable timber bridges they currently use and reported that they often used skidder bridges in their operations, followed by do-it-yourself bridges, road or deck mats, engineered portable timber bridges, and other types of portable bridges (Table 2.13). Few respondents utilized a engineered portable timber bridge. From these results, there appears to be a large potential market for engineered portable timber bridges.

When asked what prices respondents paid for their portable timber bridges, 62.5 percent paid under $2,000 and 26.6 percent paid between $2,000 and $3,500. Only 4.7 percent of the respondents paid over $7,500 for their portable timber bridge (Table 2.14). The results indicate that most respondents (nearly 90 percent) did not pay over $3,500 for their portable timber bridge. If this price range is feasible for an engineered portable timber bridge, the adoption rate of this technology may increase.

For those loggers who did not use portable timber bridges, the major factors in their decision not to use the technology were initial cost, availability of product information, and promotional efforts. The least rated factor in the decision not to use a portable timber bridge was that respondents were unsure of the benefits of portable timber bridges (Table 2.15). No significant differences were found between demographic groups (Wilk's lambda = 0.71, $F_{15, 185} = 1.58$; p = 0.08) (Table 2.16), the multivariate null hypothesis tested here was "*There are no differences between demographic regions by loggers in terms of important factors in the decision not to use portable timber bridges*". Also no differences were found between geographical operation regions (Wilk's lambda = 0.85, $F_{15, 110} = 0.42$; p = 0.96). Figure 2.9 illustrates that the variable of initial cost is different from the variable of unsure the benefits.

These results indicate that initial cost, availability of product information, and promotion efforts could be major barriers to the utilization of portable timber bridges in the forest industry. Respondents have become aware of the benefits of utilizing portable timber bridges. Portable timber bridges can be easy to operate, and can also minimize the environmental impacts of timber harvesting operations. However, a low cost and intensified marketing effort is needed to increase the utilization rate of portable timber bridges, particularly for engineered portable timber bridges. A Kruskal-Wallis test was performed to further analyze data under nonparametic statistical assumptions. This analysis revealed no significant differences between demographic regions (Table 2.15). These results correspond to the results of the MANOVA.

Regarding the open-ended questions, respondents stated that they learned how to use portable timber bridges from the company that they logged for and from field demonstrations. This indicates that major forest products companies should be included in the target market for portable timber bridges and field demonstrations also could be a useful tool for promoting portable timber bridges.

Open-ended question two asked for the best method(s) to transfer new technology information to loggers. Respondents indicated that the best method was word-of-mouth (logger to logger), followed by field demonstrations, videos, and trade shows. Researchers have found that friends and relatives are more likely to influence consumer choice than any other source of information (Assael 1992). Information from references and family groups is more credible and trustworthy than commercial sources of information. This method could be applied in the marketing strategies and tactics for portable timber bridges.

In this research, data were collected from two different types of locations: trade shows and classrooms. Trade shows resulted in 131 useable questionnaires. There were 27 useable questionnaires returned from different logger education or training classes. In order to determine if differences exist in data collection locations, both MANOVA analysis and nonparametic (Kruskal-Wallis) test were utilized.

To determine if differences existed in data collection locations regarding the important sources for receiving new technology information, the multivariate null hypothesis tested was "*There are no differences between data collection locations by loggers in terms of important sources for receiving new technology information*". This analysis resulted in significant differences between data collection locations (Hotellings = 0.83, $F_{11,140} = 2.48$; p-value < 0.01), therefore the null hypothesis was rejected (Table 2.8). Multivariate contrast analysis was utilized in order to further discern group differences. The variables which maximized data collection place separation were state agencies (foresters) and personal contact with other loggers (and with $p\text{-value} < 0.05$) (Table 2.17). Rating means for state agencies (foresters) at each location were: trade show (4.7) and classroom (3.4). This indicates that, in terms of sources for receiving new technology information, state agencies (foresters) were not preferred by classroom respondents. Rating means for personal contact with other loggers at each location were trade show (5.9) and classroom (5.1). This indicates that classroom respondents received less information from peer loggers.

A Kruskal-Wallis test was performed to further analyze data under nonparametic statistical assumptions. This analysis revealed significant differences between data collection locations. The variables which maximized data collection location separation were state agencies (foresters) and personal contact with other loggers (Table 2.17). These results were identical to the results of the MANOVA.

To test if significant differences existed between data collection locations regarding important materials in the selection of a portable bridge, the null hypothesis tested was "*There are no differences between data collection locations by loggers in terms of important materials in the selection of a portable bridge*". This analysis resulted in no significant differences found between data collection locations (Hotellings = 0.98, $F_{4, 137} = 0.37$; p-value = 0.84) (Table 2.10). One reason for this is that respondents preferred timber as the best material for a portable bridge. A Kruskal-Wallis test was performed to further analyze data under nonparametic statistical assumptions. This analysis revealed no significant differences were found between data collection locations (Table 2.18). These results corresponded to the results of the MANOVA.

To ascertain if differences existed between data collection locations in the important factors in the decision to use portable timber bridges, the multivariate null hypothesis tested here was "*There are no differences between data collection locations by loggers in terms of important factors in the decision to use portable timber bridges*". No significant differences were found (Hotellings = 0.90, $F_{6, 58} = 1.00$; p-value = 0.43) (Table 2.12). The results indicate that differing data collection locations did not result in respondents having different factors influencing their decisions to use portable timber bridges. A Kruskal-Wallis test was performed to further analyze data under nonparametric statistical assumptions. This analysis revealed no significant differences were found between data collection locations (Table 2.19). These results corresponded to the results of the MANOVA.

To test for differences existing between data collection locations in the important factors in the decision not to use portable timber bridges, the null hypothesis tested was "*There are no differences between data collection locations by loggers in terms of important factors in the decision not to use portable timber bridges*". No differences were found between data collection locations (Hotellings = 0.93, $F_{5, 69} = 0.95$; p-value = 0.45) (Table 2.16). A Kruskal-Wallis test was performed to further analyze data under nonparametric statistical assumptions. This analysis revealed no significant differences were found between data collection locations (Table 2.20). These results corresponded to the results of the MANOVA.

AHP Analysis

The question asked respondents when receiving new information on products or technology, which intermediaries are most important to them. It then asked respondents to indicate their level of preference for the more important factor by selecting a value of (1 to 9) from that factor's scale. The question compared the relative importance of one intermediary to another. Paired comparisons were made among seven pre-identified information transfer intermediaries (extension specialists, state foresters, WIT technology developers, trade shows, trade associations, procurement foresters, and companies producing and promoting portable bridges). Each respondent made 21 paired comparisons to express their preference. Individual results were geometrically averaged and one composite matrix was developed (Table 2.21).

Sensitivity analysis was employed for overall and each demographic region to determine if increasing efforts in one or more intermediaries would effect the respondent's preference. Saaty (1980) indicates that if an inconsistency ratio is around 0.1 or less, the judgments should be considered consistent. However, some inconsistency is carryover from previous experiences in most comparison processes and may not necessarily be eliminated (Saaty 1990). The inconsistency ratios for aggregate responses of overall, Mid-Atlantic region, South region, and East region were all equal to 0.01 (much less than 0.1). The Mid-West region's inconsistency ratio was 0.11, slightly over the cut off point of 0.1 (Table 2.22). It may indicate that respondent judgments from the Mid-West region may be somewhat random (Saaty 1990).

Priority (relative) weights indicated that respondents (overall) received most new technology information from companies producing the new technology (0.218), followed by trade shows (0.193), industry foresters (0.176), trade associations (0.167), state agencies (0.108), extension personnel (0.072), and WIT technology developers (0.066), respectively (Table 2.22, Figure 2.10). This indicates that private companies' promotional efforts may be greater than those of non-profit organizations. Therefore, respondents are exposed to more private company information flows than from other information channels. Sensitivity analysis indicates that when the WIT Program increased its efforts (doubling the priority weight), changes would affect the respondents' preferences in companies who produced new technology and industry forester (both increased the priority weights) and priority weights in other intermediaries were decreased (Figure 2.11).

In the Mid-Atlantic region, priority weights indicate that respondents received most new technology information from trade shows (0.224), followed by the companies who produced new technology (0.203), trade associations (0.157), industry foresters (0.147), state agencies (0.123), extension personnel (0.098), and WIT technology developers (0.048), respectively (Table 2.22). Sensitivity analysis indicates that if the WIT Program increased its efforts (doubling the priority weight) in the Mid-Atlantic region, changes would affect the respondents' preferences in companies who produced new technology and trade associations (both decreased the priority weights). No major indications were found that if WIT's priority weight were changed that it would affect respondent's priority on other intermediaries in this region. It indicates that if the WIT

Program increased its efforts in this region, the first two preferred channels for receiving technology information in this region could change respondents' preferences. Therefore, to effectively promote portable timber bridges in this region, promoters need to form a strategic relationship with the two preferred channels.

In the Mid-West region, priority weights indicated that respondents received most new technology information from trade shows (0.207), followed by trade associations (0.187), industry foresters (0.181), companies producing new technology (0.148), WIT technology developers (0.107), state agencies (0.099), and extension personnel (0.070), respectively (Table 2.22). Sensitivity analysis indicates that when the WIT Program increased its efforts (doubling the priority weight) in the Mid-West region, changes would affect the respondents' preferences toward trade shows (increased the priority weight) and trade associations (decreased the priority weights). No major indications were found that changed WIT's priority weight, which would affect respondent's priority to other intermediaries in this region. The situation here is similar to the Mid-Atlantic region, when WIT's efforts were increased in the Mid-West region, the preferences for the first two preferred channels were also changed. It indicates that trade shows and trade associations could play a important role in transferring new information in this region.

Responses to the AHP question in the South region indicated that respondents prefer companies (0.244) as their primary channel for receiving new information, followed by industry foresters (0.196), trade shows (0.140), trade association (0.140), state agencies (0.101), WIT technology developers (0.098), and extension personnel (0.08) respectively (Table 2.22). Sensitivity analysis indicates that when the WIT

Program increased its efforts (doubling the priority weight) in the South region, changes would affect the respondents' preferences in companies who produced new technology and industry foresters (both decreased the priority weights). No major indications were found that if WIT's priority weight were changed that it would affect respondents' preferences to other intermediaries in this region. Again, it indicated that portable timber bridge promoters need to cooperate with companies and industry foresters to effectively transfer portable timber bridges technology to users in this region.

In the East region, the priority weights indicated that respondents received most new technology information from industry foresters (0.247), followed by companies (0.239), trade shows (0.191), trade associations (0.140), extension personnel (0.084), state agencies (0.053), and WIT technology developers (0.046), respectively (Table 2.22). Sensitivity analysis indicates that when the WIT Program increased its efforts (doubling the priority weight), no major changes were found that if WIT's priority weight were changed that it would affect respondents' preferences to other intermediaries in this region. The results may indicate that the awareness level for the WIT Program in this region is low. And promoters of portable timber bridges may need to either increase their awareness level in this region or promote portable timber bridges indirectly by utilizing the preferred channels in this region.

Conclusions

Loggers preferred personal contact with other loggers and industry foresters as important sources in receiving new technology information, followed by logger education or training programs, trade shows, and trade magazine articles. However, the results of this study identified that loggers in different regions do have different preferred sources for receiving new technology information. It indicates that information flow differs by region. In order to successfully transfer new technology information, promoters of portable timber bridges need to utilize different information sources in different regions.

Respondents rated timber as the best material when selecting a portable bridge. There were no differences between demographic regions and data collection places by loggers in terms of important materials in the selection of a portable bridge. The most important factor in the decision to use portable timber bridges is ease of operation, followed by environmental considerations. This indicates that ease of operation (e.g., ease of installation and handling) must in the first priority when designing portable timber bridges. Environmental considerations (e.g., environmental-friendly products) can be used as a tool in the promotion of portable timber bridges. The results also indicate that differing demographic regions and data collection locations did not result in respondents having different factors influencing their decisions to use portable timber bridges.

The utilization rate for engineered portable timber bridges was relatively low (9 percent). The results indicate that respondents have become aware of the benefits of utilizing portable timber bridges, but respondents also indicate that initial cost, availability of product information, and promotion efforts may be the major reasons for the low utilization rate for engineered portable timber bridges in logging operations. No significant differences were found between demographic groups and data collection places by loggers in terms of important factors in the decision not to use portable timber bridges.

AHP analysis indicates that respondents received most new technology information from companies producing the new technology, followed by trade shows, industry foresters, trade associations, state agencies (foresters), extension personnel, and the WIT Program. Portable timber bridge promoters need to utilize or cooperate with these channels, especially companies, industry foresters and trade associations, to effectively transfer portable timber bridge technology to users. However, results of the study identified that loggers in different regions have different preferred channels for receiving new technology information. Portable timber bridge promoters need to recognize the differences and utilize different channels in different regions to increase the utilization of the technology.

More marketing efforts are needed for promoting portable timber bridges to end users and design of portable timber bridges must also focus on reducing total cost. Marketing activities must address and utilize different sources and channels for the different regions. Traditional methods, such as word-of-mouth (logger to logger) and field demonstrations are still effective in transferring new technology to loggers. However, new communication methods, like the Internet or videos are playing an increasingly important role in technology transfer as the new century is approached.

Literature Cited

Aaker, D.A., Kumar, V., and Day, G.S. 1998. Marketing Research. 6th edition. John Wiley & Sons, Inc. New York.

Alderman, D.R. Jr. 1996. Portable stress-laminated timber bridges: Alternatives for stream crossings in harvesting operations. *Forest Prod. Journal*. In Review.

Assael, H. 1992. Consumer Behavior and Marketing Action. 4th edition. PWS-Kent Company. New York.

Cesa, E. 1997. Program Manager, Wood In Transportation Program, USDA, Forest Service. Morgantown, West Virginia. Personal Interview. November.

Cooper, R. 1979. The dimensions of industrial new product success and failure. *Journal of Marketing* 43:93-103

Expert Choice™. 1994. Expert Choice for Windows™, Version 9.0. Expert Choice, Inc. Pittsburgh, PA.

Grimm, L.G. and Yarnold, P.R. 1995. Reading and Understanding Multivariate Statistics. The American Psychological Association. Washington, D.C.

Irwin, H. and More, E. 1991. Technology transfer and communication: lessons from Silicon Valley, Route 128, Carolina's Research Triangle and Hi-Tech Texas. *Journal of Information Science* 17:273-280.

Johnson, R.A. and Wichern, D. W. 1992. Applied Multivariate Statistical Analysis. Third Edition. Prentice-Hall, Inc. Englewood Cliffs, NJ.

Large, D.W. and Barclay, D.W. 1992. Technology transfer to the private sector: A field study of manufacturer buying behavior. *Journal of Product Innovation Management* 9(1):26-43.

Piper, W.S. and Naghshpour, S. 1996. Government technology transfer: The effective use of both push and pull marketing strategies. *Int. Journal Technology Management* 12(1): 85-94.

Rosenberg, N., Ince, R., Skog, K., and Plantigna, A. 1990. Understanding the adoption of new technology in the forest products industry. *Forest Prod. Journal* 44(3):57-62.

Russell, K. 1997. Portable Timber Bridges: An Eco-friendly Solution for Stream Crossings. NA-TP-01-97. USDA, Forest Service, Northeastern Area. Morgantown, West Virginia.

Saaty, T.L. 1980. The Analytic Hierarchy Process. McGraw-Hill. New York.

Saaty, T.L. 1988. Multicriteria Decision Making: The Analytic Hierarchy Process. RWS Publication. Pittsburgh, PA.

Saaty, T.L. 1990. Decision Making For Leaders. RWS Publication. Pittsburgh, PA.

Saaty, T.L. and Vargas, L.G. 1984. Comparison of eigenvalue, logarithmic least squares, and least squares methods in estimating ratios. *Mathematical Modelling* 5:309-324.

Smith, R.L. and Cesa, E. 1998. An assessment of "technology push" in the Timber bridge industry. *Forest Prod. Journal* 48(1):42-46.

Swift, L.W. 1985. Forest road design to minimize erosion in the Southern Appalachians. *Proceedings.* Forestry and Water Quality: A Midsouth Symposium. Cooperative Extension Service, University of Arkansas. pp.141-151.

Taylor, S.E. and Murphy, G.L. 1992. Portable timber bridges designs for temporary forest roads. ASAE Technical Paper 92-4559. pp.23. ASAE, St. Joseph, MI.

Taylor, S.E., Ritter, M.A., Murphy, G.L., Keliher, K.P., and Thompson, J.D. 1995. Portable glulam timber bridge design for low volume forest roads. *Proceedings*. Sixth International Conference on Low-volume Roads. pp. 22. National Research Council-Transportation Research Board, Washington, D.C.

SAS^{TM} System for Windows^{TM} Release 6.12. 1996. SAS Institute Inc.. Cary, NC.

SPSS^{TM} 8.0 for Windows^{TM} . 1997. SPSS Inc.. Chicago, IL.

SPSS^{TM} Base 8.0. 1998. Application Guide. SPSS Inc.. Chicago, IL.

USDA, Forest Service, Northeastern Area. 1995. National Timber Bridge Initiative Accomplishments as of April 1995. Morgantown, West Virginia.

USDA, Forest Service, Northeastern Area. 1997. The Wood in Transportation Program: Fiscal Year 1997 Status Report. Morgantown, West Virginia.

Yang, J. and Lee, H. 1997. An AHP decision model for facility location selection. *Facilities* 15(9/10):241-254.