A Systems Analysis Approach to Economic Feasibility Analysis for Forest Products Utilization

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Abstract. — Systems analysis is often used in developing forest management plans and policies. This paper presents a conceptual framework for the systematic evaluation of forest product utilization technology in the context of the forest resource system. Emphasis is placed upon evaluating the economic feasibility of forest product utilization as a component of the forest resource management system.

This is a conceptual paper rather than a procedural paper. An expanded view of systems analysis is presented in an attempt to broaden thinking about what feasibility analysis means and how evaluation of forest products utilization might be improved—which is what system analysis is all about. The generalized view of systems analysis has been expressed by Casti (1987) as follows:

problems + tools + a world view = insight

Casti explains that an indispensable role is played by one’s scientific Weltanschauung or “world view” in determining the nature and degree of insight that can be gained about any problem. When translating a problem statement into a formal mathematical structure, the world view is represented by the type of formal mathematical system chosen to reflect the features of the problem. In turn, this mathematical world view dictates the questions that can be asked and the tools and techniques that can be used to seek insights and answers (fig. 1). Furthermore, I will explain that a formal mathematical model is not required in every case and that judgment and extra rational variables can be considered because systems analysis is usually a mixture of qualitative and quantitative analysis.

The primary purpose of this paper is to recognize that forest product utilization and forest resource management are inexplicably intertwined in the forest resource system. The forest resource system, a set of interacting variables, is part of a larger system that is the sum of human experience and defines the value of forest resources (Duerr et al. 1979). It is obvious that in order to manage forests economically, timber and other biomass removals must be converted into products that are marketable at a price higher than the cost of producing the products. To accomplish this, the removals generally go through some type of conversion process. This paper attempts to provide a conceptual basis for the development of these broad concepts. I begin by providing a discussion of general system concepts and methodology. Then, I present a conceptual application to the forestry sector.

System Analysis Concepts

There are probably as many definitions of systems analysis as there are systems analysts. The systems analysis concept presented here departs from previous system analysis literature in that a mathematical systems model does not have to be the central component of the problem solution. The central component of analysis may be quantitative, qualitative, or mixed, and it may be an expert person or a computer information system.

Methodological tools considered for systems analysis range from behavioral research into what exists, through values research into what is preferred, to normative research into what should be. Research efforts to demonstrate the three fundamental components of feasibility analysis—economic, technical, and socio-political—are difficult and ephemeral, either taken individually or considered together. Krone (1980) provides a statement of general system concepts that also reflects my view:
"A system is defined as a set of interacting elements. The systems approach provides understanding and comparisons within and between systems. Systems analysis is a set of techniques that are qualitative, quantitative, and mixed-deriving methodologies from the scientific method, systems philosophy, and branches of various scientific disciplines dealing with the phenomenon of choice. Systems analysis incorporates both explanatory and prescriptive methodologies."

A system is a collection or arrangement of entities or things related or connected such that they form a unity or whole. Some entities are retained in the system or are endogenous, while others are transient to it. Transient entities are generally input to the system and undergo some conversion process and, subsequently, output from the system. During the time they are in the system, they are part of the system. However, before and after they are in the system, they are external. Anything external is referred to as the system environment (Wetherbe 1984). The major benchmarks of the performance of a system are improvement of the quality of a system as evaluated and measured against standards consciously selected, and the feasibility and desirability of improvement or redesign possibilities. Systems analysis is a major instrument for this purpose.

Conceptualizing appropriate analysis models for complex problems is an essential macro tool of the systems analyst. This section provides conceptualization and structure for the identification and management of knowledge prerequisites for technology and transfer. The knowledge for systems applications can be classified into the following three categories:

1. Environmental knowledge is about the understanding, control, and direction of the environment. This knowledge falls predominantly into the physical and natural sciences.
2. Human knowledge is about the understanding, control, and direction of individuals, groups, and society. This knowledge falls predominantly into the social, behavioral, and life sciences.
3. Control knowledge is about the use and further development of knowledge within the first two categories.

PROBLEMS + TOOLS + A WORLD VIEW = INSIGHT

![Diagram of the systems view as related to formal mathematical structure.](image-url)
Quantitative Tools for Systems Analysis

Quantitative measurements allow us to organize knowledge, to compare results over time and space, to use mathematical methods to test hypotheses derived from scientific theory, to optimize system performance based upon alternative criteria, and to simulate present and future system output. It allows aggregation and manipulation of data in management information systems using more powerful and accessible computers.

Quantification allows reduction of the complexity to understandable levels for making decisions. It provides justification for stipulated system output. Through quantification we record events for later review, evaluation, comparison, and validation within the scientific method. We can design feedback mechanisms for control and decision making by quantifying reports, relationships, and events over time. Simulation is possible with quantification. This requires a structured, rational, and repeatable process, capable of sensitivity analysis by adjusting quantitative independent variables for analysis of alternative outcome arrays. Useful relationships can be observed through mathematical and statistically derived transfer functions. Quantification is necessary, although it is not sufficient to measure the efficiency, effectiveness, and quality of the systems. Systems analysis is impossible without some degree of quantification. The ability to abstract the physical and social world into quantifiable models has been a major contributor to scientific, technological, and social progress. In summary, we must quantify to understand or improve human systems.

An important aspect of the success of a modeling effort is the choice of the correct mathematical structure to represent the system under study. This surrogate system must be representative of the "real system" and of the problems to be solved by decision makers or managers in a realistic manner. It is convenient to represent the set of mathematical paradigms into four principal components (Casti 1987). These categories are operations research (OR), computer science (CS), control theory (CT), and systems theory (ST). These specific techniques can be further classified as deterministic or stochastic.

Operations research problems generally revolve around issues of planning, scheduling, and resource allocation. Methodologically, the techniques used are traditional OR tools: resource allocation, scheduling theory, inventory control, and decision analysis. Control theory, derived from aerospace and mechanical engineering problems in the 1960's, contains the concepts of system feedback, adaptive change, uncertainty, and complex hierarchy. Computer science has developed operating systems and new computer languages to be used to manage information and in conjunction with artificial intelligence or expert system techniques. These systems can also be used with OR or CT methods. Generally speaking, these models or tools are techniques of OR, CT, and CS. They start with a particular formal structure as listed in table 1 and analysts try to adapt problems to them. The basic problem revolves around how various applications can be addressed within the selected paradigm or technique.

System theory, on the other hand, differs in an important way from conventional operations research or management science methods. A systems theory world view focuses more upon paradigm construction than upon techniques and algorithms associated with a given framework. You start with the framework or point of view and explore how important concepts or issues might be addressed. The object of the systems view is to develop a set of techniques or paradigms that meet the objects of the system that may include some of the quantitative tools or methods in table 1. For example, Casti (1987) begins with the concepts of complexity, flexibility, self-repair, adaptability, self-regulation, reliability, resilience, and performance in his definition of the manufacturing process as a system. He then looks for an appropriate paradigm for the manufacturing system in a relational rather than structured way.

The indiscriminate and inappropriate use of quantitative tools has been greatly aided by the plethora of computer software that simplifies applying without necessarily implanting any understanding of underlying theoretical principles. As Wetherbe (1984) states:

"First it is important to understand the difference between theory and technique. Theory is really nothing more then the notion or ideas about how things work or the way things are. Techniques are just different methods or approaches to perform different tasks. Ideally techniques should be based upon theory...Someone who knows technique without theory is potentially a dangerous person...Anytime someone uses a particular technique without knowing the reason for the theory behind it, that person is apt to use the technique when it is inappropriate."

A common criticism of the educational process is that it tends to teach students how to do exercises rather than how to solve problems. For example, we teach students how to write a computer program, how to solve a mathematical equation, or
Table 1.—Quantitative models and techniques in systems analysis. Source: Krone (1980) and author’s interpretation.

<table>
<thead>
<tr>
<th>Model or technique</th>
<th>Application</th>
<th>Knowledge base</th>
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<tbody>
<tr>
<td><strong>Deterministic models</strong></td>
<td></td>
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<tr>
<td>Linear programming</td>
<td>Allocation, distribution, and optimization in business, transportation, inventory, construction, logistics, and networks</td>
<td>Computer science, sensitivity analysis, algebraic solutions, simplex tableau, and economics</td>
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<tr>
<td>Queuing theory</td>
<td>Waiting, services ratios and people, things, events</td>
<td>Monte Carlo, simulation, and statistics</td>
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<tr>
<td>Program management techniques</td>
<td>Production and construction planning</td>
<td>PERT (cost or time) GANTT charts, network analysis (CPM), and decision trees</td>
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<tr>
<td>Markov analysis economics</td>
<td>Marketing, sales, forecasting</td>
<td>Matrix algebra and economics</td>
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<tr>
<td>Conflict analysis</td>
<td>Business and psychology</td>
<td>Game theory</td>
</tr>
<tr>
<td>Quality assurance</td>
<td>Industry, defense</td>
<td>Technology and science</td>
</tr>
<tr>
<td>Cost/benefit</td>
<td>Resource allocation</td>
<td>Economics and statistics</td>
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<tr>
<td><strong>Probabilistic Models</strong></td>
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<tr>
<td>Dynamic programming</td>
<td>Multistage decision in production, allocation</td>
<td>Computer science and probability theory</td>
</tr>
<tr>
<td>Computersimulation</td>
<td>Systems interactions</td>
<td>Computer science and Monte Carlo</td>
</tr>
<tr>
<td>Probabilistic inventory models</td>
<td>Where demand and/or lead time are random</td>
<td>Probability theory and expected value statistics</td>
</tr>
<tr>
<td>Stochastic models</td>
<td>Computing probabilities of systems transition</td>
<td>Matrix algebra and calculus</td>
</tr>
<tr>
<td>Sampling, regression, and exponential smoothing</td>
<td>Problem solving with large populations</td>
<td>Statistics and probability theory</td>
</tr>
<tr>
<td>Bayes theorem</td>
<td>Forecasting underconditional probability and dependence, causal analysis</td>
<td>Algebra, probability theory, and knowledge of prior probabilities</td>
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<tr>
<td>Cost and benefit analysis</td>
<td>Resource allocation</td>
<td>Economics and statistics</td>
</tr>
<tr>
<td>Fault tree analysis</td>
<td>Systems behavior</td>
<td>Algebra and statistics</td>
</tr>
<tr>
<td>Artificial intelligence and expert system</td>
<td>Systems management</td>
<td>Computer science and cognitive science</td>
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1 Models that are applicable to problems where there is only one state of the world assumed and where variables, constraints, and alternatives are, after acceptable assumptions, known, definable, finite, and predictable with statistical confidence.
how to do a financial analysis. The students, however, often do not know when it is appropriate to apply these techniques. This is similar to the story of the student who is taught how to use a screwdriver—the screwdriver being symbolic of a technique such as computer programming, linear programming, or net-present-value analysis. Upon being employed, the student is excited about applying the screwdriver to screws that need to be tightened. The new employee goes about the organization looking for screws to tighten and tightens them. Eventually, however, there are no screws left to be tightened. Looking for new opportunities to apply the skill of using a screwdriver, the employee gets out a hacksaw and starts filing slots into the heads of nails. As silly as this story may seem, it is unfortunately representative of applying inappropriate techniques to the solution of a problem.

Quantitative tools and techniques reduce uncertainty and provide valuable optimization techniques for decision makers. However, only limited application has been found in research and development management in large corporations because of data limitations and mistrust of autonomous optimization algorithms (Twiss 1980). As important as quantification is to removing uncertainty and guiding management decisions, the art of quantitative systems analysis still lies in the analysts' and removing uncertainty and guiding management decisions, the ability of the analyst to judge which uncertainties are being removed advantageously and, conversely, which ones fit the Procrustean metaphor. Correctly applying quantification will usually make the difference in whether system goals are met. Krone (1980) presents a summary of potential pitfalls in the use of quantitative techniques in table 2.

Qualitative Analysis and Expert Judgment

Well defined and documented quantitative analysis is the preferred method of analysis and problem solution. However, this limits the appropriate set of problems to which these techniques will work, and the smart analyst or scientist will avoid those that do not fit the assumptions or algorithms (e.g., the so-called fuzzy systems). Conclusions drawn in the absence of quantitative measurement will have doubtful validity. On the other hand, action taken solely on the basis of quantifiable variables can lead to inappropriate, wasteful, noneffective, or undesirable results (Krone 1980). Fortunately, the choice is not an either or one, but one of sensible use of both quantitative and qualitative tools in an intelligent manner to enlighten decision makers rather than to obfuscate the problem. The central component of the analysis may be quantitative, qualitative, or most likely a mixture of the two. As Krone states:

"The object of including explicit qualitative methodologies is to provide analysts and decision makers with a rational means for the inclusion of those qualitative and often extra rational--variables in the analysis. The problem for the analysts is not whether those qualitative variables do exist in human systems. They do exist. The problem is how to rationally consider those variables on the assumption that the alternative is for them to remain implicit and unanalyzed, while they continue to move systems toward quality improvement or deterioration. If their influence is toward improvement, we would like to know more about the functioning of those variables so the process can be continued, expanded, and duplicated in other systems. If the influence is toward deterioration, we want a capability for identification, evaluation, and rectification before system failure becomes irreversible. We cannot cure an unknown system pathology. One lesson of the 20th century is that hidden pathologies tend toward system breakdowns rather than self-amelioration."

The idea here is to determine quality as measured against some standard that is measurable and can be explicated. The methodology is conceptually very simple but operationally

Table 2—Some pitfalls in the use of quantitative models and techniques. Source: Krone (1980) and author's Interpretation.

<table>
<thead>
<tr>
<th>Pitfall</th>
<th>Description</th>
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<tbody>
<tr>
<td>Adapting the problem and the real world to fit the formula (the Procrustean metaphor).</td>
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<tr>
<td>Model reification (fascination and preoccupation with details of the model, while being overcome by events in the real world—&quot;seeing the trees and not the forests&quot;).</td>
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<tr>
<td>Ignoring the axiom of &quot;appropriate methods for unique problems.&quot;</td>
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<td>Overconfidence and oversell.</td>
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<tr>
<td>Oversophisticated models and techniques requiring non cost and benefit allocation of resources.</td>
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<tr>
<td>Using the wrong model for the problem.</td>
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<tr>
<td>Using the right model incorrectly.</td>
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<tr>
<td>Tautological solutions (those highly sensitive to the statement of the problem and methodology employed).</td>
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<tr>
<td>Making a Butch (Herman Kahn's &quot;completely mistaken technical notion or fact&quot;).</td>
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<tr>
<td>Interest in only the worth (economic utility) of the outcome and not the values of the system.</td>
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<tr>
<td>De-emphasis or ignorance of qualitative or extra rational components because of relying on mathematics and associated rational models of policy making.</td>
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<tr>
<td>Overuse of technical or mathematical language, thus failing to communicate.</td>
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"A classic cross-cultural Butch was the translation of President Carter's welcoming statement in Warsaw, Poland, in 1977 from "I have a desire for peace" into "I lust for Poles."
often complex. The theoretical process involves two steps: (1) determine the quality using criteria and (2) judge that quality by comparison with standards. One important way to incorporate subjective or tacit knowledge in a system is by cognitive science using expert systems (Cleaves et al. 1987). Farnum and Lembursky (1987) found that by incorporating managerial judgment into a large simulation system that they called "this system of manual optimization," there was a better understanding of the process by management decision makers and a more realistic definition of problem objective functions and constraints.

The primary criterion is the dependent variable, stated in overall terms, for determining quality of a system in evaluation. The total net desired output is determined by it. It is not usually easy to measure, therefore, this requires the establishment of secondary criteria that are subcomponents of a system chosen for evaluation because they are correlated with and more measurable than the primary criterion. The secondary criteria become independent variables to shape the quality of the net output. They are components of input such as people, raw materials, structure, process, or output for evaluation. The primary criteria are organizational effectiveness, goals, or strategies.

Take care in choosing secondary criteria so that what you select is not just convenient to measure and that the resulting numbers fit conveniently into mathematical or economic formulas or into computer programs. There are always alternative standards to measure the quality and whether the primary goals of a system are met. Standards may be derived from both rational and extra rational variables. It is usually better to explicitly include extra rational components in the system whenever possible, because it is analytically useful to consider whether they are positive, neutral, or negative in the performance of the primary system objective. This brings us to the concept of systems leverage, which accounts for the fact that small improvements in one or more components can have significant leverage effects but in opposite directions. This is why the selection and continued review of secondary criteria for evaluation are important to the success of an enterprise. For example, if the lack of effective marketing of products produced is a limiting factor of profitability of an enterprise, a marketing initiative may be needed. Similarly, research on new residential building systems may not be effective because of restrictive building codes, lack of financing by mortgage companies, and consumer preferences for traditional housing.

Feasibility Analysis

There are two main tasks for our conceptual approach to feasibility analysis. First, to design the overall system in which the feasibility analysis subsystem is embedded, and second, to define the particular systems framework for feasibility evaluation. To place our analysis in the proper perspective, we will look at methodological considerations.

There are three fundamental and interrelated categories of research methodologies for systems analysis: (1) behavior research, (2) value research, and (3) normative research. There are also three basic categories of feasibility: (1) economic, (2) technical, and (3) socio-political. These categories of research and feasibility analysis are all interrelated in determining the system design and subsequent problem statement. Economic feasibility is the probability that economic resources are available to meet the goals of the system. Within economic feasibility analysis, it may be important to conduct a marketing feasibility study. Also included are the economical development of resources and the economic assessment of conversion processes that can efficiently produce products that are acceptable to the consumer. Technological feasibility is the probability that the scientific and technical development goals of the system are met. Socio-political feasibility is the probability that the policy or technological alternative will be acceptable to the user, decision maker, or society.

Feasibility of the conversion process, in the context of the overall resource system, is the principal concern of this paper. The economic feasibility of resource conversion is the particular subsystem that I will examine. Economic feasibility is related to technical and socio-political feasibility as well. The three feasibilities are mutually supportive even though they may use data from different sources. Economic feasibility has a great deal to do with the status of technology; technology is partially dependent upon budgets for research. Political feasibility may be determined by professional technological or economic feasibility studies. Care must be taken to consider this interdependence when conducting feasibility analysis. Economic feasibility will also interface with the available resource system and the market and consumption systems.

There are several steps in the economic feasibility analysis. The first is assessment of a need, the second is project definition, and the third is project evaluation. The first step is to identify the need to be met by the project and then to define the system goals for the project. For example, economic development may be a system goal. Utilization of a surplus forest resource, such as eastern hardwoods, may be another type of goal. The establishment of need, such as the ability to compete economically or establishing community stability through resource development, can then be translated into specific goals of greater utilization of northern hardwoods in the United States. This goal then needs to be made operational by the establishment of criteria for evaluation and measurement.

The appraisal criterion is then an important factor in determining the type of project selected for feasibility evaluation. The following criteria may be required for project evaluation: (1) organization objectives, policies, and values; (2) market needs, consumer acceptance, and marketing; (3) research and development; (4) financial; (5) production or process; (6) environmental or ecological; and (7) social and political acceptance. Note that net output can be misleading as a criterion because it measures the wrong thing. For example, if return on investment over time is allowed to become the primary criterion of a
business organization as opposed to a broader criterion of organization health and productivity, a secondary-to-primary criterion transformation has taken place that could be costly, risky, or even fatal (Kron 1980). A similar problem can exist when return on investment is used as the primary criterion to justify environmentally unwise projects in some developing countries. As Gold (1988) states:

"The most common approach to evaluating prospective technological innovations involves two steps: evaluating their expected cost savings and revenue increase relative to current capabilities; then comparing resulting gains (discounted to determine their present net value) with their investment requirements, i.e., the usual capital budgeting approach. But this essentially is the wrong criteria.

"After all, the basic objective in adopting major technological innovations which embody significant investment for many years must be to safeguard or improve a firm's competitiveness over an extended future."

"For a public enterprise the main goal is to provide benefits for the nation and to improve the national efficiency," to quote Gifford Pinchot. To do this all the components of the system under study must be scrutinized. This includes all the inputs to the conversion process over time.

According to Clifton and Fyffe (1977), a complete study of project feasibility includes: (1) market analysis, (2) technical evaluation, (3) a financial analysis, and, if needed. (4) a social profitability analysis. The market analysis involves the search for an analysis of data that can be used to identify, isolate, describe, and quantify the market. This study can be used to identify user needs. A market study generally should contain: (1) a brief description of the market, (2) an analysis of past and present demand, (3) an analysis of past and present supply, (4) estimates of future demand for the product, and (5) estimates of market share both domestic and foreign.

Technical analysis serves to establish whether or not a project is technically feasible or what research needs to be accomplished to make it so. It also provides a basis for cost estimating. The technical analysis should contain a review of techniques or processes to be applied and include: (1) description of the product, (2) description of selected or desired manufacturing process, (3) determination of plant size and schedule, (4) a study of available raw materials, (5) an estimate of labor requirement, (6) a plant location study, environmental costs, and (7) estimates of production cost for product.

Financial analysis concentrates on determining whether a project is profitable from a commercial standpoint or whether a project achieves a minimum threshold rate of return and on the amount of capital required to implement it. Information from the market and technical analysis is used to determine financial measures. A sensitivity analysis or risk analysis may also be conducted. For new projects an estimate of total project costs, capital requirements, and cash flow is desirable. An analysis of rate of return on investment and price sensitivity is also needed. A sensitivity analysis and risk analysis may be made to identify items that have a large impact on profitability.

Finally, a social profitability analysis may be performed if there is public involvement or there are established national priorities. The social profitability analysis is an evaluation of the contribution of the projects to the economy. This includes the evaluation of the project toward meeting goals such as increasing employment or net foreign exchange benefits. This may include goals of increasing markets for wood products or improving national competitiveness. Generally, some cost-benefit analysis is used in conjunction with these social objectives.

The Forest Resource System

This paper concentrates on the relationship of forest product utilization technology to the analysis of economic feasibility of forest product development that in turn is related to forest resource management. The concept of the forest as a system as explicated by Duerr et al. (1979) is useful here. They state: "A major aim is to focus the work upon integrated forestry: the creation and use of all forest values from scenery to wood. We have tried to see forestry as a system of interacting variables and also as a part of a larger social system that in the final analysis is the sum of human experience. Another aim is to view forestry not as a set of rules, but as a set of resource alternatives. Still another is to demonstrate how modern quantitative methods of generating information can fortify judgement in choosing among resource alternatives."

Thus, the forest can be viewed as a social-biological-engineering system. We can also define three major components of the overall forest resource system: the timber-output system, the technologically defined conversion system, and the marketplace where the consumption interface occurs. The forest resource system is dynamic, that is, it changes continuously through time in many dimensions—biological, technological, economic, socio-political—that are changed by humans through management activities. Most systems analysis studies in forest resources concentrate on the timber-output system. This system usually has four subsectors: timber inventory, timber growth, timber management, and timber removal. This is the major part of the timber resource system from the foresters viewpoint. However, from an overall system analysis viewpoint the other components, the forest product conversion system and the market and consumption interface are also important as are the interactions between the subsystems through time.

This paper concentrates on the forest product conversion system in the context of the overall forest resource system. The conversion process for forest resources is part of the overall forest resource system (Bethel and Schreuder 1976). The material supply operation is a function of the match between the
resource and the conversion and marketing system available to the resource. If the material being recovered is very valuable (e.g., gold, platinum, or silver), a relatively inefficient materials recovery system involving large expenditures of capital, energy, and labor per unit of material output may be economically feasible (Bethel 1980). Though it is not always recognized, a similar situation exists with forests. The total biomass of the forest is available for utilization at a cost. This includes trees, stems, branches, and even stumps and roots. Trees too small, crooked, or of the wrong species are also available. Mill residues, such as bark, slabs, edgings, trimmings, core, clippings, and round up, are also available at the conversion stage. According to Bethel, a utilization efficiency can be defined for a wood material supply system as the mass of material produced by the system as a fraction of the total stem biomass of the forest. Analogous to the metal materials supply system, a forest-based system can have low efficiency for high-valued materials like black walnut, mahogany, or rosewood. But, the efficiency must be much higher for low-market value material if it is to be economically feasible.

The forest-based materials supply is biologically renewable and therefore can change through time. Manipulation of the forest on the one hand and the manufacturing facilities on the other hand permit progressive improvements in utilization efficiency. A large simulation model was developed by Farnum and Lembersky (1987) for Weyerhaeuser Corp. that illustrates the interrelation between timber and conversion technology. The model was used to derive normative timber management strategies for future plantation based upon alternative growth and mill conversion assumptions. The model had four modules: biological growth and yield, harvesting and handling cost and productivities, mill conversion recoveries and values, and financial returns. A combination of an approach using judgment based on managerial experience was used rather than strict mathematics to develop a system of manual optimization. Using this system, they showed how advanced sawmill technology using small logs would provide a superior alternative to the conventional utilization and management systems.

These opportunities for change in the system permit reaction to changes in market preferences and conversion technology. Changes in the forest-based material supply system occur slowly over long time periods and generally require considerable expense. Bethel (1980) cites an example of such a system applied to tropical hardwoods. It includes a reference material system (RMS) as the integrating and synthesizing component (Bhaget and Hoffman 1980).

This illustrates the systems analysis approach to economic feasibility analysis for forest products utilization. With the use of process conversion models and proper data, the forest materials supply system can be evaluated in terms of utilization efficiencies. The results can be portrayed in the form of RMS. In a similar way, the flow of capital, energy, and labor can be evaluated through the material production system. Environmental considerations can be considered as constraints on the system.

Technology changes occur over longer periods of time. These technological changes influence wood utilization efficiencies. The rate of technological change can be effected by forest products research efforts. Therefore, technological change and research components are also included in the concept of systems analysis through time or a dynamic systems analysis.

The Forest Utilization System

The conversion or manufacturing process can be viewed as a system-determined science (Casti 1987). The conversion process is a multifaceted system that can be viewed from a number of perspectives of the overall process. The conversion process system can be expressed in a hierarchical fashion with raw materials being the lowest level and values the highest. What determines a systems problem in manufacturing is the relative emphasis upon issues of process and function, grounded in constraints from the natural resources, requiring a knowledge of several disciplines.

The concept of process implies that all of the inputs to the conversion process should be considered for change. A new machine or a method of organization that reduces the cost of production and thereby increases the efficiency of producing an existing product is just as important as development of a new product. The weakness in process technology in the United States has been pointed out by Thurow (1987).

The conversion process in forest products is typically product orientated. The customers or end users are not generally considered in this mold. Marketing considerations for customers holds that products are not an end in themselves but merely the means to satisfy the customers needs or desires. Feasibility analysis begins with the determination of research studies to satisfy identifiable human needs. This considers the process as being the conversion of scientific knowledge directly into the satisfaction of customer need in the market and consumption interface. The product then becomes merely the carrier of the technology and the form is only defined after the technology and the need have been clearly matched. Similarly, available forest resources should guide technological feasibility for particular regions.

Conclusion

The production of timber products generally leads to preoccupation with things rather than the concept of process. Forest industry is perceived as a process that converts raw materials from the forest into products, which in turn are converted into money by selling to customers who are willing to pay more for these goods than it costs to produces them. The margin between the price paid and the cost to produce yields is the profit that can be reinvested to sustain growth of the industry and provide wealth to shareholders directly and to society indirectly.
Most analysis and planning systems are resource driven. The viewpoint of this paper is that they should be driven by market and consumption systems and the technology and conversion systems, which may be a constraining factor and can be changed by research or technical development. The resource system is also modified by cultural activities, environmental change, and other biological factors. Capital investment and prospective future investment are also important factors. Existing establishments tend to want to prolong the status quo and maintain vested interests. What is needed is an outside look that utilizes available resources and ideas (Drucker 1988).

Business-driven resource decisions are viewed as generally preferred to those based only on timber-output system decisions. Better yet are ones in which the biological and resources system interfaces with a market and consumption system and a conversion and technology system. A good example of business-driven strategy is the development of the composite panel products, like waferboard utilizing aspen that was a surplus resource and was inexpensive to grow in the Midwest. High-cost plantations of red pine might have been the conventional resource manager’s alternative for forest development in the 1950’s. Systems analysis provides a way to look at forest resource management and development and broaden the perspective of the management decision making when looking at factors other than the resource base.

**Literature Cited**


