

Optimizing Weyerhaeuser's Renewable Resources



Weyerhaeuser Company is an enterprise that is actively engaged in all stages of the forest products business, from growing trees to building homes. The company was founded in 1900 and has grown to be a Fortune 100 company and a premier participant in the forest products industry. In 2006, Weyerhaeuser had grown to a company with \$22 billion in sales, operating in five countries, owning more than six million acres of timberlands and actively managing an additional 30 million acres. Weyerhaeuser's global operations are headquartered in Federal Way, Wash.

Corporate Structure and Operations Research

THE COMPANY operates in six business segments:

- Timberlands, which includes logs, chips and timber;
- iLevel (building products), which includes softwood lumber, plywood, veneer, composite panels, oriented strand board, hardwood lumber, engineered lumber, raw materials and building materials distribution;
- Cellulose Fiber, which includes pulp, paper and liquid packaging board;
- Containerboard, Packaging and Recycling;
- Real Estate; and
- International.

Supporting these segments are enabling staff groups including information technology, finance, transportation, purchasing and research.

In the early 1960s, George H. Weyerhaeuser retained a public accounting firm to evaluate the benefits of a more scientific approach

to managing the company's business. The report found significant opportunities in the area of raw material allocation (which trees should flow to which mills), transportation and production planning.

Mr. Weyerhaeuser agreed with the findings, and in 1962 established a corporate operations research group. This group, which included engineers, programmers, systems analysts and O.R. analysts, initiated the structure and analyses for addressing questions such as:

- What is a log worth?
- How should logs be allocated from forest to mills?
- How should a roll of paper from a paper machine (up to 20 feet in length) be cut into shorter marketable rolls to minimize trim loss?
- Are there better ways of making plywood panels?

Organizational changes in the early 1970s resulted in this group being disbanded in 1972. One reason for this was the severe mismatch between the promise of recent conceptual advances and the reality of the limited computing resources of the time. For the next several years, operations research as a function languished. Fortunately, many of those who were a part of the original O.R. group were redeployed to other parts of the company and subsequently were supporters of O.R. activities that emerged in the late 1970s. In 1978, the research organization recruited a number of employees with an O.R. background. During the next decade, O.R. applications flourished. One of the projects was the basis for the winning entry in the 1985 Edelman Prize competition.

Today, the Statistics Mathematics and Operations Research (SMOR) unit at Weyerhaeuser has 16 professionals, six of whom are fully dedicated to O.R. projects. Additionally, a number of individuals throughout the company have strong O.R. skills. These serve as a part of the network that enables an O.R. application to move from concept to implementation.

O.R. Applications at Weyerhaeuser

OVER THE PAST 45 YEARS a wide range of O.R. applications have been designed, crafted and deployed. They range from extremely long-range strategic models of forests that span many decades to real-time models that provide operational solutions in less than a second. A few of these are described below to give an overview of the hierarchical nature of Weyerhaeuser's O.R. applications.

Forest Planning Systems

Long-range forest planning. Weyerhaeuser forests are managed as sustainable resources, supplying raw material for nearly 300 converting facilities. As a vertically integrated business, Weyerhaeuser

All About the Roundtable

INFORMS has two types of members: individual and institutional. The latter (usually a company) joins by joining the INFORMS Roundtable and appointing as its representative the person in overall charge of O.R.

The Roundtable has been very active since its founding in 1982, with three meetings each year and much communication in between. It, its member institutions and its member representatives take a strong interest in how INFORMS serves the needs of practitioners, and have undertaken many initiatives and provided many services toward this end. These involve, for example, public awareness of O.R., both of the annual INFORMS conferences, continuing professional education, one of the prizes and various committees.

In addition, the Roundtable has an advisory responsibility to INFORMS. One bylaw states that it "... shall regularly share with INFORMS leadership its views, its suggested initiatives and its implementation plans on the important problems and opportunities facing operations research and the management sciences as a profession and on the ways in which INFORMS can deal proactively with those problems and opportunities ..." By tradition, it meets with the newly elected INFORMS president-elect each spring to discuss practice-related topics of interest to him or her, and with the entire INFORMS Board each fall to discuss topics of mutual concern.

The Roundtable membership comprises about 50 organizations. Further information is available at <http://roundtable.informs.org>.

This series of articles aims to share with the INFORMS membership at large some information and insights into how O.R. is carried on in practice today.

uses O.R.-based tools for each aspect of the timberlands management cycle from soil preparation to planting to management to final harvest. Long-range forest planning considers the many decisions involved in macro-level forestland management. The planning horizon can be as long as two rotations of the forestlands. A rotation is the cycle from planting through final harvest to replanting.

Depending upon the species, the duration of a rotation can be as short as 20 years to as long as a century. Most decisions pertain to timing of forest treatments such as when should a tract be fertilized, thinned, pruned and ultimately harvested? Constraints here include developing a harvest plan that generates a uniform flow of harvestable trees from year to year, while also respecting considerations for wildlife, streams, roads and governmental requirements.

Since production forestry is farming on a larger time scale, weather can have notable impacts. Hurricane Katrina is a recent example. In addition to the huge human toll, it also caused significant damage to a portion of our southern timberlands. Our O.R.-based long-range harvest planning system was essential to the process of reassessing this disruption and formulating new plans.

Geographic planning system. Within Weyerhaeuser, the midterm is defined as the first 10 to 15 years of the long-range plan. In this time span, the harvest plans from the long-term planning system are evaluated more closely in terms of converting facilities, products, transportation and markets. At this level, separate more detailed models are developed for most major geographic areas. These systems are based

upon linear and mixed integer problem formulations that support exploration of opportunities in the midterm as a part of the company-wide investment decision setting (IDS) process. In addition to supporting IDS, these models aid business assessments of near-term (1-2 years) opportunities in facilities, markets and forestlands.



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Operational harvest planning. The next level of detail involves operational harvest planning. In this phase, specific tracts of timber are identified for harvest, establishing material flows to production facilities. Again, linear programming models support the business analysts as they formulate final harvest plans.

Converting Trees to Products

A TREE has the potential to be converted into a wide array of products. The process of converting it to products involves a series of irreversible decisions. O.R. tools are embedded at the core of the conversion processes. Two examples associated with lumber manufacturing are stem merchandising and log breakdown.

Stem merchandising. Merchandising in the forest products business is the process of cutting a truck length portion (long log) of a tree into shorter sections (logs) for processing in mills. As trees are delivered to our mills, the discovery process continues. Like snowflakes, each long log is different from all others; possessing different taper, sweep (crookedness) and cross-sectional attributes. In most mills, each long log is scanned for diameter, length and, in some cases, for internal defects. Metal items such as bullets and fencing materials can be embedded in a tree.

Assuming the tree has no metallic defect(s), the scanned image of the stem is analyzed via a series of O.R. algorithms to determine the best set of logs to cut from the stem – a process called bucking. At this stage of the process, things happen quite quickly. A stem is scanned, an optimal decision is made and communicated to an operator, and the bucking decisions executed in less than 15 seconds. The bucking solution produces a set of stem segments, called logs, which are available for further processing.

Log breakdown. As a log enters a mill it is again scanned with an even finer level of resolution. The current state of scanning provides more than 100 points around its circumference at three-inch intervals down the log. Current computing capabilities enable this scanned image to be solved for the optimal set of lumber products in less than a quarter of a second. As the individual pieces flow through the mill, they pass through further scanning and optimizing processes.

The above described optimization processes support the path to manufacturing lumber products. This is but one of several paths that can be followed in the process of converting a tree into products. The stem merchandising and log breakdown applications have provided annual benefits of approximately \$20 million for the past 20 years.

Other manufacturing applications. The lumber path was described because it is one of the early processes in which O.R. was applied. Other manufacturing applications use O.R. tools to address cutting stock problems, bottleneck analyses, decision analyses and capacity planning.

Other business processes. Transportation has been another fertile area for the beneficial application of O.R. techniques. Our recycling business handles about 25 percent of the old corrugated containers (OCC) in the United States, transporting this material from major metropolitan areas to a series of mills. Several years ago, Willamette Industries was merged with Weyerhaeuser. Both companies were active in recycling, and it became immediately clear that the transportation plans for the combined system were woefully inefficient. A linear programming model of the combined system was

quickly developed, providing significant cost savings. Other models have been developed to optimize our flatbed trucking activities.

Implementing O.R. at Weyerhaeuser

HOW DO THESE projects happen? The SMOR unit functions as internal consultants, operating on a break-even basis with the goal of billing revenue matching costs. In a typical year, the unit initiates new projects that realize annual benefits ranging from five to 10 times the annual cost of the unit. Additionally, there are other projects which are deemed to be beneficial, but whose financial contributions are more difficult to quantify.

Most of our projects result from referrals within the corporation. The O.R. analysts are well known by one or more senior managers, with projects flowing fairly regularly from these contacts. Typical O.R. projects are initially envisioned by someone within a business working with an O.R. analyst. Occasionally, a candidate O.R. project is viewed as desirable, but risky, from the business perspective. If the O.R. analyst believes the risk to be modest, we will initiate the project from an internal pool of funds. This pool is available to develop a quick prototype. In most situations, the prototype is sufficient to demonstrate the project's capability to succeed. From this point, the project is supported by the business client.

Over the years, our most successful applications have been in organizations that have one or more business managers who have had some exposure to optimization during their collegiate experience. Frequently these exposures have been obtained during an MBA program. The other part of the equation is the O.R. analyst.

Within the profession, it is easy to view an O.R. analyst as one who has mastered a set of O.R. skills. Our experience finds this to be only a part of the O.R. analyst's tool set. The rest of the tool set necessary to make an O.R. analyst effective include 1) a knack for actively hearing and understanding the user's problem, 2) an excellent set of software skills, 3) strong interpersonal skills at many organizational levels, 4) an ability to work as a team member, 5) a capability to quickly sort out the significant from the insignificant, and 6) a nose for where an O.R. application can provide significant benefit.

As we look forward, the quantity and quality of operational and business data continues to improve. We see computing capabilities continuing to rise according to Moore's law. The ability to deliver effective, even evocative visual solutions is improving rapidly. The business schools are giving students an appreciation of the potentials of O.R. New and more powerful O.R. techniques are being discovered.

These are very encouraging trends from an O.R. analyst's perspective. In addition to improving the way we currently do business, these trends point to a future in which many of today's intractable problems will first become possible and then become routine. The need to quickly develop complex applications will continue to accelerate. Meeting these evolving needs is the challenge of the O.R. community at Weyerhaeuser. Successful OR/MS applications will lead to continuing benefits to Weyerhaeuser, our forests, our customers and our planet – and we find that's pretty good motivation. **ORMS**

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