MANAGING PULP MILL FIBER COSTS
IN AN INTEGRATED WOOD PRODUCTS ENTERPRISE

Ralph E. Colberg 1/

ABSTRACT

In a typical Southern Pine pulp mill, wood costs can be as much as sixty percent of the total cost for manufacturing slush pulp. As a result, measures that reduce wood fiber costs can have a greater impact on profit performance than almost anything that can be done in the mill itself.

But wood procurement is a complex enterprise. Roundwood and chips, supplied by numerous contractors spread over a sizable geographic area, must somehow flow to the mill at measured rates sufficient to maintain balanced inventory levels. All of this occurs in an operating environment easily disrupted by the unexpected.

Many wood procurement managers have been conditioned to believe that a fiber supply shortage is somehow equivalent to committing professional suicide. With this in mind, the prudent manager will structure a wood supply network that is virtually fail-safe. But this in insurance, and insurance costs money. We can easily incur a million dollar annual premium to protect ourselves against a hundred-thousand dollar risk that might occur at five to ten year intervals.

This paper describes the quantitative procedures that were used in the Mead Corporation when senior management made a firm commitment to a wood cost reduction program -- to accept some greater risk, but reduce the annual insurance premium.

The US pulp and paper industry has recently been through some tough times. Perhaps we were lulled in the belief that we were the "wood basket" of the world, and as a result didn't worry a great deal about our long term competitive position. For years we had grown our trees, made our pulp, and with few exceptions had sold our finished goods at prices that were profitable. But all of this complacency was shattered early in this decade when we found ourselves in the unfortunate position of not being able to compete with overseas manufacturers. A dollar that was overpriced relative to other currencies was certainly an underlying cause. The dollar has since fallen, and as a result our fortunes have improved. But is this a permanent cure, or have we merely treated the symptoms while the underlying disease remains unchecked.

I can't speak for others in this industry, but I can tell you that recent economic events taught Mead a valuable lesson. Now, more than ever, we

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appreciate our role as but one of many players in a world market. If we are
going to successfully compete for overseas sales, or hold our own in domestic
markets, then we must be a cost effective producer on a world-wide scale. We
can do little to influence foreign exchange rates, or similar exogenous forces
that to some extent control our financial destiny. We can, however, exercise
greater control over those internal elements that determine our own costs and
manufacturing efficiencies.

**BACKGROUND**

Wood fiber purchases are often the largest single expenditure in pulp
manufacturing. In a typical Southern Pine mill, wood costs can be as much as
sixty percent of the total cost for producing slab pulp. As a result,
industrial foresters who are responsible for wood procurement can have more
impact on profit performance than almost anything that can be done in the mill
itself.

One would think that some thirty years in this industry would be
sufficient to insulate me from the unexpected, yet I'm still bewildered when I
see the wood cost issue neglected at many mill locations. I don't mean to
imply that these costs are not a major concern, but rather that so little is
done to fully understand or control them. It's almost as though there is a
wall at the mill gate that somehow blocks communications between mill manage-
ment and woodlands. You can't see it, and you can't touch it, but its
presence is manifest in the way people view their responsibilities.

Manufacturing experience is the path to senior management in virtually
all forest products firms. By virtue of his background and experience, the
typical mill manager will focus his attention on mill issues. His perspective
tends to be limited to events that occur downstream from the woodyard gate,
and his exposure to woodlands is probably limited to weekly or monthly cost
meetings. While he is concerned about wood costs, he knows little about wood
procurement and will probably accept what he is told. He may occasionally
rattle the woodlands cage, but this lasts only until the next major mill
crisis occurs. In general, he trusts his wood procurement manager, and he
assumes that the job is being done in a responsible manner.

The wood procurement manager, on the other hand, is concerned with the
flow of wood fiber to the mill gate. His is a difficult task. Roundwood and
chips, supplied by numerous contractors spread over a sizable geographic area,
must somehow flow to the mill at measured rates sufficient to maintain
balanced inventory levels. All of this occurs in an operating environment
easily disrupted by unexpected events that appear almost random in nature.
Competitors, strikes, or weather that is too good or too bad can all disrupt
his plans. Is it any wonder that there is a smile on his otherwise somber
face only at that moment when the inventory passes from too little to too
much.

It's not widely known, but when Moses came down from the mountain he
apparently had with him a third stone tablet etched with a little known
eleventh commandment. The truth in all of this is lost in a clouded history,
but oral tradition tells us that deeply emblazoned in scorched letters were
the words "Thou shalt not suffer a wood supply shortage." Perhaps it's all a
myth, but whether by dictate, experience, or observation, the typical wood
procurement manager has been conditioned to believe that a fiber supply short-
age is somehow equivalent to a cardinal sin. With this in mind, the prudent
manager will structure a wood supply network that is virtually fail-safe.
Numerous remote woodyards, satellite chipmills, and perhaps a sawmill or two
will all serve as "safety valves" to help regulate wood fiber flows. But this
is insurance, and insurance costs money. We can easily incur a million dollar
annual premium to protect ourselves against a hundred-thousand dollar risk
that might occur at five to ten year intervals.

These brief introductory remarks are my attempt to describe a widespread
organizational structure that in many firms hampers any attempt to control
wood costs. On the one hand, there is senior management with "bottom line"
responsibilities for overall operations. On the other, a woodlands group
responsible for supplying wood fiber at minimum cost, but also responding to
a conflicting security goal. The latter is seldom recognized as a specific
objective, but instead becomes accepted as part of the cost of doing business.
The net effect is that supply security often serves to undermine cost control
measures. The issue is further clouded by the use of transfer prices and
budgeting methods that mask the real cost of wood deliveries.

THE MEAD EXPERIENCE

The recession of 1982 caught Mead at an inappropriate time. We had
recently committed capital for major expansions at Escanaba, Chillicothe, and
our Northwood affiliate. A loss of sales, coupled with sizable capital
expenditures, placed us in a perilous position. Mead experienced one of the
worst years in its long history, and at one time our stock had plummeted to
the point where the entire company could have been acquired for a price that
was less than it would have cost to build a new greenfield mill.

With our corporate survival at stake, Mead responded in an aggressive
manner. Those costs that could be controlled were cut to bare-bones levels.
Nothing was sacred, including raw materials. Fortunately, Mead corporate
woodlands had been looking more closely at wood costs for the previous two
years, and had caught management's attention with a number of recommendations
that represented sizable savings at our Chillicothe mill. We therefore were
given almost "carte blanch" permission to explore opportunities for wood cost
savings at all of our mill locations.

Mead's Wood Procurement Planning Model

In the next few minutes, I'll briefly describe a Mead developed model
that is now used to evaluate opportunities for reducing wood costs. The model
has been implemented and used at a number of mill locations. What I will
describe is a general structure, containing a cross section of most of the
various formulation techniques.

To the best of my knowledge, Mead was among the first to attempt building
a detailed model of the wood procurement function. Others had developed what
were basically accounting applications, but we were more interested in a tool
that could be used to evaluate "what if" type questions. Linear programming
was selected as a suitable analytical framework, largely because of the
powerful micro-economic data provided by an LP solution. While a simulation
model might be a logical alternative, these do not provide the incremental

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values that we consider important guidelines for determining where the wood supply system should be changed. These values are especially useful in an integrated wood procurement network where chips from captive wood products facilities are an important component. The usual accounting methods, using arbitrary transfer prices, simply do not measure the "true" worth of these chips.

Our Southern mills were selected as the first locations for study. These mills are located in one of the nation's most competitive wood baskets, and if wood costs could be reduced here, than surely we could do so at other Mead locations as well.

Figure I is a schematic showing the structural elements in a typical formulation. The model simulates interrelated timber harvest and wood fiber purchase activities for a single planning period. It is used to develop short-term wood procurement strategies. Other models are used to investigate longer-term issues spanning multiple planning periods.

The model is structured in four major sections that represent fiber flows from stump to mill woodyard: timber harvests, timber allocations, purchased wood, and wood products manufacturing. In addition, there is a fifth financial section that accumulates the net cash cost for all wood fiber deliveries.

Timber harvest activities represent the largest of the four sections. Available stumpage is divided into two components: Mead-owned land, and open-market supplies. Captive supplies are the planned cut from company-owned or controlled lands. These volumes are derived from a second model that is used to schedule long-term timber harvest and forest management activities. Open-market wood supplies are calculated from timber resources data provided by the U.S. Forest Service.

The Southern and Southeastern forest experiment stations have both developed comprehensive data bases containing the latest timber inventory data for their respective regions. These data are updated at frequent intervals, and represent the best information available. Our first task was to gather from these data per acre volumes and tree diameter distributions for selected tenures and timber types.

The non-industry private lands are the main source of purchased stumpage at all of our Southern locations, with most of the required volumes cut from pine and mixed pine and hardwood stands. Our mills do use some hardwood fiber, but in the past the amount has been rather insignificant. The proportion is expected to increase as we, like others, consider increasing our use of the less expensive hardwood resource.

We began by gathering the latest acreage and inventory data for merchantable pine and mixed pine-hardwood stands growing on non-industry private lands, and since hardwood fiber is a potential growth opportunity, for the upland hardwood types as well. The data bases were screened to include only those plots that fell in natural stands. For each of the three broad timber types we calculated average per acre volumes for pine and hardwood growing stock, and tree diameter distributions.

Southern mills were the first to promote intensive plantation management.
<table>
<thead>
<tr>
<th>PURCHASE</th>
<th>CUT</th>
<th>ACTIVITIES</th>
<th>ALLOCATE</th>
<th>SELL</th>
<th>LOGS</th>
<th>TRANSFER</th>
<th>CONSTRAINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMBER</td>
<td>PWD</td>
<td>SAW'T</td>
<td>CHIPS</td>
<td>PULPMILL</td>
<td>SAWMILL</td>
<td>PWD</td>
<td>SAW'T</td>
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<tr>
<td>TOTAL PINE</td>
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<tr>
<td>PWD CUT</td>
<td>%</td>
<td>PWD</td>
<td>-1.0</td>
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<td>SAW'T CUT</td>
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<td>SAW</td>
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<td>MARKET PWD</td>
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<td>MARKET CHIPS</td>
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<tr>
<td>LOG YIELD</td>
<td>LOG</td>
<td>DIA</td>
<td>MIX</td>
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<tr>
<td>PWD SALES</td>
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<td>+/-1.0</td>
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<tr>
<td>SAW'T SALES</td>
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<td>+/-1.0</td>
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<tr>
<td>HOURS PROCESSOR</td>
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<td>H/U</td>
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<td>HOURS HEADRIG</td>
<td>H/U</td>
<td>H/U</td>
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<tr>
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<td>M/U</td>
<td>M/U</td>
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<tr>
<td>TONS HOG FUEL</td>
<td>T/U</td>
<td>T/U</td>
<td>T/U</td>
<td>T/U</td>
<td>-1.0</td>
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<td></td>
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<tr>
<td>TONS CHIPS</td>
<td>T/U</td>
<td>T/U</td>
<td>T/U</td>
<td>T/U</td>
<td></td>
<td>-1.0</td>
<td></td>
</tr>
<tr>
<td>MBF LUMBER</td>
<td>M/U</td>
<td>M/U</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>PULP MILL CHIPS</td>
<td>T/U</td>
<td>T/U</td>
<td>T/U</td>
<td>T/U</td>
<td></td>
<td>+1.0</td>
<td></td>
</tr>
<tr>
<td>PULP MILL FUEL</td>
<td>T/U</td>
<td>T/U</td>
<td></td>
<td></td>
<td></td>
<td>+1.0</td>
<td></td>
</tr>
<tr>
<td>COST</td>
<td>$/U</td>
<td>$/U</td>
<td>$/U</td>
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<td>+/-U</td>
<td>+/-U</td>
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</table>
As a result, in parts of our operating area old-growth natural stands are rapidly disappearing, with much of the cut coming from pine plantations that are less than thirty years in age. This trend will continue, resulting in smaller, lower quality logs for wood products manufacturing. To measure the likely impact of this change, the pine types were further stratified into plantations and natural stands. Forest Service data provided plantation acreage, with volumes and diameter distributions derived from sample plots measured in merchantable stands growing on company land.

With these data, we can structure a series of matrix vectors that represent expected yields from the various timber types, and for each county in the operating area. Vector elements are the percent distribution of product yields for a single unit of wood removals. Expanding a bit on the formulation shown in Figure I, the general form for a vector representing pine removals from a plantation or natural stand is as follows:

\[
\begin{align*}
\text{CUT ONE UNIT OF PINE} \\
\text{FROM COUNTY } X \\
\text{TOTAL VOLUME PINE CUT} & \quad 1.0 \\
PULPWOOD CUT & \quad \% \ PWD \\
CHIP-N-SAW CUT & \quad \% \ CNS \\
SAWTIMBER CUT & \quad \% \ SAW \\
\text{ASSOCIATED HARDWOOD PULPWOOD} & \quad \text{UNITS} \\
\text{ASSOCIATED HARDWOOD SAWTIMBER} & \quad \text{UNITS}
\end{align*}
\]

and for an upland hardwood site the general form is:

\[
\begin{align*}
\text{CUT ONE UNIT OF HARDWOOD} \\
\text{FROM COUNTY } X \\
\text{TOTAL VOLUME HARDWOOD CUT} & \quad 1.0 \\
PULPWOOD CUT & \quad \% \ PWD \\
SAWTIMBER CUT & \quad \% \ SAW \\
\text{ASSOCIATED PINE PULPWOOD} & \quad \text{UNITS} \\
\text{ASSOCIATED PINE CHIP-N-SAW} & \quad \text{UNITS} \\
\text{ASSOCIATED PINE SAWTIMBER} & \quad \text{UNITS}
\end{align*}
\]

The amount that can be cut from a single county is limited by available supplies. But there is no universal rule that can be used to measure these supplies. One approach is to assume that only the surplus growth is available, and that the individual firm can safely cut a specified amount. Another is to assume that some portion of the growing stock can be cut each year.

The observant will readily see the computational limitations in either approach. I'm not here to argue their relative merits, but merely to suggest that each is an acceptable alternative. At mead, we avoid some of the controversy by using both.

In addition to volumes, for each county we also calculate net growth and
drain on non-industry private lands. Deducting from this our own average annual removals gives us a reasonable estimate of the total surplus that is available. We then develop a supply constraint that is the larger of three numbers:

... (Surplus Growth) x (A Specified Multiplier)

... (Growing Stock Inventories) x (A Specified Multiplier)

... Average Annual Mead Removals

The multipliers are user input numbers that represent our own best estimate of the proportions that are available to us. They are not number pulled from a hat. They are developed from an extensive review of actual annual removals for the previous ten years.

It's probably no surprise to learn that the amount of growing stock or surplus growth that we can successfully control diminishes as we move further from the mill. Using growing stock as an example, we found that at current stumpage prices we can successfully compete for up to three percent in nearby counties, and for lesser amounts as we move outward. From this, we developed a set of multipliers for each county that are a function of the distance from the nearest major Mead-owned processing center. We can then calculate supply constraints, and adding these to our general formulation for pine removals we have the following revised structure:

<table>
<thead>
<tr>
<th>CUT ONE UNIT OF PINE FROM COUNTY X</th>
<th>CONSTRAINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PINE</td>
<td>1.0</td>
</tr>
<tr>
<td>PWD CUT</td>
<td>% PWD</td>
</tr>
<tr>
<td>CNS CUT</td>
<td>% CNS</td>
</tr>
<tr>
<td>SAW CUT</td>
<td>% SAW</td>
</tr>
<tr>
<td>HDWD PWD</td>
<td>UNITS</td>
</tr>
<tr>
<td>HDWD SAW</td>
<td>UNITS</td>
</tr>
</tbody>
</table>

Our multipliers give us our best estimate of the maximum volumes that are available "at current stumpage prices." We can then add to the matrix a set of additional purchase volumes that are available at incrementally higher costs. With these, we can theoretically measure the trade-offs between paying more for nearby wood, or moving outward and incurring higher freight rates. But frankly, quantifying these number is a difficult task, and we are unable to clearly identify either the incremental volumes, or the dollars.

We are familiar with the studies that have measured price elasticities for Southern pine, concluding in general that supplies are relatively inelastic. But how many dollars does it take to increase your ratio of successful stumpage purchases by a specified amount, and what effect will this have on future prices? We don't have satisfactory answers to these questions, and at present are using what is little more than our best guess. We are, however, attempting to sharpen our analytical techniques, and develop a better approach.
In addition to wood that is cut from our own lands or purchased stumpage, there are residue chips, and some added "casual wood" that is produced by local individuals who cut their own timber. These supplies are also included in the model.

In our formulations we assume that all wood that is cut must be allocated to an internal market, or outside sales. To prevent infeasibilities, we do allow downgrading to lower valued products -- chip-n-saw to pulpwood, for example. With these options added, our vectors for pine removals and allocations to the pulp mill take the general form shown in Figure II. Since we are minimizing costs, in the objective function all revenue items are negative, while costs are positive. Maximizing an objective function with reverse signs would provide the same answer.

**FIGURE II**

<table>
<thead>
<tr>
<th>Cut One Unit</th>
<th>Pulp Mill</th>
<th>Downgrade</th>
<th>Sell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of Pine</td>
<td>PWD</td>
<td>CNS</td>
<td>Saw</td>
</tr>
<tr>
<td>From County</td>
<td>PWD</td>
<td>CNS</td>
<td>Saw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saw</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constraint</th>
<th>PWD</th>
<th>CNS</th>
<th>Saw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| PWD Cut    | % PWD    | +1.0     | +1.0 |
| CNS Cut    | % CNS    | -1.0     |      |
| Saw Cut    | % Saw    | -1.0     | -1.0 |

| Hardwood PWD | -1.0 | +1.0 | -1.0 |
| Hardwood Saw | -1.0 | -1.0 | -1.0 |

| Pine Chips  | T/U T/U T/U | = Tons Prod |
| Hardwood Chips | T/U T/U | = Tons Prod |

| Pine PWD Sales | 1.0 | = Market |
| Pine CNS Sales | 1.0 | = Market |
| Pine Saw Sales | 1.0 | = Market |
| Hardwood PWD Sales | 1.0 | = Market |
| Hardwood Saw Sales | 1.0 | = Market |


The vectors allocating timber to wood products manufacturing are somewhat more complicated. Mead views wood products operations as part of the fiber supply system, with higher valued lumber or plywood products produced only to reduce pulp mill wood costs. Integrating solid wood manufacturing as part of the model presents a challenge. A realistic portrayal of each wood products mill is required.

As we build our wood procurement model, we are simultaneously developing simulations for the wood products facilities as well. Extensive mill studies
are undertaken to determine recoveries and throughput rates for each machine center. With these data in hand, we can structure in the wood procurement model a solid wood segment that measures the "real" cost of our own chips, unencumbered by transfer prices or accounting mystique.

Figure III summarizes the formulation for timber allocations to a typical sawmill. Tree-length pine sawtimber or chip-n-saw material is delivered to the woodyard where it is processed, producing topwood chips and logs of various diameters. Logs are sawn, with product recoveries recorded in a series of row accumulators. Total mill output is constrained by upper limits for the headrigs, kilns, and the tree-length processor.

**Figure III**

<table>
<thead>
<tr>
<th>Cut one Unit</th>
<th>---- Allocate Pine To ----</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of Pine</td>
<td>--- Pulp Mill --- --- Sawmill --- --- Saw Logs --- --- Chip Logs --- --- Transfer ---</td>
</tr>
<tr>
<td>From County</td>
<td>PWD</td>
</tr>
<tr>
<td>--------------</td>
<td>-----</td>
</tr>
<tr>
<td>TOTAL PINE</td>
<td>1.0</td>
</tr>
<tr>
<td>PWD CUT</td>
<td>-1.0</td>
</tr>
<tr>
<td>CNS CUT</td>
<td>-1.0</td>
</tr>
<tr>
<td>SAW CUT</td>
<td>-1.0</td>
</tr>
<tr>
<td>CHIPS</td>
<td>T/U</td>
</tr>
<tr>
<td>FUEL</td>
<td>T/U</td>
</tr>
<tr>
<td>6-Inch Logs</td>
<td>%/U</td>
</tr>
<tr>
<td>7-Inch Logs</td>
<td>%/U</td>
</tr>
<tr>
<td>Hours Processor Time</td>
<td>H/U</td>
</tr>
<tr>
<td>Hours Headrins</td>
<td>H/U</td>
</tr>
<tr>
<td>MBF Kiln Capacity</td>
<td>M/U</td>
</tr>
<tr>
<td>COST</td>
<td>%/U</td>
</tr>
</tbody>
</table>

Our objective function minimizes the net cash cost for usable wood fiber deliveries on the chip pad. This is a straightforward calculation for wood that is delivered direct, but requires some further explanation for sawmill chips. The following relationship is used to measure the "real cost" for our own chip transfers:

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DELIVERED WOOD COSTS AT THE SAWMILL

+ SAWMILL CONVERSION COSTS

- NET SALES REVENUES (EXCLUDING CHIPS)

/ UNITS OF CHIPS PRODUCED

= REAL COST/UNIT AT THE SAWMILL

+ FREIGHT/UNIT

= REAL CASH COST/UNIT AT THE PULP MILL

Operating hours on the merchandiser and headrigs are linked together. That is, if one is operating, then the other is too. The equality relationship is maintained, and infeasibilities are prevented, by providing adequate opportunity to chip logs rather than saw them. We also include vectors that allow overtime hours at a premium cost, and the ability to slack manufacturing hours with corresponding labor savings.

The model also has vectors that represent wood that is purchased and temporarily stored at satellite woodyards, and chips that are produced at remote chipmills. A woodyard vector is similar to direct deliveries, but with added costs for freight and handling. Chipmill vectors simulate roundwood conversion to chips, with an incremental cost for chipmill operations.

The objective function minimizes delivered costs for usable pulp mill fiber on the chip pad. Delivered costs are adjusted to reflect bark and fines, but with an offsetting credit for fuel values.

Solution results are presented in a series of meaningful reports that summarize wood allocations and costs. These include:

... A summary of costs on the chip pad for all wood fiber deliveries.

... More detailed reports summarizing average costs for direct delivered roundwood and purchased chips, and fiber from satellite locations — company-owned sawmills, chipmills, and remote woodyards.

... Reports summarizing volumes, allocations, and costs for wood cut from each county in the operating area.

... A summary of capacities utilized at the mill woodyard, and at remote locations.

... Incremental opportunity values for added wood processing capacities, or additional fiber supplies.

CONCLUDING REMARKS

I've briefly described the approach used by Mead to investigate wood cost issues. In closing, I'm compelled to make one further observation. Models are by definition an abstraction, and as a result can never be anything more
than a "tool" that can point us in the right direction. Management makes decisions; a model can do nothing more than help us make these decisions with greater confidence.

While we prefer linear programming, other less complex methods can be just as effective. The analytical approach is of far lesser importance than is the existence of an operating environment wherein change is permitted. At Mead, we have a progressive management team willing to try new ideas, and a senior management group dedicated to a wood cost reduction program even if some risk is involved. As a result, at those locations where the model was used virtually all that was recommended has been implemented, with a sizable reduction in wood costs. Costs that were escalating at more than a ten percent rate as recently as 1982 are now under control, and in general have declined in real and nominal terms.

Have we run out of wood at any Mead location where this program was used? No, we've not, and it's no more likely that we will now than it was in the past. We have merely learned to operate in a more efficient manner, and with a lower insurance premium.