NEW HARVESTING DEVELOPMENTS IN SOUTHERN USA

Bryce J. Stokes
Project Leader
USDA Forest Service
Auburn, Alabama

Abstract

Logging in the Southern United States is undergoing change because of high costs, economic pressures, timber supply, work force requirements, and external pressures including environmentalism, regulations, and poor professional and public images. This paper reviews some of these important issues and looks at new technologies that are responsive to these challenges. New developments are not strictly limited to innovative equipment and technology, but include changes in the fundamental thoughts, beliefs, and procedures that affect the basic existence of the logger.

Issues

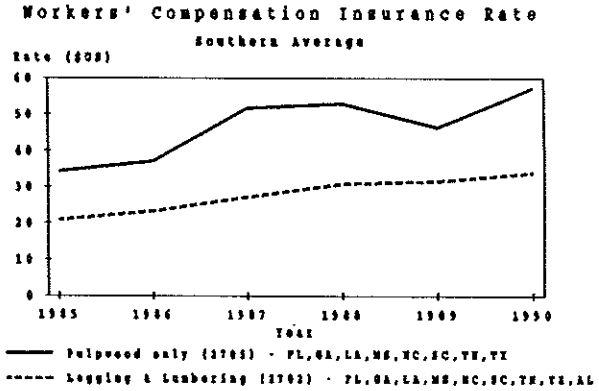
At the beginning of a new decade, logging in the Southern United States is undergoing significant changes. Some of these changes are good and some are bad for the profession. Many changes are from internal pressures that have resulted from self-examination and desire for improvement, but unfortunately, there are many external pressures. There are old challenges such as high costs, less profit, unstable markets, shrinking timber base, and work force requirements. New problems include increased regulation, public criticism, international competition, a declining public and professional image, and a poor business economy.

This paper discusses new developments and changes that influence logging in the South. These include, in a broad sense, costs and the economy, environmental and other external pressures, and adoption of new technologies in response to these challenges.

Costs and the Economy

Loggers have had to become better business managers. This has been due to high costs, regulations, and limited operating capital. Few loggers know their true operating costs and think only in terms of cash flows (Deal 1986). They do not generally know profit margins on specific tracts or profit/loss until tax time. Loggers have begun to realize that they must cover their variable and fixed costs on every tract harvested.

High costs include equipment, labor, fuel, and insurance. Worker's compensation rates are playing a significant role in new developments. Worker's compensation insurance (WCI) rates have been increasing dramatically over the last five years (Culhane 1991). An average for the southern states by two classifications is shown in Figure 1 below. Since 1985 the rates have more than doubled. The WCI classification 2702, Logging or Lumbering includes logging, transportation to the mill, construction, operation, maintenance or extension of logging roads or railroads, and drivers applies in all states. Eight southern states excluding Alabama, Arkansas, Kentucky, and Virginia also have a differential rate for manual pulpwood operations, WCI Classification 2705, is much higher than Classification 2702.



Increased insurance costs have driven many loggers out of business or significantly changed their way of doing business. Some progress has been made in addressing WCI costs. Several states have organized associations for the specific purpose of reducing WCI rates. Mississippi loggers initiated a new WCI classification for mechanized logging operations that is 15 percent below the standard manual rates. Florida and South

Carolina associations, and the American Pulpwood Association are also working to reduce insurance costs. As WCI rates begin to reflect the inherent safety of mechanized systems, there will be a greater effort to mechanize. These organizations have lobbied for rate differentials between mechanized operations and the higher risk, manual operations. They have also worked to implement rates based on safety incentives, reclassification of non-hazard exposed employees, and risk assessments.

An increased demand for hardwood pulpwood and lumber products forced industrial expansion in the late 1980's (Rummer 1989). Competition for hardwood pulpwood increased due to growing demand in domestic and export markets. A relatively sudden shift in export markets developed in hardwood chips from the Southern region. Chip exports are increasing at both Gulf and Atlantic ports and have resulted in the construction of chipyards and chip-handling facilities along major waterways. The expanding hardwood chip export market occurred at the same time as rising domestic demand for hardwood pulp and hardwood grade logs. The increased demand greatly increased stumpage price and decreased supply.

The U.S. economy has been on a downswing since last year. Housing starts fell as much as 34 percent from last year. Panel and lumber production are down over 15 percent. Mergers within the industry have stopped. Now there is over-capacity, low raw-material prices, and low demand. Solid wood and paper sales are directly related to the economy. When not in an expanding role, industry switches to a preservation role that includes quotas, little risk taking, and absolutely no expansions or developments.

Regulations and the Environment

Safety and Transportation

Logging is a dangerous occupation which is reflected in the high Workmen's Compensation Insurance rates. On another legislative front, the new Occupational Safety and Health Administration (OSHA) logging safety standard was issued for public comment this spring. The primary modifications in the standard are: (1) extended coverage to all logging operations, (2) required safety equipment for chainsaw operators, and (3) mandatory operations, safety, and first aid training. The American Pulpwood Association is supporting the draft standard (Rummer 1989). Hopefully, successful implementation will improve the safety record of logging. The challenge for industry, however, is to develop effective training programs for loggers.

OSHA will implement the revised logging safety standards later this year (Anonymous 1991). The old safety regulations were outdated and applied only to manual pulpwood operations. The new OSHA standards apply to all logging operations.

Major requirements include:

(1) Workers must be trained before taking on jobs and must receive refresher training. All new employees must be supervised until they demonstrate an ability to perform safely.
(2) Employers must make sure workers wear protective boots, hardhats, gloves, chain saw chaps, helmets and face shields.
(3) Employers must ensure that chain saws are frequently inspected for safe operation. Chain brakes must be operational on those that have them.
(4) All supervisors and timber fellers must receive first aid training. A person familiar with first aid must be present in each work area.
(5) Trees must be felled as soon as they are cut; no leaners or lodged trees. Also, dead trees must be removed from a worksite before cutting can begin.
(6) Workers must be in ready contact with other workers.
(7) Employers must provide operator's manuals and have them attached to or in close proximity to all machines.
(8) Passengers are not allowed on skidders, tractors, and other machines unless there is seating and protection provided.
(9) Seat belts must be fastened at all times while operating tractors and other machines that are required to have the belts.

Concern about trucking safety has fueled interest in truck driver training workshops. As many as 5,000 logging truck drivers may have completed the combined safety and maintenance course that is

being offered across the South by state associations and the American Pulpwood Association. Commercial driver's licenses are now required. These are issued according to federal guidelines based on knowledge and skills tests. Mandatory drug testing for truck drivers is now in effect.

The enforcement of the Federal Bridge Weight formula in every state will impact transportation costs (Deal 1986). Many trucks will not meet the tolerances on axle and tandem weights. Truck configurations will change and the use of in-woods weighing systems will increase.

Environmental Concerns

The red-cockaded woodpecker is the spotted owl of the South. Environmentalist litigation has resulted in court-ordered forest management for the woodpecker on Forest Service lands in Texas and most of the Southern region (Rummer 1989). The court decision requires an 100-acre reserve around each colony tree. Management guidelines will probably dictate longer rotations and selective cutting for woodpecker management areas. Such regulation may soon extend to all federal and state land and eventually, private lands to some extent.

Pressure is being brought on the Forest Service in the South to stop clearcutting. This is creating interest in un-evenage management and non-clearcutting reproduction cuts. Management regimes under consideration are shelterwood, seed tree, group selection, and single-tree selection. The purpose is to maintain a continuous high forest cover for water quality, recreation, wildlife, and visual quality. The Forest Service is dedicated to "new forestry" in which the forest is managed for multiple uses instead of timber production and the preservation of ecosystems and biological diversity. A recent ban on clearcutting of the Quachita National Forest in Arkansas resulted in an outcry by the forest industry. The ban was reversed by the Department of Agriculture because it was announced without public notice or hearings. However, the management plan was accepted as approved; this means very limited use of clearcuts when other cutting options are available.

The trend is definitely away from intensively managed, artificially regenerated, monoculture stands on public land. The extent of this trend past public land boundaries is not yet known. Several companies in the West, mostly California, have halted clearcuts because of public opinion.

Environmental regulations are being developed for timber harvesting at the state and county levels. Most of the southern states have voluntary Best Management Practices (BMPs). Virginia now requires a compliance inspection and Florida has 2-year audits of BMP compliance. Of particular concern are guidelines for harvesting sensitive sites such as wetlands.

The elimination of forestry's exemption from state sedimentation laws is also a real threat. There is growing sentiment throughout the South for the timber industry to adhere to the same restrictions as developers and building contractors. Several civic and environmental groups are pushing for more regulation of logging operations at both the state and local levels.

Controlled burning is also receiving attention from regulators because of smoke problems. The outcry has lessened as less agricultural land is cleared and the forest industry improves on smoke management.

Best Management Practices

The impact of forest practices on the environment was an important issue throughout the 1980s, and will be more important in the 1990s (Cubbage and DeForest 1991). Environmental protection has focused attention on the effects of forest practices on site productivity, water quality, wildlife, and other forest outputs. In fact, concerns over forest practices have led most states in the South to develop BMPs to control forestry-related pollution or other environmental degradation. These voluntary guidelines apply to all public and private forest lands. Of all the forest practices, timber harvesting undoubtedly receives more scrutiny and criticism than others, including site preparation, planting, or herbicide

application. Part of this scrutiny is based on adverse public perceptions of timber harvesting. But much of the concern is based on the significant damage to water quality that can be caused during timber harvests. Several states have developed substantial programs to monitor compliance, most have serious educational programs for loggers and foresters, and a few have regulatory components in their water pollution control programs.

BMPs are defined as "Methods, measures, or practices selected by an agency to meet its nonpoint source control needs." BMPs include but are not limited to structural and nonstructural controls as well as operation and maintenance procedures.

Summarizing all the southern BMPs is difficult. BMPs generally cover the following practices (DeForest et al. 1990):

(1) Road and landing design
(2) Stream crossings
(3) Water bars and broad-based dips
(4) Retiring roads and trails using seed, fertilizer, and mulch
(5) Operations in Streamside Management Zones (SMZs)
(6) Site preparation work including burning, mechanical, and chemical treatments
(7) Pesticide use with aerial and ground applications.

The first five items are generally relevant to harvesting practices--whether preparing a site to be harvested, performing the harvest, or post-harvest site rehabilitation.

Wetlands

Wetland harvesting regulations and BMPs also are becoming more important, and have the potential to affect large amounts of forest land in the South (Cubbage and DeForest 1991). Federal regulations delegated control of dredge and fill operations in the nation's waters and wetlands to the U.S. Army Corps of Engineers. The definition of wetlands has gradually expanded since 1972 to include much of the Coastal Plain. Forestlands that are frequently flooded for two weeks or more during the growing season, have gray and mottled soils, and that support hydrophytic plants are currently classed as wetlands.

Timber harvesting operations may occur in wetlands without a federal permit, but converting forests to another use requires a permit. However, during timber harvesting in wetlands, loggers must specifically comply with a number of regulations in order to remain exempt. The construction of forest roads is not exempt. Roads and skid trails which meet the BMP guidelines may be exempt if they meet several, additional criteria such as minimal number, width, and length; located sufficiently far from streams or other water bodies; properly bridged or culverted; properly maintained and stabilized to prevent erosion; and other requirements. This is essentially a quasi-regulatory approach to protecting wetlands.

Several southern states are considering or have developed specialized BMPs for forested wetlands. Florida, Texas, Louisiana, and South Carolina have wetland BMPs in place, and Georgia has just developed them and North Carolina will have them soon.

The development and promotion of BMPs for timber harvesting is intended to protect water quality, prevent other damage to the environment, and to prevent losses to site productivity. Given the wide public support for environmental protection and the generally adverse image of logging, loggers and landowners need to voluntarily comply with harvesting BMPs whenever possible. Uniform voluntary compliance will be the key to preventi(strict regulation.

Compliance with BMPs will, however, have significant impacts on timber harvesting and the forest industry (Cubbage and DeForest 1991). BMPs can restrict where and when forestry operations can occur. Complying with BMPs may abbreviate harvesting periods, even though with today's equipment many sites--including wetland sites--are physically accessible all year long. Development of less intrusive equipment, such as low ground pressure tires or even economical cable yarder systems, will help protect the environment and avert mandatory regulations. Areas that are economically marginal, however, may become unprofitable to log if BMPs are much more expensive than conventional practices. As regulatory and political constraints on logging increase, the accessible timber inventory

will decrease, and the cost of fiber will be affected. BMPs may take some sensitive areas out of production permanently.

If nonregulatory BMPs fail to protect water quality, states can and will shift to tougher regulations governing forestry operations. We have seen this trend all over the United States. For now, most southern states are relying on mostly voluntary BMPs to reduce nonpoint source pollution. Education will continue to be the principal mechanism for promoting the use of BMPs in forestry operations. However, there will probably be more rigorous monitoring of BMP compliance to document the effectiveness of the voluntary system.

The forest industry's and loggers's image has certainly been bashed in recent years. The preservationists have expertly used media exposure to sway public opinion. They have promoted the "green movement" using such issues as endangered species, wilderness, old-growth, recreation, biological diversity, and global warming to preserve forestland from logging. The forest industry, on the other hand, has not been able to successfully demonstrate that they are responsible stewards of the land as well as users. The industry, and loggers in particular, are too fragmented and unorganized in public relations. Generally, the industry is responsible, sensitive, and ethical in management of all resources from forestlands.

Harvesting Technology

Harvesting Systems

The most recent Pulpwood Logging Contractor Survey shows a trend toward more productive mechanized operations in the South. Over 45 percent of the contractors surveyed produce more than 100 cds/week. These highly productive operations account for 90 percent of the volume produced. Feller-bunchers with grapple skidders are now the prevalent southern harvesting system. As crews shifted to higher output levels, transportation systems changed to tractor-trailer rigs.

A major change in logging has been the adoption of felling saws into conventional operations. The saws were originally developed to solve problems of butt damage on sawtimber. The technology was implemented to solve product recovery problems instead of enhancing cost efficiencies (McClary 1991b). Many companies have mandated a no-shear policy, which improves worker safety by replacing the need for chainsaw felling. Felling saws have also proven to be cost competitive with shears and increased productivity has lead to their use in pulpwood production.

Almost 85 percent of all new sales have been felling sawheads instead of shears. Almost exclusively, they have been mounted on rubber-tired, drive-to-tree carriers. Presently there are at least 40 models. The technological advances of felling saws has not slowed, surpassing many times the simple shear design.

As hardwood demand increases, there has been more interest in environmentally sensitive, cost-efficient harvesting systems for wetlands and upland hardwood sites. Pine management is also changing in response to the hardwood demand, with the objective of developing multi-product pine stands rather than just pulpwood. This is creating more interest in thinning systems and merchandising during the final harvest. Increasing competition for the hardwood resource is leading to longer hauls. The manufacturers are faced with the challenge of developing new systems for the changing utilization of pine as well as improved systems for harvesting and transporting hardwood.

Several modifications to conventional logging systems have taken place within the last few years. The most noticeable has been a direct result of the labor supply and costs. Because of increased insurance cost and decreased availability of workers, mechanization has replaced many typical labor-intensive harvesting functions. Chainsaw felling, a high risk function, has been replaced by felling saws. Another function in transition is that of processing. Gradually, the saw work at the stump and at the deck, and gate delimbing are being replaced by slashers and processors. In many instances, one machine can replace up to three workers, and give significant savings in insurance costs and benefits. In addition, system productivity and product recovery can be enhanced.

Cut-to-length Systems

Cut-to-length harvesters and forwarders are a radical change from conventional tree-length operations. These new systems, based on Scandinavian technology, are a complete replacement of equipment, methods, maintenance, crew organization, and transportation. Cut-to-length systems require a higher capital outlay with two machines costing up to $800,000 (U.S.) and requiring specific tree size, volumes, and terrain conditions for economical operation (McCary 1991a). Single grip harvesters do both felling and processing with the felling head. Double grip processing is done by a separate attachment from the felling head. A single grip machine is more productive, especially when harvesting small trees. The double grip machine can handle larger stems. Delimbing knives strip the limbs from the tree as it is fed through the felling head by rollers or a stroke mechanism. These forwarder/processor systems enhance sorting, merchandising, and recovery of wood.

In 1986 full-tree and tree-length harvesting accounted for 94 percent of the U.S. logging methods (McCary 1991a). A recent poll showed that 16 harvester heads are now available in North America, 11 imported from Scandinavia. Currently there are five major distributors of Scandinavian-style harvesters, three have manufacturing in North America. Although the number of operations are still very limited, there is a strong interest and a "wait and see" attitude among loggers, the forest industry, and equipment manufacturers.

There are several advantages of the cut-to-length system. These include reduced environmental impact and increased wood recovery. The carriers have a low ground pressure and are highly maneuverable. Trees are processed at the stump returning nutrients to the soil and providing a mat for the machines. There are also several disadvantages: possible lower production, high capital costs, specialty markets, products, transportation, requires skilled and trained workers, demands more planning and supervision, and limited to softwoods. Such systems are probably more suited for working in managed stands and in thinnings. They will also be used for improved grade recovery.

In-woods Flailing and Chipping

The need to obtain maximum value from the raw material is also generating interest in improved in-woods chipping systems. Chain flail delimber/debarkers are increasing in use across the South to provide quality, clean chips for the pulp and paper industry. One new pulp mill has announced plans to purchase 60 percent of its input volume in chip form. Currently there are approximately 65 chain flail debarkers operating in the South.

Increased wood recovery and reduced harvesting and transporting costs are usually common objectives of logging contractors and forest owners. The development and use of portable in-woods chippers has significantly increased utilization and allowed recovery of small diameter, low quality trees at an acceptable cost. However, whole-tree chipping produces a chip of unacceptable quality for most pulping processes because of the contamination of the pulp from bark. This has restricted the use of in-wood chips almost exclusively as an energy source; because larger trees are usually recovered as roundwood for pulpwood or sawtimber, the productivity and utilization advantages of whole-tree chipping has been restricted to only a portion of the stand components or low-quality stands. Flail debarking allows the use of in-wood chi for pulp.

The recovery of total tree biomass and most components of a stand is a practical economic and management alternative to tree-length harvesting (Stokes et al. 1989). First, the increased utilization of woody biomass provides additional revenues from the site. Second, the removal and utilization of stems and crowns reduces site preparation costs and makes tree planting easier. Third, from a different perspective, better utilization helps provide an additional resource of raw materials from an already declining inventory of standing timber in the Southern United States.

Modifications for improvements in flail technology for debarking has become accelerated during the 1980's as the

concept became more feasible. Basically, the change in technology involved the addition of another flail drum and more wear-resistant chains. This dual-flail concept was the key to increased productivity and improved debarking quality so that in-woods chips would be acceptable at mills producing fine paper.

Disadvantages include higher capital costs to the logger for specialized flail and chipping equipment as compared to tree-length operations. Also, some handling, transporting, and processing problems are associated with recovery of limbs, tops, and bark from the flail.

Tree-length harvesting allows mill merchandizing and improved recovery of sawlogs. Also, there are some advantages to leaving forest residuals on the site to avoid site degradation. If biomass for energy production is important, whole-tree harvesting brings the forest residuals to the mill in one operation.

An analysis between alternative harvesting methods showed that 64.4, 62.3, and 61.5 percent of the total tree biomass was recovered as clean chips from the flail/chip, whole-tree, and tree-length harvesting methods, respectively (Stokes and Watson 1990). A higher percentage of the total tree biomass was diverted to residues in the delimbing and debarking processes by the tree-length method than by the other options. Gate delimbing and drum debarking accounted for 16.1 percent of the total tree biomass being converted into residues by the tree-length method. In-woods flail delimbing/debarking converted 15.1 percent into residues. Whole-tree drum debarking resulted in 14.7 percent of the total tree biomass going to residues.

More acceptable chips were recovered from the flail/chip option, primarily due to the increased stem wood utilization and recovery of acceptable chips during the screening process. A higher percentage of the total biomass was diverted to forest residues in the flail/chip option. If the flail rejects were recovered, then only 18.3 percent of the total biomass would be left on the site. This amount would then be only slightly more than the whole-tree system.

Low-impact Logging

Wet sites and steep slopes propose problems to conventional logging operations and can result in high costs and residual site damage. From a logger's point of view, such sites impact the operational efficiency, increase costs, and reduce profits. From a landowner, forest management and an environmental perspective, unacceptable residual site impacts can cause degradation to site productivity, water quality, and aesthetics. The forest industry and loggers realize the value of minimizing site damage and are looking for low-impact harvesting systems. Today's harvesting systems must not only be able to physically operate and be economically feasible, but they also have to be socially acceptable. Systems should consist of machines that minimize rutting and compaction, and need less roadbuilding than conventional systems.

Engineers and manufacturers have been concerned with tractive effort, or mobility (Jackson and Stokes 1991). Most current technology is based on having sufficient trafficability to traverse difficult terrain and maintain production. Innovative approaches are now needed.

The American Pulpwood Association conducted a survey of wetland loggers in 1986 in the Southeast (Stokes 1988). This survey concluded that over half of the felling was mechanized and 96 percent of the wood was extracted by ground skidding (50 percent used rubber-tired skidders only). Jackson (1990) surveyed loggers operating in the Mississippi River Delta. The delta loggers were less mechanized than the loggers in the southeast. Almost 90 percent used chainsaw felling only. However, 98 percent used rubber-tired skidders. Some of the river delta loggers used crawler tractors and forwarders in addition to the rubber-tired skidders.

Chainsaws are usually used to fell much of the timber on wet and steep sites because of mechanical limitations. The high-cost insurance rates and declining availability of skilled sawhands has resulted in more mechanization. For year round logging, many operations have added swing, tracked feller-bunchers. Such

machines, although costly, reduce disturbance by limiting the amount of travel on the site and through the use of wide tracks. In extremely wet sites, portable mats can be used to increase feller-buncher mobility and reduce site disturbance. New felling technology includes lightweight, long reaching machines that combine high production with little disturbance. A grapple-saw concept would increase the flexibility of the feller-buncher. It would reduce the weight on the end of the boom and allow the felling machine to perform limited bucking and topping. Such a machine can cut the trees, cut off the tops, and some of the larger limbs, buck logs, and pile stems. Integrating limited processing and piling into the felling function can reduce subsequent extraction impacts. This concept will be tested in the near future.

Rubber-tired skidding has been the most widely used and cost-effective wood extraction method. The cable skidder is able to operate under extremely difficult conditions. The grapple skidder is highly productive and relatively safe. Special tire options have evolved including wide and dual tires. Several studies have shown the benefits of using wide tires for better flotation, having access to more timber, less soil damage, and reducing damage to the residual stand. Disadvantages of wide tires include high costs, reduced reliability, maneuverability loss, and increased maintenance. Tire widths have changed from the conventional 71- to 86-cm (28- to 34-inch) width. Today many operations are using 109- or 112-cm (43- or 44-inch) wide tires in the southern coastal area. Wide, 127- and 173-cm (50- and 68-inch), tires are just now becoming acceptable in the South. Such tires can develop less than 3 psi on the soil and are still relatively maneuverable.

Another alternative is track skidding; this includes rigid steel track, flexible steel track, and flexible rubber track. Advantages of track skidders are lower ground pressure and higher traction than conventional rubber-tired skidders. Historically these options have been relatively expensive.

Large forwarders have been introduced in wet area and steep slope logging and have had slow success. Several manufacturers are marketing large forwarders. Wide-tired forwarders in Eastern Canada have shown (1) increased access to wood without roadwork, (2) improved stability, safety and comfort, (3) wet season logging, (4) less maintenance and more productivity due to machine staying on top of ground, and (5) reduction, if not almost elimination, of residual damage to the site. Tree-length forwarders can move up to 25 ton payloads and with wide tires have a loaded static psi of 6.8. This type of machine has exceptional value in long-distance wood movement. Large payloads reduce the number of passes required on the same trail. Clambunk skidders have been used successfully on steep slopes and in marsh lands.

Cable systems have been used on a ve limited basis. The primary advantage of cable yarding is reduced site impacts. Disadvantages are higher costs and specialization of the operation. Usually such systems have been home built and were equipped with a short tower or pole. Recently, a West Coast swing yarder was evaluated in southern hardwoods. Another option that has had acceptance, although it can be very costly, is the use of helicopters. This system gives the least amount of impact except from the building of decks and roads. It may be cost effective in certain situations, but it is not the answer to all the problems of harvesting wet sites.

Other new concepts are towed vehicles specialty matting, and lift devices. (traction was provided by a drum at roadside, then specially designed, lightweight vehicles can carry more wood with less rutting. Since slip is zero, soil movement is reduced. Specialty matting and matting-handling equipment may help access the more difficult sites. Current matting is a cumbersome, unsophisticated method but may become a primary method of wood removal. Other methods may include lift devices, such as balloons and more helicopters. Helicopters have proved to be cost-effective in certain situations if short flights can be maintained.

Roadbuilding is more disturbing to the site than harvesting. Also roads are expensive to build and maintain. Options include the use of specialty equipment that can haul on lower quality roads or transport the wood further without the use of roads. Matting is a way of using low

quality roads for transport. Another option is central tire inflation systems that allow the use of low pressure tires.

Several machines have a particular application where they will excel above the others. We need to consider carefully our options, and use our technology wisely to halt increased social regulation. More research is required to completely understand the options and to properly select and apply the technology as it is developed.

Summary

Logging in the Southern U.S. is undergoing change due to high costs, economic pressures, and external forces. This change has brought about new developments in the way loggers do business. New developments are not limited to equipment, but extend to better management, improved operating methods and techniques, and social sensitivity. Loggers are still faced with high costs for machines, fuel, parts, labor, unstable markets, a shrinking timber base, and a declining work force. External pressures include increased regulation, public criticism, and a fluctuating economy.

A significant new development has been the high insurance rates for forest workers. This item has caused the loggers to organize and collectively respond to a problem. Logging associations want to reduce costs, improve image, and have a voice in government. Internal costs still shape new developments more than external forces. However, the industry is mandated with more regulations. Examples are stricter safety, trucking, and operating practices.

Environmental concerns have increased local and state regulation. Most states have self-imposed Best Management Practices. If the industry fails to meet the environmental guidelines, acceptable BMPs may become regulatory instead of voluntary. The environmental impacts of timber harvesting are being scrutinized. Regulations are fully implemented on public lands and may not be too distant for all logging activities.

New developments do not always mean new technology. However, many of the new machines are being used in response to demands other than improved efficiency and reduced costs. Many machines are environmentally sensitive and are being implemented in response to external challenges.

Developments must continue for low-impact equipment and acceptable methods for timber harvesting. Equipment and systems should be designed to minimize compaction and erosion, and to minimize residual stand damage during harvests. Harvest planning has to be concerned with harvest, transport, regeneration, road layout, and environmental control measures. Improvements in efficiency was a goal that was achieved in the 1980s. Environmental protection will be the mandate for the 1990s.

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