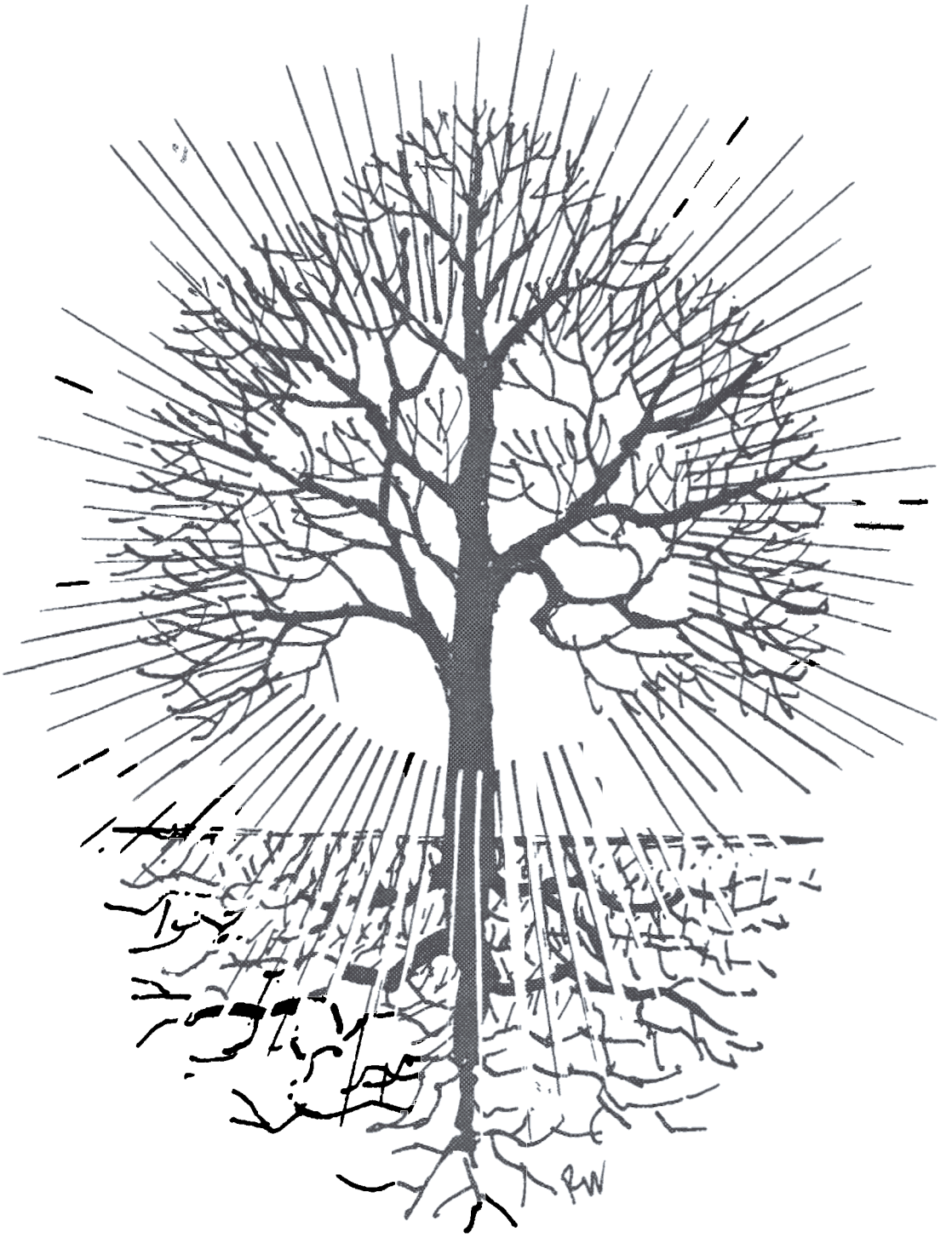

Forest Biomass As an Energy Source

Study Report of a Task Force of the Society of American Foresters

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Society of American Foresters
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Task Force Members

RICHARD L. DOLB (chairman). Assistant to the Manager, Office of Natural Resources, Tennessee Valley Authority, Norris.

JAMES S. BETHEL. Dean, College of Forest Resources, University of Washington, Seattle.

PAUL COX. Assistant Chief Administrator, California Department of Forestry, Sacramento.

THOMAS H. ELLIS. Assistant Director, Planning and Applications, Forest Products Laboratory, USDA Forest Service, Madison, Wisconsin.

ROBERT L. JAMISON. Director of Energy Management, Weyerhaeuser Company, Tacoma, Washington.

PETER KOCH. Project Leader, Forest Products Utilization Research, Southern Forest Experiment Station, USDA Forest Service, Pineville, Louisiana.

A RAY SHIRLEY. Director, Georgia Forestry Commission, Macon.

T. A. WALBRIDGE, JR. Professor of Industrial Forestry Operations, Department of Forestry and Forest Products, Virginia Polytechnic Institute and State University, Blacksburg.

HAROLD E. YOUNG. Professor, Complete Tree Institute, School of Forest Resources, University of Maine, Orono

BRUCE J. ZOBEL. Professor of Forest Genetics, School of Forest Resources, North Carolina State University, Raleigh.

ROBERT D. DAY, JR., Resource Policy Director for the Society of American Foresters, was staff liaison.

The views expressed in the report are those of the Task Force on Forest Biomass as an Energy Source. They do not necessarily reflect positions of the Society of American Foresters.

Summary

Forest biomass—a renewable, versatile source of energy—can contribute the equivalent of approximately 9.5 quads to U.S. energy needs. (This value is exclusive of wood required for conventional products, but includes aboveground biomass in net growth from commercial forests; mortality; and wood from land clearing, noncommercial lands, urban tree removals, and urban wastes.) If commercial forestland were fully stocked and intensively managed, biomass available for energy could increase to the equivalent of 18.9 quads by mid-21st century.

Biomass can be burned directly or converted to gas, oil, and char. Many forest industries, particularly pulp and paper manufacturers, now burn biomass for up to half their fuel needs. Blending biomass-derived alcohol with gasoline and using biomass in electrical generation may become practical.

To achieve U.S. biomass potential, the first step is fully stocking and otherwise upgrading existing forest stands. Attention should be given to refinement of multiple-product management systems, to genetic improvement of species, and to silvicultural treatments. Research is needed on harvesting systems and nutrient drain. New marketing systems are essential to assure consumers of dependable biomass supplies. Improvement is necessary in wood combustion and conversion technology. Biomass plantations may eventually be developed; special planting stock and cultural systems will be required.

Ways of precisely estimating biomass growth, standing stock, and utilization are important, especially if demand for energy biomass is to be met without disrupting existing supply systems or depleting the resource base. Foresters must help educate the public and encourage policies to prevent exploitation of forests.

Increased use of biomass for energy may affect traditional uses favorably. Wood grown and wastes retrieved for energy may also be used for conventional products. Increased utilization will justify better roads and more efficient harvesting systems. These improvements, in turn, may result in more reliable raw materials supply, lower industry inventories, and product diversification.

Increased demand for biomass might also, however, cause wood to be diverted from traditional uses. Too rapid expansion of biomass harvesting could lead to oversupply. Both extremes can be avoided by unified national policies and careful long-range planning.

The task force recommends that SAF adopt a national position favoring use of biomass for energy, by

- encouraging improved estimates, equipment, and technical systems,
- supporting forest practices, economic incentives, and legislation to increase growth of biomass,
- promoting use of waste wood,
- encouraging substitution of wood for more energy-intensive materials,
- supporting needed research.

The Society should also promote awareness of the energy potential of biomass and encourage foresters' participation in policy formation.

Forest Biomass as an Energy Source

The Task Force on Forest Biomass as an Energy Source was chartered by the Society of American Foresters on September 26, 1977, and took its present form following an amendment to the charter on October 5, 1977. It built upon the findings of two previous task forces. the Task Force on Energy and Forest Resources and the Task Force for Evaluation of the CORRIM Report (Report of the Committee on Renewable Resources for Industrial Materials). Reports of these two task forces have been published (Saeman et al. 1977, 1978)

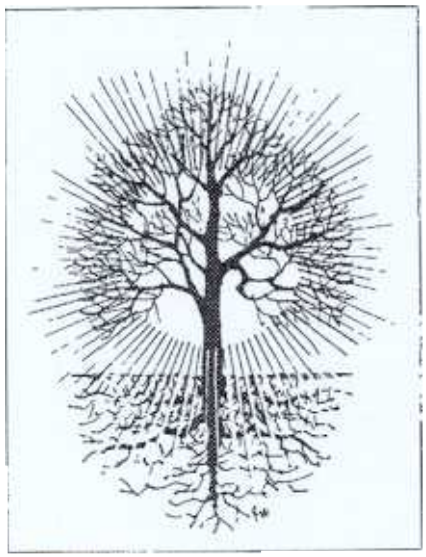
Its charter directed the present task force to (1) study the potential of forest biomass as an energy source; (2) study possible effects on traditional biomass uses; (3) recommend whether SAF should adopt a national position and, if so, outline a proposed position; and (4) recommend other SAF activities relating to forest biomass as an energy source

The task force proceeded by reviewing the literature, analyzing documents and statistical reports, and contacting persons engaged in research and development.

I. Potential of Forest Biomass As an Energy Source

Forest biomass is all tree and woody shrub materials from root tips to leaf or needle tips. Until recently, foresters have measured only the boles of trees merchantable for traditional products. Attention is turning, however, to volumes in small stems, tree tops, and roots as well.

Estimates of total biomass, including weight tables for complete trees, have been made only for a few areas of the nation, mainly in the South and the Northeast. Until much more is known about total biomass volume, even the



theoretical potential of U S. forests cannot well be estimated. The actual potential, in turn, will be affected by many other factors, among them harvesting and utilization techniques, transportation and distribution of raw materials and finished products, and a variety of environmental considerations. Even so, estimates in this paper are considered conservative enough to justify the conclusions reached The figures are based largely on traditional measures of boles and on rather crude projections of the limited work already completed on total tree biomass.

The data indicate that biomass now available can contribute significantly to U.S. energy needs. Not only is it relatively plentiful, but—unlike fossil fuels—it is renewable Too, it is versatile. It can be burned in traditional solid forms, reduced to chips, or converted to liquids, gases, or char The Council on Environmental Quality has stated (1978) that "in the absence of major breakthroughs in development of batteries or inorganic liquid fuels, biomass offers the most practical solar-based alternative for powering trucks, buses, and automobiles."

Energy needs

The Federal Energy Administration (FEA) estimated in 1976 that annual energy use in the United States was about 75 quadrillion BTUs (or 75 quads), and that use by 1985 would be 98.9 quads. The agency also estimated that even under the most favorable conditions the U.S. cannot expect to gain more than 6 quads from emerging technology by 1990. A more realistic figure, it indicated, might be 2 quads

The emerging technologies evaluated by FEA included solar, geothermal, and synthetic fuels, but evidently excluded forest biomass. Energy currently obtained from wood is estimated at 1.1 to 1.7 quads. Members of the task force are confident that wood use for energy is increasing greatly, but we have no way of knowing the extent

Current potential

Annual aboveground biomass growth on commercial forests in 1970 was estimated at 450 million dry tons (Zerbe 1977) In addition, available biomass included something like 120 million tons from natural mortality and another 152 million tons from such miscellaneous sources as land clearing, noncommercial forestland, and removals of street and park trees and other urban wood waste. In lieu of 152 million tons from these miscellaneous sources, however, the task force used a more conservative estimate of 110 million.

The total available in 1970 from all sources, then, was about 680 million tons. Manufacture of timber products used about 195 million tons of this total,

leaving 485 million, or about 8 quads of energy, for fuel or other purposes.

Extrapolations from these 1970 figures can be made for a current estimate. Recent unpublished estimates (data of Thomas H. Ellis, USDA Forest Service, October 1978) indicate that net annual growth is now 530 million tons, 18 percent higher than in 1970, and current industrial use is 200 million tons. Thus, the equivalent of 9.5 quads is now potentially available.

Future supply

Table 1 indicates future U S biomass potential after subtraction of industrial demand, which is estimated at a moderate level. Current annual stand growth is 38 cubic feet of wood per acre If stands were fully stocked they would average 74 cubic feet per acre. Biomass from all sources except commercial forest growth is assumed constant Increases in commercial volume are projected for full stocking during the years 2010 to 2035, and after that for full stocking combined with such intensive practices as accelerated reforestation, stand improvement, commercial thinning, use of genetically improved species, improved harvesting methods, and increased protection. By the middle of the 21st century, the estimates show, U.S forests could supply up to 18.9 quads of energy, while still meeting the need for conventional products.

These estimates do not include belowground biomass (stump-root systems), which may yield an additional 20 percent Nor do they include any increases from intensive management of lands presently regarded as noncommercial, only utilization of existing biomass from these lands is figured in. Also, the estimates assume that no significant acreage would be committed to biomass plantations. If 10 percent of the arable land that is currently private forest, pasture, range, and hay land were used for intensive biomass production, up to 4.5 additional quads of energy could be produced at current estimated yield levels. Future yield increases could raise the figure to 8.3 quads, if new technology were used on biomass farms (Inman 1977).

Biomass as an alternative to fossil fuels and electricity

Forest biomass will be particularly significant to the economy when substituted directly for oil and natural gas. Current U.S. oil consumption is approximately 36 quads. About one-half that total is imported, creating a serious balance-of-trade problem. The need to improve the balance should bring about policies to encourage use of biomass as an alternative fuel. Biomass could also significantly reduce peak energy loads in areas heavily dependent on electricity for space heating.

The most promising immediate prospect is use of chips and solid wood in newly developed wood-burning furnaces, which are over 80 percent efficient (Riley 1976) and virtually pollution-free. Such furnaces are particularly suited for commercial and institutional buildings that require 200,000 to 500,000 BTUs per hour. Work is under way to develop similar furnaces for small buildings such as private homes (Hill 1977) Even where some smoke is emitted, wood is preferable to coal and oil because it contains little sulfur.

Technology is also developing rapidly for the processes of total gasification and pyrolysis. Total gasification yields a fuel for gas-fired boilers Pyrolysis produces oil, gas, and char and is suited for large energy-users who can refit existing oil and gas furnaces. Output ranges from 150 million BTUs per hour for large stationary units to 40 million BTUs per hour for smaller mobile ones. The smaller units, which can be moved on a flatbed trailer, might be transported to logging sites; wood could be converted to gas for use on site in powering the chipping facility, and converted to char and oil for transport away from the site. Char, one of the best solid fuels known, is very clean and can be burned alone or blended with oil or coal to increase the burning efficiency of these fuels and reduce their sulfur emission.

In converting to biomass for fuel, forest industry is in a particularly advantageous position: it is experienced in processing wood and usually has fairly large concentrations at plant sites. Many companies are moving rapidly toward energy self-sufficiency. The pulp and paper industry, a large energy consumer, is about 50 percent self-sufficient now. Most mills have a bark-fueled boiler and also burn black liquor.

It is technically feasible to use biomass to produce alcohol, as a gasoline substitute or blend, but the process will not be economical until gasoline prices approach $1.50 per gallon. Certain other processes, such as wet oxidation, improved fermentation, and conversion to oil, are being investigated. During World War II, vehicles in Europe and

Japan were propelled with charcoal, alcohol, and other forest biomass materials.

In heavily forested regions where fossil fuels must be imported, it may be practical to use biomass to generate electricity. Vermont and Oregon already have small plants in operation, and analyses indicating economic feasibility have been completed for several other areas. Because of losses of 65 to 75 percent in generation and transmission, however, electrical generation is one of the least efficient uses of biomass. Large capital investment and resource commitments to electrical generation also reduce the opportunities to utilize more efficient small-scale technology. Also, truck transportation costs for wood fuel become excessive for large (>100 megawatts) power plants.

Homeowners in rural areas where forests are abundant are harvesting and

Table 1. Estimates of U.S. aboveground forest biomass potential.[1]

Source	1970	1976[2]	2000[2]	2010 to 2035, with full stocking	2035 to 2085, with full stocking and intensive management[3]
	Million oven-dry tons				
Net growth from commercial forest	460	530	600	800	1,200
Mortality[4]	120	120	120	120	120
Other sources[5]	110	110	110	110	110
Harvest for conventional product uses	−195	−200	−260	−260	−320
Total	485	560	570	770	1,110
Energy equivalent (in quads)	8.2	9.5	9 7	13 1	18 9

[1]*Estimates derived from data published by Zerbe (1977) and USDA Forest Service (1977) Moderate industrial demand is projected*

[2]*Net growth estimates from Thomas H Ellis, USDA Forest Service, October 20, 1978*

[3]*Moderate industrial demand is projected to the year 2020, and it is also assumed that intensive management will double growth on 50 percent of commercial forests*

[4]*Assumes mortality is recoverable. Intensified management may reduce mortality, but an equivalent volume would be available as live wood*

[5]*Land clearing, noncommercial lands, urban tree removals, and urban wastes.*

burning more and more wood for both primary and supplementary residential heating. Recent studies in the Tennessee Valley (unpublished data, Division of Forestry, Fisheries, and Wildlife Development, TVA, 1978) show that homeowners reduced their electrical consumption 45 to 70 percent during December, January, and February by using wood stoves It is estimated that 6,000 wood stoves are in use in north Georgia (conversations with E. L. Klein, wood energy project manager, TVA, 1978) and that 50 percent of Maine residents now use wood for heat (Ripley and Doub 1978).

II. Social and Scientific Needs To Achieve Biomass Potential

Perhaps the greatest challenge to full realization of forest potential for energy as well as for conventional wood products lies in the simultaneous realization of other cultural values. Use of the forest resource must not preclude wildlife development, recreational opportunities, watershed protection, esthetic concerns, and subtle environmental considerations. The task force believes that considerable debate will center around such issues as the nation awakens to the significance of biomass as an energy source. Professional foresters must be prepared to face such concerns and address all such legitimate issues; and the means must be found to fashion major policy decisions out of a reasonable synthesis of public and professional opinion. Trade-offs will be necessary, and the forestry profession should ensure that they are based on the best possible scientific evidence.

Because forests are already stocked with large volumes of biomass, because the same acres have traditionally sustained multiple uses, and because professional foresters have a well-developed scientific base for managing these lands, we believe existing stands offer the greatest potential for biomass production for the foreseeable future. Later, biomass plantations established on farmlands, grasslands, and on acreages such as rights-of-way for highways, powerlines, and gas lines may become significant.

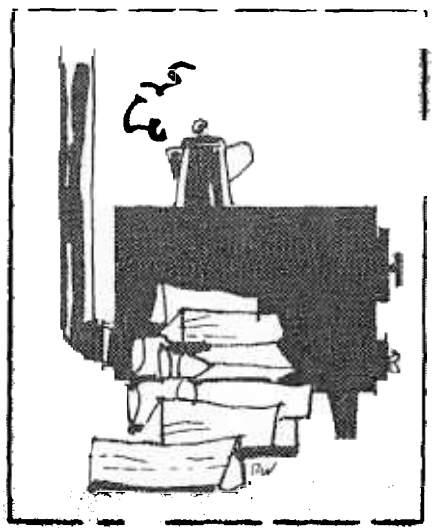
Upgrading existing stands is an immediate need. Introduction of improved stock would increase growth, and in combination with creative management would contribute to improved wildlife habitat, esthetics, and environmental protection. Refinement of multiple-product management systems, especially of cultural systems, is needed. Greater attention should be given to genetic improvement of species (both native and exotic), particularly species heretofore not considered commercial. Research is also needed on regeneration techniques, rotation lengths and intermediate harvests, fertilization and irrigation, and other silvicultural treatments New cultural systems will, in turn, require new utilization processes.

Development of efficient and economical harvesting equipment and systems will be needed for existing forests that are managed primarily to produce conventional wood products but have significant residues, and for existing forests that will be managed primarily to produce energy.

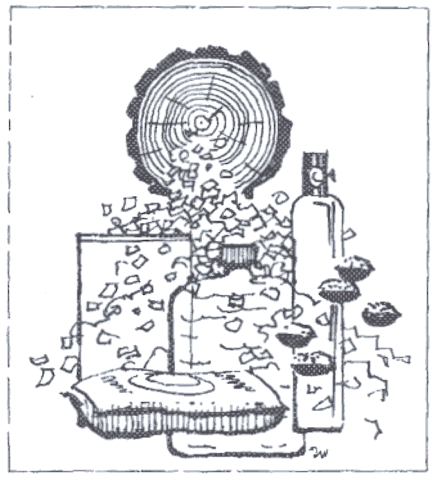
Further evaluations of nutrient drain resulting from intensive harvesting must be made.

Establishment of marketing systems is a necessity. Only through such systems can the cost of biomass be competitive and the supply to consumers be dependable. In many regions, wood energy is now economically competitive, and a major reason why more institutions have not converted is their apprehension about dependable supplies Threatened by recent supply problems with natural gas and oil, consumers are reluctant to make large investments to switch to a fuel that has virtually no developed marketing and delivery system. Those consumers who are switching are insisting on long-term supply contracts. The forest products industries, in the unique position of being their own suppliers, are exceptions to this general reluctance.

Development of improved combustion and biomass conversion technologies is important. Work is needed to improve wood burners and to establish efficiency ratings Auburn University, through a grant from the Department of Energy, recently organized a national center to test and rate residential equipment; fireplaces and stoves now in use vary in efficiency from 10 to 60 percent. Also needed are more efficient and more automated furnaces, new pyrolysis equipment, and fuel preparation systems for more efficient handling and cleaner combustion. Such developments are critical to increase consumer acceptance and to meet environmental standards.



To achieve the nation's full potential, biomass plantations eventually may be needed. Toward this end, systems of intensive culture should be developed for application to croplands, grasslands, and other areas that, even in pursuit of current goals, are managed far below their productive capacity. Here too, genetically improved native plants and exotic species should be evaluated. In particular, these studies should include the treatment of coniferous species to increase production of oleoresin, a petrochemical substitute. Work to date indicates that oleoresin yield from pine trees can be increased two to ten times through treatment with the herbicide paraquat. Petrochemical substitutes from the forest could contribute 0.85 quads to the national energy budget (McGuire 1977). Harvesting systems appropriate to biomass plantations are another requirement.



Any major commitment to production of biomass for energy will require more complete and reliable procedures for estimating growth, standing stock, and utilization. We must be able to establish biomass limitations and project yield and utilization.

Increase in demand for wood as an energy source may disrupt existing timber supply systems and deplete the resource base. The risks will be greatest in the absence of hard information and strong national policies and programs. If foresters fail to educate the public and establish effective controls, many forests, particularly private nonindustrial ones, may be exploited for short-term gain. As a profession, foresters must help establish policies that balance development and use for the greatest public good.

III. Implications for Traditional Uses

How will using biomass for energy affect traditional uses, especially in resource supply, product pricing, and

market stability? Although the task force could not make the quantitative analysis this question deserves, we do have some observations based on data and on personal experience.

Benefits

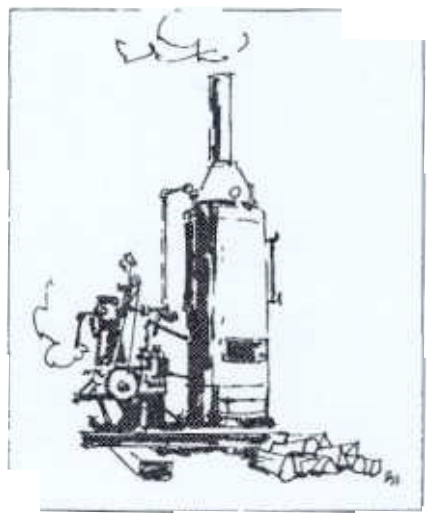
To date, the effort of many forest industries to become energy self-sufficient is the principal influence of increased use of forest biomass. Manufacturing wastes and bark, formerly written off as part of operating costs, now furnish up to half the fuel burned at many pulp and paper and fiber plants. Other wastes, such as logging residues and cull trees, are increasingly salvaged for energy. As systems and markets are developed, wastes can also be used for conventional or reconstituted wood products A number of plants are already making wood fuel products such as pellets.

A recent study (Goldstein, Holley, and Deal 1978) in the North Carolina Piedmont showed several benefits from utilization of hardwood species that were previously thought unmerchantable. Chipped low-grade hardwood was used to produce industrial process steam, fiberboard, and chemicals; all three products, the study concluded, would give timber owners a market for low-grade trees. In addition, the authors said, "the whole-tree chipping-logging system results in a well-prepared site with all culls removed"; such preparation ordinarily would cost $50 or more per acre.

Benefits were also shown in a recent unpublished study of four middle Tennessee counties having 425,500 acres of forest on sites classified as average or poorer. The study (unpublished analysis, Division of Forestry, Fisheries, and Wildlife Development, TVA, 1978) assumed that 55 percent of the low-grade hardwood harvested would be available for energy, and would replace 11 percent of oil and natural gas used in the area, saving consumers about $3 million per year. Stand improvements resulting from the harvest would be worth an additional $640,000 annually for 20 years Removal of the low-quality wood would reduce site preparation costs and hasten natural regeneration, reduce planting costs, provide fire protection, increase landowner income, and possibly enhance scenic values and recreation opportunities.

Intensive forest management and frequent harvesting will require access systems that are well planned from both an environmental and an economic standpoint. Capital for development of such access may be difficult to find in the beginning, but sustained increase in the biomass harvest will help overcome such economic restraints. As growth and utilization increase, technological advances also should lead to more efficient harvesting systems. With a dependable raw material flow, industry inventories can be lowered, reducing overall operating costs. In addition, industries now primarily concerned with manufacturing conventional products are likely to diversify for more complete resource use.

Emphasis on the growth of forest biomass dor energy in no way precludes use for conventional fiber products. The ultimate disposition of the



material will still be determined by society's needs and the relative economic net values of the products.

Possible problems

The major hazard in the orderly development of the nation's wood energy potential lies in the normal tendency to overreact to both opportunities and economic pressures. Booming sales of wood stoves for home heating and rapid conversion by commercial, institutional, and some manufacturing operations to wood-fueled systems may result in local or regional economic dislocations. For example, raw materials might be diverted from such established uses as pulp and paper and fiberboard. At the same time, too rapid expansion of biomass harvesting may lead to local or regional overproduction. Both trends could lead to price fluctuations adversely affecting both wood energy industries and raw materials for conventional uses, at least temporarily.

These problems would be expected, however, to ease as the wood energy industry matures. At the same time, the task force believes that vigorous development of a unified national policy, combined with careful long-range planning, can prevent or ease the adverse effects of boom-or-bust cycles. In the long run, it is imperative that forest growth be increased, costs of harvesting be lowered, new product development and production processes be accelerated, and energy and conventional product operations be integrated into the broadest possible forestry industry growth.

IV. SAF Policy and Activities

The task force recommends that SAF adopt a national position on forest biomass as an energy source. The position should cover the points outlined below and should receive wide publicity, including presentation to Congress and the White House.

Circumstances and opportunities

U.S. forest resources could be mobilized to supply in perpetuity up to 20 percent of the nation's current energy consumption if the problem of harvesting residual wood at a price competitive with fossil fuels were solved. Such mobilization would complement rather than threaten traditional timber uses and the economy they support; would improve the biological health and productivity of the nation's forestlands, and would strengthen the U.S. position in the world economy and generate significant employment.

Recommended SAF activities

1. The Society of American Foresters should promote achievement of U.S. biomass potential by

- publicizing the significance of biomass as an energy source,
- encouraging improved estimates of supply and utilization potential,
- helping to ensure that equipment and technical systems are available to produce wood energy economically,
- promoting forest practices and incentives to increase the growth of biomass,
- supporting legislation to produce biomass on idle or abused lands,
- promoting use of industrial and logging wastes, underutilized trees, silvicultural thinnings, and urban tree removals and wood wastes.

2. SAF should encourage substitution of wood for energy-intensive materials such as aluminum, steel, plastic, and concrete, as recommended by the earlier Task Force on Energy and Forest Resources.

3. SAF should support research and development of improved silvicultural, logging and transport, marketing, and energy conversion systems; encourage economic analysis of the effects of alternative biomass use; and stimulate research on environmental impacts

4. SAF should also support efforts to educate the profession and the public as to the energy potential of biomass, and promote foresters' participation in policy formation and information exchange Especially important are

- encouraging forestry schools to increase biomass curriculum,
- encouraging foresters to take part in policy and other institutional processes that can influence major deci-

sions on biomass use,

- urging foresters to work with private and public utilities to promote biomass as an energy source,
- supporting establishment of a national clearinghouse for biomass information,
- integrating research by foresters and other technical and scientific professionals, such as engineers, architects, and chemists,
- promoting distribution of integrated technical information to legislators and government administrators,
- emphasizing that the USDA Forest Service should have primary responsibility for development of national forest biomass potential.

V. Further Task Force Recommendations

The task force recommends that the SAF Council, in addition to adopting a position similar to that outlined, also establish a means to obtain members' opinions on biomass and report on these views. The *Journal of Forestry* should be utilized to the extent feasible. Further, the task force believes that establishment of a group to monitor significant national activities would be wise; the same group could recommend Society positions and policies. The task force recommends too that the needs identified in this report be assigned to existing working groups, where such assignment is appropriate, and that new working groups be created for the needs that do not fit an existing group.

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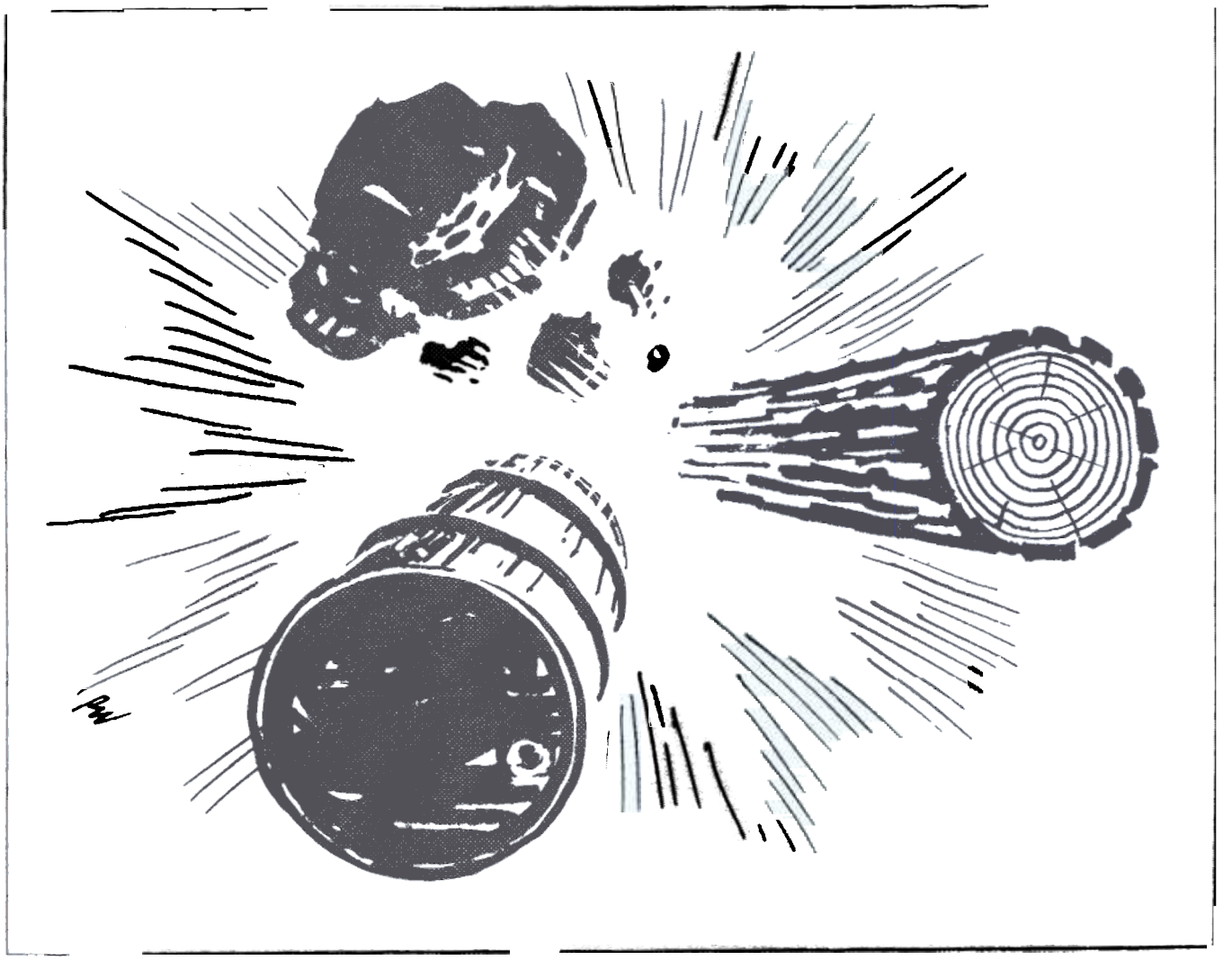

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Society of American Foresters
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Washington, D.C. 20014