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**SHORT-ROTATION WOODY-
CROPS PROGRAM**

**Quarterly Progress Report
for the Period Ending
May 31, 1981**

J. H. Cushman
J. W. Ranney

ENVIRONMENTAL SCIENCES DIVISION
Publication No. 1901

MASTER

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SHORT-ROTATION WOODY-CROPS PROGRAM

Quarterly Progress Report for the Period Ending
May 31, 1981

J. H. Cushman, Technical Assistant
J. W. Ranney, Field Program Manager

This report contains material prepared by
the individuals listed on the following page.

ENVIRONMENTAL SCIENCES DIVISION
Publication No. 1901

Date Published - April 1982

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This document contains reports from the principal investigators of research projects in the Short Rotation Woody Crops Program. The investigators who prepared reports, their institutions, and the relevant grant or contract numbers are listed below.

Institution	Investigator(s)	Contract Number
University of Arkansas	T. T. Ku	UCC-ND Subcontract No. 7941
BioEnergy Development Corporation	T. B. Crabb	UCC-ND Subcontract No. 9061
University of Florida	D. L. Rockwood L. F. Conde	DOE Grant NO. DE-FG01-80-CS-84011
University of Georgia	K. Steinbeck C. L. Brown	UCC-ND Subcontract No. BA-7860 PA-X02
University of Houston	J. R. Cowles H. W. Scheld	DOE Grant No. ET-78-G-01-3037
University of Illinois	G. L. Rolfe	DOE Grant No. ET-78-C-01-3067
Kansas State University	W. A. Geyer	UCC-ND Subcontract No. 7934
Michigan State University	J. W. Hanover	DOE Grant No. DE-FG01-78ET20595
Michigan Technological University	R. L. Sajdak	DOE Grant No. ET-78-G-01-3071
University of Minnesota	R. S. Farnham	DOE Grant No. DE-FG01-78ET20588
Mississippi State University	S. B. Land, Jr.	SERI Subcontract No. XP-9-8075-1
North Carolina State University	D. J. Frederick R. C. Kellison W. E. Gardner	DOE Grant No. ET-78-G-01-3038
North Central Forest Experiment Station USDA-Forest Service	D. Dawson	Interagency Agreement 800R 20763
The Pennsylvania State University	P. R. Blankenhorn T. W. Bowersox C. H. Strauss	UCC-ND Subcontract No. 7928
The Pennsylvania State University	W. E. Sopper D. R. DeWalle S. N. Kerr	DOE Grant No. DE-FG01-78ET-20590
Seattle City Light/ University of Washington	L. S. Dolan P. Schiess	DOE Grant No. DE-FG01-78ET20593
University of Vermont	F. Laing	DOE Grant No. DE-FG01-78ET-20596
Virginia Polytechnic Institute and State University	W. B. Stuart T. A. Walbridge	DOE Grant No. DE-FG01-78ET-20597
University of Washington/ Washington State University	R. F. Stettler P. E. Heilman	DOE Grant No. DE-FG01-78ET-20599

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ABSTRACT

CUSHMAN, J. H. and J. W. RANNEY. 1982. Short rotation woody crops program quarterly progress report for the period ending May 31, 1981. ORNL/TM-8156. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 124 pp.

Progress of twenty projects in the Department of Energy's Short Rotation Woody Crops Program is summarized for the period March 1 through May 31, 1981. Individual quarterly reports are included from each of the projects. These reports discuss accomplishments within specific project objectives and identify recent papers and publications resulting from the research.

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1.0 SUMMARY

This report covers the progress of the Short Rotation Woody Crops Program (SRWCP) from March to May 31, 1981. The SRWCP is designed to improve the productivity and decrease the costs of growing wood in short rotation systems. The program is supported by the Department of Energy's Biomass Energy Technology Division. Oak Ridge National Laboratory (ORNL) provides field management. This quarter, the SRWCP consisted of twenty research projects at nineteen different institutions.

The major program activity this quarter was the annual review of projects and proposals. Thirty-one proposals and preproposals for new or continued research were evaluated. Twenty continuing projects and nine new projects were approved for funding in 1981-1982. Most of the continuing projects have DOE grants that will expire between June and August 1981. The funding mechanism will be converted to Union Carbide Corporation subcontracts through ORNL as they expire and are renewed. Work on the new subcontracts began as soon as the projects were approved for funding.

This quarter saw the beginning of the growing season. Most of the research projects assessed winter survival and began scheduled spring planting and plot maintenance. Some winter damage was reported, and continuing drought makes the survival of some of last year's plantings in the Southeast questionable. However, all projects are on schedule. No serious delays are anticipated.

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2.0 BACKGROUND

The Short Rotation Woody Crops Program (SRWCP) is designed to improve the productivity and increase the cost efficiency of growing and harvesting woody plants for fuels and petrochemical substitutes. It is a field-oriented long-range research program that includes over twenty individual research projects at institutions across the United States. Oak Ridge National Laboratory provides field management for the program, which is sponsored by the Department of Energy's Biomass Energy Technology Division.

The Short Rotation Woody Crops Program was started in 1977, with a DOE Program Research and Development Announcement. Most of the continuing projects in the program originated with proposals written in response to that announcement. Until the summer of 1981, the program was called the Fuels and Chemicals from Woody Biomass Program. The name was changed to reflect the program emphasis on research related to growing woody biomass.

The major SRWCP research areas are: (1) species screening and genetic selection; (2) stand establishment and cultural treatment; and (3) harvest, collection, transportation, and storage. Species screening and genetic selection projects emphasize the selection of promising species, or strains within a species, for biomass production under short rotation intensive culture. Because these projects are looking for species that will grow rapidly under cultural practices which are also the subject of research, they often have experimental components such as variation in spacing or herbicide treatments in common with the stand establishment and cultural treatment studies (Area 2).

Stand establishment and cultural treatment is the largest research area in the program. The establishment period is critical in intensive silviculture. Stand establishment studies are looking at methods of site preparation, production and treatment of planting stock, planting techniques, fertilization, irrigation, and weed control. The goal of stand establishment studies is to produce a stand of healthy, rapidly growing trees at some specific spacing. Cultural treatment studies are determining the effects of variations in spacing, length of cutting cycle, fertilization, irrigation, and site differences on biomass yields. Many of the establishment and management studies are using more than one species and can also be considered species-screening studies.

Research Area 3 (harvest, collection, transportation, and storage) is the smallest area in the program. Short rotation coppice forestry will need harvesting systems that can handle large volumes of small material. The cutting mechanism will have to sever multiple sprouts from a single stump and leave the stumps and root systems in shape to regrow.

This report covers the progress of the SRWCP from March to May 31, 1981. During this period the project consisted of twenty research projects. All were continuations of work reported in earlier progress reports. This document consists of reports from nineteen of the twenty projects. No report was received from the project at Utah State University. Introductory material discusses major ORNL activities and summarizes progress in each of the major program areas.

3.0 MAJOR PROGRAM ACTIVITIES

3.1 ANNUAL REVIEW OF PROJECTS AND PROPOSALS

The annual technical review of projects and proposals for the Short Rotation Woody Crops Program was held in Atlanta, Georgia, March 17-19, 1981. Eight outside reviewers assisted ORNL technical advisors in evaluating reports and proposals. Sixteen existing research projects, eleven complete proposals, and four preproposals were evaluated. Three individuals reviewed each project or proposal, recording ratings and comments on evaluation forms designed for the review.

Proposals were rated on progress (renewal proposals), proposer capabilities (new proposals), technical quality of proposed work, and relevance to the objectives of the woody biomass program. Reviewers were asked to give specific comments as well as numerical scores. Because preproposals do not have enough detail for such a review, reviewers commented on them but did not give them numerical scores. Each review was conducted independently. When reviews of the same proposal differed, the reviewers discussed their differences with the ORNL advisors. Reviewers could revise their scores after such discussions, but they were not required to reach a consensus.

ORNL gave DOE's Biomass Energy Systems Division summaries of the reviews and recommendations for 1981 projects and funding levels on April 2, 1981. The projects approved by DOE for 1981-1982 are listed in Table 1.

Table 1. Short Rotation Woody Crops Program (SRWCP) Projects by status

Institution	Investigator(s)	Title
<u>Continuing Projects</u>		
BioEnergy Development Corporation	T. B. Crabb	Eucalyptus plantations for energy in Hawaii
University of Houston	J. R. Cowles H. W. Scheld	Cultural and management practices for the Chinese tallow tree
University of Vermont	F. Laing	The production of biomass for energy on abandoned farmlands in the Northeast
Mississippi State University	S. B. Land, Jr.	Genetic selection of American sycamore in the mid-South
University of Florida	D. L. Rockwood L. F. Conde	Biomass and chemicals from woody species in Florida
University of Illinois	G. L. Rolfe	Woody biomass production through solar energy conversion
Michigan State University	J. W. Hanover	Tree species and management strategies for biomass production in the Lake States
Michigan Technological University	R. L. Sajdak	Application of sugar maple and black locust to biomass/energy
University of Minnesota	R. S. Farnham	Use of wetlands for production of woody plants for energy
North Carolina State University	D. J. Frederick R. C. Kellison W. E. Gardner	Species selection and silvicultural systems for biomass in the Southeast
USDA-FS, North Central Forest Experiment Station	D. Dawson	Establishment of <u>Populus</u> energy plantations
Pennsylvania State University	P. R. Blankenhorn T. W. Bowersox C. H. Strauss	Net energy and economic analyses for producing <u>Populus</u> hybrids
University of Arkansas	T. T. Ku	Use of understory vegetation as a renewable energy resource
Seattle City Light	L. S. Dolan P. Schiess	Cultural treatment for selected species for the Pacific Northwest
Virginia Polytechnic Institute and State University	W. B. Stuart T. A. Walbridge	Short rotation harvesting machines and systems

Table 1. (continued)

Institution	Investigator(s)	Title
<u>Continuing Projects</u>		
Pennsylvania State University	W. E. Sopper D. R. DeWalle S. N. Kerr	Maximizing woody biomass production using municipal wastewater
Kansas State University	W. A. Geyer	Great Plains energy forest
University of Washington	R. F. Stettler P. E. Heilman	Evaluation and genetic improvement of black cottonwood for coppice
Utah State University	C. M. McKell	Selection of high producing shrubs of the Western United States
University of Georgia	K. Steinbeck C. L. Brown	Increasing the biomass production of short rotation coppice forests
<u>New Projects</u>		
Packaging Corporation of America	M. J. Morin	Demonstration plantations for the Lake States
University of Arizona	L. Hogan D. A. Palzkill	Screening and development of semi-arid plants for increased productivity
Biosys Corporation	C. Vail	Land for mini-rotation silviculture in Western Lake States
Texas A&I University	P. Felker	Production of woody biofuels from mesquite
USDA-FS, Pacific Northwest Forest and Range Experiment Station	D. S. DeBell C. A. Harrington	Increasing the biomass production of alder plantations in the Pacific Northwest
University of Alaska	J. Yarie	Wood for energy in the Taiga
Mathtech Corporation	W. J. Barr	Harvesting of short rotation biomass
University of Georgia	W. L. Nutter	Sewage and short rotation integrated system
Michigan State University	J. W. Hanover	Research in support of IEA Group B activities - tag alder seed collection

3.2 TRANSFER OF CONTRACT MANAGEMENT TO ORNL

In the past, SRWCP projects received grants or contracts directly from the Department of Energy. This year, ORNL will begin to serve as the contracting agent as well as the technical monitor for the program. Existing DOE contracts and grants will not be renewed. After they expire, funds will reach projects through new subcontracts with Union Carbide Corporation, Nuclear Division (UCC-ND), which operates ORNL for the Department of Energy. We expect to have the new subcontracts in place as the old ones end. The change should not cause breaks or delays in funds for any project. It will simplify the process of making minor changes and adjustments to subcontracts. The exceptions to this change are the projects at Seattle City Light/University of Washington and the University of Washington/Washington State University, which will receive renewal funds through contracts with DOE's regional office in Seattle. Projects at USDA-Forest Service research stations will be covered by interagency agreements negotiated by DOE's Oak Ridge Operations Office.

Most of the continuing projects in the program have grant expiration dates between June and August. Work on UCC-ND subcontracts for these projects began immediately after they were approved for renewal. Subcontracts will be initiated for new projects as soon as work on the continuing projects is completed.

3.3 OTHER ACTIVITIES

J. W. Ranney, Field Program Manager, represented the Department of Energy at March meetings of the International Energy Agency's Planning Group on Biomass Growth and Production in Toronto, Canada. Planning

Group members and participants include representatives from Belgium, Canada, Denmark, Finland, Ireland, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The planning group is supporting a variety of studies on aspects of intensive forestry and coppice management and is creating means for international collection and distribution of woody species important for biomass production.

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4.0 MAJOR PROJECT ACTIVITIES

4.1 SPECIES SCREENING AND GENETIC SELECTION

This quarter, screening and selection projects report activities ranging from new experimental crosses to analysis of harvest data. One project which was represented in this section, Peter Felker's mesquite (Prosopis spp.) screening trials, was completed this quarter and will be reported in a final report on the entire project. Mississippi State University reports harvest data from the first two of four sycamore (Platanus occidentalis) plantings. This study examined the performance of families of trees from the same sixteen geographic sources at two different sites. There were significant growth differences between sites and among families. However, the trees that performed the best and the poorest at both test sites were from the same geographic sources.

Michigan State University and the University of Washington/Washington State University report work on inter- and intra-species crosses to increase the genetic diversity available for selection. Both projects are working with species of Populus. Michigan State is experimenting with trembling and bigtooth aspens (P. tremuloides and P. grandidentata). The University of Washington/Washington State University project is crossing black cottonwood (P. trichocarpa) and eastern cottonwood (P. deltoides).

This quarter also saw all projects assessing winter survival and beginning or continuing scheduled growing season maintenance and monitoring. While the University of Vermont reported heavy freeze damage, all projects are essentially on schedule.

4.2 STAND ESTABLISHMENT AND CULTURAL TREATMENT

The majority of the research projects in the Short Rotation Woody Crops Program fall into this category. Some problems being studied include the propagation of planting material, planting techniques, and weed and insect controls. The most important goal of these studies is to determine the amount of woody material we can expect to produce in short rotation systems. The most important factors which affect production appear to be site type, species, fertilization, spacing, and number of years between harvests. Most of these studies are looking at several species, spacings, site types, and cultural treatments. Because many projects are comparing different species or different strains of a species, some of the work reported in this section can also be considered to be species screening or genetic selection studies.

All projects are essentially on schedule. This quarter saw the start of the 1981 field season in most regions. Most of the projects that had scheduled planting this spring completed it during the quarter. Studies in many parts of the country reported very good early season growing conditions. Extreme weather and vandalism did cause problems in a few areas. Several new studies were begun.

Last year, drought affected almost all projects in the eastern half of the country. This spring, reports of very good spring weather and early growth came from Texas (University of Houston), Hawaii (BioEnergy Development Corporation), Wisconsin (North Central Forest Experiment Station), and Kansas (Kansas State University). In the Southeast the drought continued. North Carolina State University reports that the survival of one of last year's test plantings is questionable. The

University of Florida reports very low water tables and suspects poor seedling germination and growth in its greenhouse may be caused by salts in the watering system. The only unusual pest problem was reported by The Pennsylvania State University (Sopper, DeWalle, and Kerr), where gypsy moths may be reducing this year's biomass production. BioEnergy Development Corporation's planned seed orchards are being delayed by slow progress in vegetative propagation research.

Studies of stump sprouting and coppice regrowth are beginning in several projects. Most of the earlier sprouting work in the program had used natural stands or plantations planted for various reasons before the SRWCP studies started. The new studies, which are reported this quarter by Kansas State University and the Universities of Houston, Florida, and Georgia, are looking at regrowth in SRWCP spacing and treatment trials. The species in the various tests include silver maple (Acer saccharinum), Chinese tallow tree (Sapium sebiferum), eucalyptus (Eucalyptus spp.), and sycamore.

The major activities scheduled this quarter were planting and plot maintenance. Seven projects had stand establishment work planned for 1981. Three of these projects (Kansas State University, the University of Illinois, and the North Central Forest Experiment Station) essentially completed the planting this quarter. The others reported planting, seedling, production, and site preparation for later this year. The University of Florida, University of Georgia, and University of Minnesota all prepared planting stock for planned tests. All regular maintenance and sampling activities are proceeding as scheduled. No unusual conditions or delays are anticipated.

Some new observations and conclusions are presented in this quarter's reports. The University of Arkansas shows the results of understory biomass harvests in pine and mixed pine-hardwood forests. In Hawaii, the BioEnergy Development Corporation found that Eucalyptus saligna growing on plots with good weed control had twice the diameter and almost twice the height growth of trees growing in competition with weeds. The North Central Forest Experiment Station moved its spring planting date from April to the last half of May, based on data from the past two years. The University of Florida's genetic studies are finding high variability in biomass production and frost hardiness in progeny tests of Eucalyptus grandis, E. viminalis, and Casuarina spp. The University of Georgia found that over 90% of the black locust (Robinia pseudoacacia) and princess tree (Paulownia tomentosa) plantlets produced by tissue culture and outplanted in December 1979 were alive in April 1981.

4.3 HARVEST, COLLECTION, TRANSPORTATION, AND STORAGE

There is now only one project which falls in this category, Virginia Polytechnic Institute and State University's "An Integrated Investigation of Procurement, Harvesting, Drying, Transportation, and Storage of Woody Biomass." This quarter, Virginia Polytechnic Institute and State University reports on several tests of its recently developed forest residue baler. Results of time and force analyses of the baler feed mechanism are presented, and baling tests using crushed forest residues and simulated short rotation material are described. The simulated short rotation material consisted of mixed hardwood stems which were run through a sugar cane test mill. In three days the material air-dried

from greater than 100% moisture content to an 18% moisture content while sitting in a loose pile. The dried material formed a very compact bale with the highest solid volume content of any experimental bales from the trial.

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5.0 SPECIES SCREENING AND GENETIC SELECTION REPORTS

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FUELS and CHEMICALS FROM WOODY BIOMASS
QUARTERLY REPORT

Name: James W. Hanover

Institution: Michigan State University

Project Title: Tree species and management strategies for biomass production
in the Lake States.

Reporting Period: March 1, 1981 to May 31, 1981

Introduction:

We are continuing to monitor the species trial plantations while expanding work on the genetics of promising species. Our ultimate goal of infusing genetic improvement in biomass species will most quickly be met with this strategy. Greenhouse and nursery work is just beginning to gear up at the end of this quarter, and field activities will markedly increase next quarter. Work on cutover sites is progressing, and will continue to be more important with time.

Tasks: 1. Advisory and Coordination

A tour of Kellogg Experimental Forest was conducted this quarter by Jim Hanover for members of the Forestry Department and other faculty members on campus interested in biomass production. One of our species trials and other high yield plantations are at the forest, and were visited by the group. The purpose of the tour was to allow interaction among researchers regarding potentials and problems with biomass production.

2. Seedling Production

Production of several species for use on cutover sites was begun during this quarter. Red and black oak and blue spruce were started in the greenhouse, and trembling and big-tooth aspen (see Task 8) were started in the nursery. The honeylocust rangewide progeny/provenance test continue to grow in the greenhouse. Also, 4200 hybrid poplar cuttings were distributed to 4-H members throughout Michigan as part of an Energy Tree Project. Each of the participating members will measure survival and growth rate for a five year period to provide us with information on clonal differences throughout the state. Preparations were also made for sowing the seeds for species that will be used on the cutover sites.

3. Site Preparation

Seven acres of a 28 acre northern hardwood forest were clear-

cut at Chatham, MI. The sawlogs were cut by hand and a feller buncher was used to cut and pile the pulpwood-size trees. The large tops were dragged to an adjacent field and the rest of the slash is being removed by firewood cutters.

Approximately five acres of the tract will be treated in August, 1981 with Roundup & Garlon 3A to control stump sprouts and volunteer seedlings. The remaining portion of the area will be used for experimental herbicide research before planting.

Similar areas have been cut on Michigan Consolidated Gas Company and Menasha Corporation land and will be treated in the fall. Species to be tested on all or some of the properties include jack pine, red pine, white pine, english oak, red oak, green ash, European black alder, American elm, black locust, and Douglas-fir.

4. Plantation Establishment

Several genetics plantings of species under consideration for biomass production in the Lake States were established this spring. Three white spruce seed orchards and an eastern white pine progeny test were started. In addition several large (3-4 acre) plantations of Douglas-fir were established at Kellogg and other sites. Interior Douglas-fir appears to have considerable potential for fiber production in the Lake States with proper selection of seed source.

5. Plantation Management

All species trial plantations were sprayed and mowed as needed during this quarter. Other plantations of direct interest to this project were also maintained. This work will continue throughout the summer.

6. Progeny Testing

A major progeny test of trembling and bigtooth aspens (Populus tremuloides and P. grandidentata) and reciprocal crosses between the two species is now underway. Graduate student Greg Reighard has collected 126 open pollinated sources of the two species from 75 counties in Michigan. He has also produced 52 trembling by trembling crosses, 80 trembling by bigtooth, 41 bigtooth by bigtooth, and 62 bigtooth by trembling crosses. All these sources and crosses have been sown in the nursery for out-planting next spring at three sites in Michigan.

7. Plantation and Site Evaluation

A recently released hybrid poplar clone, Populus x euramericana

cv. Eugennii (Imperial or Carolina poplar) has shown much promise for use in Michigan. Graduate student Ruth Woods analyzed a number of test plantings and found that with proper weed control this clone has an excellent growth rate. A copy of her paper is attached.

Young boxelder trees near one of our species trial plantations are growing very well. They will be cut and measured to determine volume/ac/yr. Seeds will also be collected so this species can be included in our trials.

8. Tree Selection and Seed Collection

No new selections or collections were made this quarter. New selections will be made this summer and several different collections will be made this fall. A comprehensive and systematic collection of Eastern tag alders is in the planning stages and should commence fall, 1981.

9. Economic Analysis

The clearcut at Chatham (see #3) and its eventual reforestation will give us good information on the cost of working on cutover sites, and on the feasibility of using these sites for biomass production.

- Presentations:
- A.
 - 1. Tom Stadt
 - 2. Update of Upper Peninsula Activities
 - 3. Monthly
 - 4. Upper Peninsula Extension Center Staff
 - B.
 - 1. Robert Stine
 - 2. Overview of Program
 - 3. March 11, 1981
 - 4. Michigan DNR, Forestry Division Annual Meeting, Big Rapids, MI
 - C.
 - 1. James W. Hanover
 - 2. Status of tree energy project
 - 3. May 27, 1981
 - 4. Alpha Zeta Honorary Society, Michigan State University

Publications: Baertsche, Stephen R. 1980. The potential utilization of short rotation biomass produced trees as a feed source for ruminants. Ph.D. Thesis, Mich. State Univ., East Lansing.

Wood, Ruth. 1981. Growth characteristics of 'Imperial' Carolina poplar over a range of soil types. Tree Planters Notes. (In press).

Wood, Bruce and J.W. Hanover. 1981. Accelerating the growth of black walnut seedlings. Tree Planters Notes 32:35-38.

Gockowski, Ron. 1981. Financial comparison of Accelerated-Optimal-Growth to bare root seedlings in simulated red and jack pine pulpwood plantations in Michigan. M.S. Thesis, Michigan State University, East Lansing.

June 1, 1981

Report No. 81-2

Report Period: 1 March 81 - 31 May 81

CONTRACT TITLE AND NUMBER:

Genetic Selection of American Sycamore for Biomass Production in
The Mid-South.

March 1 - May 9, 1981:

Subcontract No. XP-9-8075-1, Supp. Agreement No. 2
under

Prime Contract No. EG-77-C-01-4042

with

Midwest Research Institute, SERI Division

May 10-May 31, 1981:

(contract no. not yet assigned)

with

Union Carbide Corporation, Oak Ridge National Laboratory

CONTRACTOR NAME:

Mississippi Agricultural and Forestry Experiment Station

Department of Forestry

(Attention: Dr. S. B. Land, Jr.)

P.O. Drawer FD

Mississippi State, MS 39762

CONTRACT PERIOD: 9 Mar. 1979 - 9 May 1982

1. Contract Objective: No change
2. Technical Approach Changes: None
3. Contract Tasks:

(a) Subcontract with SERI for May 10, 1980 - May 9, 1981:

Task 6. - Assess genetic variation in biomass
production at 2 sites.

The oven-dry weight of stem and limb biomass at plantation age five averaged 15.7 metric tonnes per hectare for the Vicksburg and Mississippi State University sites combined. This represented an average rate of production of three tonnes per hectare per year for trees planted at a 3 X 3 meter spacing. An additional 1.5 tonnes of leaf dry matter was present, and the green volume of stem and limb material was nearly 35 cubic meters per hectare. Differences between the two planting years in biomass produced were not significant. Site differences, however, were highly significant, with the site near Vicksburg producing 65 per cent more biomass than the Mississippi State University site.

Seed sources differed significantly in the amount of biomass produced. Results were similar for both dry weight and green volume. Sources from the southern two latitudinal transects produced 28 percent more dry matter than did sources from the northernmost transect (Table 1). These latitudinal trends were the same at both sites. Within a latitudinal transect there was a tendency for the source from near the Mississippi River to outperform the sources to the east and west of that river's alluvial plain. There was a significant interaction between sites and sources within latitudinal transects, however. This interaction was primarily due to the sources "K" and "T". Source "K" did very well relative to the other sources when

Table 1. Seed source and latitude means for oven-dry weight per hectare of stems and limbs in five-year-old sycamore progeny tests at two sites in Mississippi.

Latitude and Seed Source	Oven-Dry Weight of Stems & Limbs (Tonnes/Ha)		
	Vicksburg (Issaquena Co.)	Miss.State Univ. (Oktibbeha Co.)	Combined Over 2 sites
<u>30°45'N:</u>	<u>21.5</u>	<u>12.5</u>	<u>17.0</u>
M	18.5	11.0	14.8
P	21.7	11.9	16.8
B	21.5	13.8	17.6
F	24.4	13.3	18.9
<u>32°00'N:</u>	<u>21.7</u>	<u>12.7</u>	<u>17.2</u>
A	21.1	12.9	17.0
J	20.8	11.4	16.1
N	23.1	14.0	18.6
O	21.9	12.4	17.2
<u>33°15'N:</u>	<u>18.8</u>	<u>12.0</u>	<u>15.4</u>
L	18.3	12.0	15.1
K	20.3	11.6	15.9
G	20.5	12.7	16.6
C	16.1	11.6	13.9
I	14.5	9.6	12.0
T	15.1	13.4	14.3
H	18.4	10.6	14.5
S	15.5	9.6	12.6

planted at the Vicksburg site, but very poorly at the Mississippi State University site. Source "I" did the opposite. The overall best sources ("F", "N", and "B") and poorest sources ("I" and "S") exhibited little interaction, however, as they were consistently the best and poorest sources at both sites. These best sources combined maximum biomass production per tree with high disease resistance, while the poorest sources were both slow growing and highly vulnerable to disease. Therefore, for the two sites being tested there is no need to select different seed sources for each of the sites. Use of seed from near the Mississippi River in southwestern Mississippi and southeastern Louisiana can result in as much as a 50 percent increase in biomass yield at plantation age five over what would be obtained from seed from northeastern Mississippi or west central Arkansas. Biomass determinations at the remaining two sites in Mississippi, as proposed for the third-year phase of this study, will provide seed-source recommendations for other parts of the Mid-South.

Significant differences in biomass yields per hectare were also obtained among mother tree families within seed sources. Year-by-family interactions were not significant. A majority of the top-yielding families came from sources "F" and "N", and most of the lowest-yielding families were from sources "I" and "S". These results reflect the seed source effects already noted. However, not all families from a good source were equally good, as illustrated by the fact that only three of the ten families from the top source ("F") are represented among the top ten families. Additional gains in biomass yields beyond those derived from seed source selection can be obtained from selection of particular seed-parent trees within sources. As an illustration, families "F-1-01" and "F-1-10" averaged 22.35 dry tonnes per hectare for stems and limbs, which was an 18-percent increase over the average for all ten families from source "F". A narrow-sense heritability of 0.72 on family means was obtained for stem-plus-limb dry weight per hectare. Thus, the expected genetic gain from selection of mother trees "F-1-01" and "F-1-10" would be 0.72 times 18 percent, or 13 percent above the mean performance of source "F". For the two sites tested, the best families were "F-1-01", "F-1-10", "N-1-09", and "N-2-06". These families consistently ranked among the top five families at each site, so that separate selection programs would not be needed to match varieties to sites. Recommendations for other sites in the Mid-South, or for one overall selection program for the entire region, must await results from Phase III of the present studies.

Task 7. - Obtain equipment and personnel for 1981.

Five persons have been hired, and equipment (supplies) have been ordered and received for field and laboratory work in phase III of the Study.

(b) Contract with Oak Ridge National Laboratory for May 10, 1981 - May 9, 1981:

Task 1. - Cut trees at 2 sites and take biomass samples.

Sixty-four trees representing one replication at the Laurel site in s.e. Mississippi have been cut, measured for green weights, and sampled. This task is on schedule.

Task 2. - Obtain lab measurements on samples.

This task has just started, and is on schedule.

4. Open Items: All items for Phase II (May 10, 1980 - May 9, 1981) are completed. Remaining tasks (3-5) in Phase III (May 10, 1981 - May 9, 1982) will not begin until all biomass sampling and lab measurements are completed in August, 1981.

5. Summary Status Assessment and Forecast:

The next quarter (June-August) will consist of biomass sampling and lab measurements. These tasks (1 & 2) will be completed at the end of August.

S. B. Land, Jr.
Project Manager

Quarterly Report to U.S. Dept. of Energy
June 1, 1981

The Production of Biomass for Energy on Abandoned Farmlands
in the Northeast

Contract DOE FG 0178 ET 20596
Submitted by F. Laing

Significant, but variable, damage occurred over-winter in the 1979 plantings. Variations are found in species and sites but not in fertilizer level. Plantings made in 1980 were also damaged but to a much lesser extent.

The damage is believed to be due to two distinct weather features. The winter season October 1980 through January 1981 was much colder than normal but with little or no snow cover. The soil was frozen to a considerable depth which may have caused mortality through water loss. Large numbers of ornamental plantings in the area were severely damaged or killed during this period. An argument against this cause is that the 1979-80 winter season was similar but little mortality occurred in the plots. However, please note that the 1980 plantings were not so severely damaged this year so size may be a factor. The period February through April were much warmer than normal, resulting in a "normal" degree day year.

The second weather feature were two nights of heavy frost in mid-May. Newly emerged foliage on a number of species was killed, made obvious by the dead foliage. In most cases refoilation has started although it is not yet possible to ascertain which individual trees will make good recovery. For this reason the percentages given with the species are estimates. A brief description of affected species follows:

Black locust - 25-75% damaged with most loss at Site 9, less at Site 5, lowest at Site 10. Many are opening new foliage but approximately 30% of those affected are dead or not viable.

Red maple - 50-75% damaged with most at Site 10, less at Site 5. The damage in most cases is dieback of the leader, most to a distance of 0.5 - 1.0 meter. About 20% will not survive.

Silver maple - 50-75% damaged, most at Site 1, less at Site 10. The damage is much less extensive with leader dieback generally less than 0.5 meter. Most will survive.

White ash - 75% damaged but almost all showing good recovery.

Green ash - about the same as white ash.

Hybrid poplar - no clone number. 90% showing dieback of leader but less than 0.5 meter.

Bristly locust - 90% damaged, most of which are not viable. These were planted only at Sites 8 and 9.

The remaining hybrid poplar clones showed no damage, sugar maple slight damage. As noted above more recent plantings showed much less damage than the 1979 plots. A more careful assessment of each of the sites will be made when it becomes clear which stems are not viable or competitive.

Two additional replicates have been planted at Site 11, Johnson, Vt. The 5 species used are hybrid poplar, red maple, white ash, black locust, and black cherry; spacing is at 1 x 1.5 meters.

Planting is now underway at Site 12 on the flood plain in Burlington, Vt. Although the area was treated with Roundup (glyophosphate) last fall before plowing additional herbicide treatments will be required. Granular Ronstar or Dacthal WP are to be tried as the plots are established.

Personnel at the Miner Institute in Chazy, N.Y. have prepared an area of about 1.5 ha. which will be planted after Site 12. Herbicide treatment will be required following planting with the actual treatment dependent on the weed population. This area will serve as a first trial for the 4 species planned (hybrid poplar, black locust, silver and red maple). Three replicates at 1 x 1.5 m spacing in plots 24 x 25 m will be established. Following this an additional area for 3 more blocks will be prepared for 1982 planting.

Seedbed establishment has been moderately successful. The seedlings will be transferred to nursery beds as warranted. Seed collection from local individual trees of the desired species will be made as the seed crops mature.

Initial checking of wild biomass coppices will follow the planting work. The areas from which successional species have been cut to obtain weight data will be observed for coppicing.

FUELS FROM WOODY BIOMASSQUARTERLY REPORT

NAME: Reinhard F. Stettler and Paul E. Heilman
INSTITUTION: University of Washington and Washington State University
PROJECT TITLE: Evaluation and Genetic improvement of Black Cottonwood
for Short-Rotation Coppice Culture
REPORTING PERIOD: March 1 - May 31, 1981

Field Trials -- 1A and B

Both field plantings are growing well and seem to be in excellent health.

A trickle irrigation system has been installed in these two experimental plantations, but has not yet been needed because of unusually wet weather this year.

1980 growth data (2nd year) were statistically analysed and compared with those of 1979 (first year). There were considerable changes in the height growth of individual clones in the two consecutive years as expressed by a low overall correlation ($r=0.343$) between first and second year ht. growth for the 55 clones. This was to be expected since first year height growth also reflects sprouting and rooting ability.

Volume growth was somewhat more consistent between the two years ($r=0.460$). Among the top 17 clones that had a significantly higher volume growth in 1980 than the standard "Robusta," fourteen had been among the top 17 also in 1979. The highest performer, Hybrid 5 (a. *P. trichocarpa* x *P. deltoides* hybrid), was significantly different from all other clones in both years, as shown by Duncan's multiple range test. Its average volume after two years was 268% of that of "Robusta"; the corresponding value for the best performing black cottonwood was 207% compared to "Robusta."

Growth of the mixed red alder-cottonwood in Trial 1B continues to improve compared to the pure cottonwood planting. In June, samples of roots and nodules from the interplanted alder were collected. These samples will be used for estimation of rate of nitrogen fixation according to the acetylene reduction technique and for estimation of root and nodule biomass of the alder. Similar samples and measurements will be collected again in the fourth year prior to final harvest. As has been done every year, samples of foliage will be collected this year to continue the monitoring of the effect of red alder on nitrogen status of cottonwood foliage.

Field Trials 2 and 2a

The outplanted seedlings produced during 1980 (population samples as well as interspecific hybrids) have well survived the winter and exhibit vigorous early growth. Weeds in these plantings are a particular problem this year because of a wet spring, but they are satisfactorily controlled by a combination of cultivation and use of roundup as a directed spray.

1981 Crossing Program

Our 1981 crossing program was aimed at expanding the genetic base of our interspecific hybrids (P. trichocarpa x P. deltoides) as well as exploring the relative merits of intra-vs. interpopulational crosses in black cottonwood, involving selected trees from three different populations (Granite Falls, Orting, and Longview). These efforts have met with considerable success and resulted in the following seedling material:

- (a) 441 interspecific hybrids from 30 parental combinations and covering a larger portion of the P. deltoides distribution range (Southern Illinois, Missouri, Louisiana, and Texas);
- (b) 1084 seedlings from 26 intrapopulation crosses of black cottonwood;
- (c) 1889 seedlings from 51 interpopulational crosses of black cottonwood.

Visitors and Publicity

May 28: Dr. R. Barnes, a physiologist from Duke University, with Dr. Leo Fritschen, microclimatologist at the University of Washington.

June 14: Drs. William Libby and R. Burdon from the New Zealand Forest Research Institute, both geneticists; and Dr. R. Ballard, a research manager from Weyerhaeuser Co.

During both winter and spring quarters, students from a forest genetics course and a dendrology course visited the plantation as a demonstration of clonal variations and interspecific hybridization.

On May 28, KING TV of Seattle produced a short program on our energy plantation.

6.0 STAND ESTABLISHMENT AND CULTURAL TREATMENT STUDIES

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Quarterly Report

Fuels And Chemicals From Woody Biomass Program

June 1, 1981

Name: Timothy T. Ku
Institution: University of Arkansas at Monticello
Project Title: The Use of Understory Vegetation as a Renewable
Biomass Energy Resource
Reporting Period: March 1, 1981 - May 31, 1981

The following tasks have been accomplished since the last annual report submitted on March 1, 1981:

- * Preparation of Renewal proposal which was submitted on March 1, 1981.
- * Analysis of biomass data for all 40, 0.2 ha plots (see discussion).
- * Slow progress on clearing of understory vegetation in buffer areas surrounding the 3.05M x 3.05M subplots of each plot:
 - ** Elimination of the larger understory, 4-14 cm (1.5"-5.5") DBH in all 40 plots.
 - ** Elimination of the smaller vegetation in the effective areas surrounding the subplots of 12 plots. This task should be completed for the remaining 28 plots during the summer.
- * Soil and chip sample preparations for analysis.
- * Papers presented by the Principal Investigator:
 - ** Understory Vegetation for Energy. International Union of Forestry Research Organization (IUFRO) Working Party S1.02-09 Maintenance of Site Productivity Conference, Atlanta, GA, April 30-May 1, 1981.
 - ** The Use of Understory Vegetation As A Renewable Biomass Energy Resource. The Third Science, Engineering and Technology Seminar, Houston, TX May 23-24, 1981.

CC: Dr. D. S. Ousterhout
Dr. L. O. Warren

DISCUSSION ON UNDERSTORY BIOMASS

In order to characterize the understory biomass in uneven-aged southern pine forests located in the Gulf Coastal Plain region of southern Arkansas and northern Louisiana, a series of 0.2 hectare (0.5 acre) rectangular plots were established. To cover a range of stand-and-site conditions, the plots were stratified according to the following: pine and pine-hardwood forest types, high and low stand density classes and good and poor sites. During 1979-81, 5-replications of the above 8 stand-and-site conditions were established in a 14-county area (Fig. 1).

In each of the 40 plots, 18 subplots were established, each 3.05M x 3.05M (10' x 10') in size. Nine subplots were harvested in summer during full-foliage and nine subplots were harvested in winter. All vegetation 14 cm (5.5") DBH and smaller were harvested at 15cm (6") above the ground and chipped. Total green weight for each subplot was determined in the field and subsamples were collected, weighed fresh and oven-dried at 70°C. Moisture content of the green chips was calculated so the dry weight of the understory biomass for each subplot could be determined. Plot dry weights were determined by adding the 9 subplot dry weights and expanded to dry tons per hectare. The grand average in understory biomass for all 40 plots was 23.35 T/ha (Table 1).

Statistical analysis indicated a significant difference between good sites (19.98 T/ha) and poor sites (31.06 T/ha) for summer harvest (Table 2). In winter harvest (Table 3), high density pine-hardwood (17.89 T/ha) and low density pine (18.86 T/ha) were found to be significantly different than high density pine stands (28.72). However, since there was no difference between the summer and winter harvests, all plots were pooled to give a larger data base. High density, pine-hardwood (18.10 T/ha) was still significantly different from high density pine stands (27.76 T/ha).

A regression model was developed to predict the understory biomass for all stand-and-site conditions using easily measurable variables:

$$\hat{Y} = 9.4515 + 15.2997X_1 + 34.9823X_2 + 64.4087X_3 + 115.2642X_4$$

where: $\hat{Y}$ = The predicted dry weight in T/ha.

X_1 = number of stems in the 5cm (2 in) dbh class.

X_2 = number of stems in the 7.5 cm (3 in) dbh class.

X_3 = number of stems in the 10 cm (4 in) dbh class.

X_4 = number of stems in the 12.7 cm (5 in) dbh class.

The regression coefficient was 0.85, a respectable value considering the range of diversified southern pine stand-and-site conditions.

Figure 1. Understory Biomass Plot Location Map.

Table 1. Understory Biomass (T/ha) by Stand Types

PINE				PINE HARDWOOD			
High Density		Low Density		High Density		Low Density	
Good Site	Poor Site	Good Site	Poor Site	Good Site	Poor Site	Good Site	Poor Site
----- SUMMER HARVEST -----							
19.28	48.37	9.24	47.31	15.34	18.46	20.48	18.42
19.69	34.91	26.39	34.89	10.32	20.52	26.76	17.03
32.90	25.94	19.74	10.53	22.78	29.22	38.46	50.52
13.46	20.98	9.05	23.07	8.90	23.30	14.10	12.56
25.48	26.91	24.52	27.73	23.11	11.05	57.55	18.02
22.16	31.42	17.79	30.71	16.09	20.51	31.47	23.31
26.79		24.25		18.30		27.39	
25.52						22.84	
				24.18			
----- WINTER HARVEST -----							
20.22	51.02	14.62	31.06	18.73	14.97	25.68	23.30
30.46	28.40	12.78	24.04	11.84	10.15	29.22	32.62
22.47	21.98	16.63	13.80	28.23	13.40	18.21	32.06
17.65	25.50	6.32	18.76	18.22	28.50	2.22	10.46
36.08	33.43	31.48	19.09	5.30	29.59	50.68	21.69
25.38	32.06	16.37	21.35	16.46	19.32	25.20	24.03
28.72		18.86		17.89		24.61	
23.79						21.25	
				22.52			
----- AVERAGE -----							
19.75	49.69	11.93	39.18	17.04	16.72	23.08	20.86
25.07	31.66	19.59	29.47	11.08	15.34	27.99	24.83
27.68	23.96	18.18	17.17	25.51	21.31	28.33	41.29
15.56	23.24	7.69	20.92	13.56	25.90	8.16	11.51
30.78	30.17	28.00	23.41	14.21	20.32	54.11	19.86
23.77	31.74	17.08	26.03	16.28	19.92	28.34	23.67
27.76		21.55		18.10		26.00	
24.65						22.05	
				23.35			

Table 2. Understory Biomass (T/ha) by Stand Types (Summer Harvest)

	Pine		Pine-Hardwood	
	High Density	Low Density	High Density	Low Density
Good Site	22.16	17.79	16.09	31.47
	19.98*		23.78	
Poor Site	31.42	30.71	20.51	23.31
	31.06*		21.91	

* $P > 0.05$

Table 3. Duncan's New Multiple Range Test

Stand Type	Stand Density	Biomass(T/ha)		<u>1/</u>
		Summer	Winter	Average
Pine	High	26.79	28.72 ^a	27.76 ^a
Pine-Hardwood	Low	27.39	24.61 ^{ab}	26.00 ^{ab}
Pine	Low	24.25	18.86 ^b	21.55 ^{ab}
Pine-Hardwood	High	18.30	17.89 ^b	18.10 ^b

1/ Means with the same letter are not significantly different (p 0.05)

BIOMASS ENERGY SYSTEM
QUARTERLY REPORT

Name: Thomas B. Crabb, Vice President and Manager

Contractor: BioEnergy Development Corporation
P. O. Box 1801
Hilo, Hawaii 96720
C. Brewer & Co., Ltd. subsidiary

Contract Identification & Number

Eucalyptus Plantations for Energy Production in Hawaii
DE-FC03-78ET20074

Reporting Period:

March 1, 1981 - May 31, 1981

Contract Objectives:

1. Increase the biomass production of Eucalyptus.
2. Determine the optimum cultural requirements to maximize yield.
3. Assess planting, cultivation, harvesting and transportation equipment requirements, modifying existing equipment if necessary.
4. Determine the optimum mixture of biomass (eucalyptus and bagasse) at the generator for production of electricity.
5. Evaluate a complete production/conversion system which utilized optimum management conditions in relationship to costs.

General:

From January 1, 1981 through May, a total of 92 acres has been planted with 18 acres or 20% of total in experiments. The following six experiments have been installed with the objective of increasing eucalyptus biomass production or determining optimum cultural requirements:

1. Spacing study at Ka'u K-765
2. E. globulus provenance trial at Ka'u K-765.
3. Euc-Legume ratio mix at Ka'u K-765.
4. Viterra 2 hydrogel trial at Ka'u K-765.
5. Species III screening trial at Kamae F-27B.
6. Potting media trial in the nursery.

Crop Logging:

The Hamakua coast has been experiencing unusually dry weather in 1981 with only 32 inches of rainfall through April. The ten-year average rainfall is 23 inches or 92 inches in 4 months.

The eucalyptus trees appear to be responding to this dry weather with lush, green leaves and greatly increased growth. This effect may be due to increased aeration or reduced nutrient leaching and denitrification.

Leaf samples were taken in fertilizer plots where no urea was added and a relatively high level of nitrogen (1.8%) was found in 1981. A year ago when 99 inches of rain fell from January through April, the foliar level of nitrogen was in the deficiency range of 1.1% for these same plots.

Weed Control:

Data from a weed control experiment in Kamae demonstrated the importance of herbicide weed control in stand establishment. The weed control plots received 2 to 3 applications of herbicide after outplanting (Paraquat + Simazine and Roundup + Simazine). The no weed control plots received sickling only 6 months after outplanting.

Herbicide applications tremendously increased Eucalyptus saligna growth. Diameter breast high doubled and height almost doubled with the application of herbicides.

The herbicide, Amitrol, is also currently being evaluated. Not only does it provide fairly good control of grasses and broadleaf weeds but it breaks down into nitrogenous compounds that act as fertilizers. Unfortunately, Amitrol adversely affects mammal's thyroid glands and can cause goiters and adenocarcinomas.

Vegetative Propagation:

Four eucalyptus seed orchards need to be established as one of BioEnergy's project goals. Delayed activity in this area is due to the need to improve vegetative propagation methods so that superior eucalyptus trees can be cloned.

An intermittent mist house has been set up and trials are now underway to determine the optimum conditions for vegetative propagation of eucalypts.

Conservation Land:

BioEnergy Development Corporation is planning to clear and plant eucalyptus trees in 341 acres of Conservation-zoned land. A request for a Conservation District Use Permit was submitted along with an Environmental Assessment to the Hawaii Department of Land and Natural Resources.

Mr. Susumu Ono, Chairman of the Board of Land and Natural Resources, has required an Environmental Impact Statement be submitted. Mr. Richard Webb, Environmental Consultant, has been awarded the contract to write an EIS and he is currently working on it.

BioEnergy will probably encounter some resistance to the use of the Conservation land for a biomass plantation. Mrs. Mae Mull, President of the Hawaii Audubon Society, has already expressed her group's opposition to the use of Conservation land for eucalyptus plantings.

Projected Experiments Through 1981:

1. MicroNutrient trial at Onomea V09B.
2. Liming trial at Amaulu.
3. Rock phosphate trial at Amaulu.
4. Herbicide effect trial at Kamae F-26A.
5. Eucalyptus-Legume ratio test at Kamae F-27C.
6. Species IV trial at Kamae F-27D.
7. Predictions of biomass yields for E. saligna.
8. Determination of heating values for various mixtures of bagasse and woodchips.
9. Vegetative propagation trial in the nursery.

Presentations:

1. Craig D. Whitesell and Susan C. Miyasaka. April 27, 1981. Fertilization for Biomass Production. 14th Hawaii Fertilizer Conference at Kapaa, Hawaii.
2. Susan C. Miyasaka. May 1, 1981. Species Screening Trials for a Biomass Energy Plantation on the Island of Hawaii. 6th Big Island Conference at Hilo, Hawaii.
3. BDC slide presentation to Christian Women's Organization (100) to update them on project by Thomas B. Crabb.

Visitations:

- 2/2/81 - Dr. Kobe Shoji, Consulting Physiologist from Alexander and Baldwin, accompanied by four Sudanese visitors visited the project reviewing its progress and discussing results with the BDC salaried staff.
- 2/3-2/4, - Craig Whitesell, Research Forester, U. S. Forest
4/23/81. Service, spent three days assisting in guidance on technical aspects of the project.
- 2/13/81 - Dr. & Mrs. Hamilton from the East-West Center Environmental Department accompanied by Apolonio Veragaras from Thailand visited the project and familiarized themselves with our progress and results.
- 2/18/81 - Dr. Burger, Mel Smith and Dan Shon from Brewer Chemical reviewed project with staff giving assistance in herbicide and nutrient field.

- 2/20/81 - Al Blanchard, Energy Specialist from the County of Kauai spent some time visiting the project.
- 2/27/81 - Ken Harding, Economic Development Director from the County of Kauai visited and reviewed project.
- 3/2/81 - Howard Horiuchi, State Forester, accompanied by three Micronesian visitors visited the project to acquaint themselves.
- 3/2/81 - John Bidish, SCC Honolulu; Howard Steuermer, SCS Honolulu and Bob Caldwell, SCS Portland. Project visitation and familiarization.
- 3/5/81 - Vic Lepman and photographer from the magazine, "Honolulu" made a project visitation to acquaint themselves prior to writing an article.
- 3/10/81 - Robert Doty, Research Forester, U. S. Forest Service (Hydrologist), to discuss cooperative hydrological test in upper Hilo Coast tree farm area.
- 3/24/81 - Owen Williams, Island Manager of Hawaiian Equipment Company and Philip Marshal, Link Belt representative, toured project with idea in mind to offer suggestions on harvesting methods and machinery.
- 3/24/81 - Aileen Yoshinaga, staff member, Honolulu Department of Energy, visited and acquainted herself with project.
- 3/25/81 - Mike Tulang, Conservationist, SCS. Project visitation and discussion on cooperative effort in furthering Federal objectives between SCC and BDC.
- 3/25/81 - Dave Clark, Pacific Machinery, Sales Representative. Assistance in field operations and primarily infield herbicide equipment.
- 3/26/81 - Environmental Advisory Committee. Quarterly meeting to keep members acquainted with progress. Reviewed specifically endangered plant and bird survey recently completed in Conservation area.
- 3/31/81 - Thao Khamoni, Economic Analyst. Project visitation and consultation.
- 4/9/81 - Dr. Paul Yuen, Director, HEW and staff member Art Seki; Bob Meriam, State Forestry Service and Robert Fujita, PRI. Project visitation and discussions on land ownership, Eucalyptus potential and capabilities in regards to a possible PRI Tree Farm Project on the Island of Hawaii.

FUELS FROM WOODY BIOMASS

QUARTERLY REPORT

NAME: Donald L. Rockwood and Louis F. Conde

INSTITUTION: School of Forest Resources and Conservation
University of Florida, Gainesville, FL 32611

PROJECT TITLE: Energy and Chemicals from Woody Species in Florida

REPORTING PERIOD: 1 March 1981- 31 May 1981

TASK 2: SPECIES AND TREE SELECTION

During this reporting period, data from the Eucalyptus grandis genetic trials were analyzed, E. viminalis and Casuarina screening trials were monitored, seedlings of several species were raised for reestablishment of some trials, and several presentations reviewing woody biomass research were made.

Substantial variations among E. grandis progenies was noted for biomass production through 1.4 years, with the yields of the better progenies being about 50% greater than the average of the 33 progenies at the La Belle, Florida, site. No progeny and spacing interaction was detected in the study with 4,444 to 40,000 trees/ha under investigation. Yields at the densest spacing were four times greater than at the widest spacing.

E. viminalis and Casuarina progenies located near Newberry, Florida, showed a high variability in frost-hardiness following temperatures as low as 8°F. Survival of E. viminalis progenies average 71% with a range from 50-100%. All Casuarina were killed above ground but a number of progenies showed some regrowth.

Black alder, E. viminalis, Casuarina, and melaleuca seedlings were produced to replace or augment studies previously established. Several black alder seed sources will be planted this summer near Perry. Approximately 50 progenies of E. viminalis will be outplanted at one or two northeast Florida sites. Casuarina and melaleuca progenies which had grown well in earlier plantings will be employed to assess biomass productivity at sites near La Belle.

Summary publications of E. grandis results to date were prepared, and several review presentations were made.

TASK 3: BIOMASS FUEL AND SILVICHEMICAL PROPERTIES

More than 1000 E. grandis samples were processed in the previous quarter. Samples were taken from the 1/4-tree-high stem discs collected from the 1) selection plots, 2) spacing plots, 3) Nelder's plots, and 4) fertilizer plots. Wood and bark were separated and their density and moisture content were measured. The determinations have not been completed and will be continued in the next quarter.

TASK 4: BIOMASS YIELD

In March, 5 of the 10 Melaleuca coppice plots described in previous reports were harvested to measure production levels 2 years after the initial cut. The 5 plots near Ft. Myers have been lost to urban sprawl. Second year yields and mean annual increments (MAI) are shown in the attached table. Contrary to expectations, MAI over the two year period was not higher on average than the MAI for the five plots after one year (2.8 dry mt/ha). This may be a reflection of the poor site quality. Casual observations of other areas that had been fertilized after an initial cut indicate substantially greater regrowth than has been measured on our unfertilized plots.

In March and April two reps of the Eucalyptus grandis Nelder trials, one rep of the progeny and spacing trials, and all of the fertilizer treatments, were harvested to 15 cm stumps. Fresh weights were obtained in order to validate the regression equations developed in January. Materials from each treatment and/or progeny were returned to the lab for fuel quality determinations (see Task 3). Initial coppice production by May has been good.

TASK 5: SILVICULTURAL REQUIREMENTS

In May the Casuarina seedlings being grown for July outplanting in La Belle were inoculated with a preparation of ground root nodules obtained from existing trees. Germination and growth of Casuarina in the nursery has not come up to expectations but there will be enough trees to establish a planting in July. Germination and growth of Melaleuca in the same nursery has been an almost total failure. Tests are currently underway to determine the cause of the poor results with both Casuarina and Melaleuca. Initial suspicions center on problems with salts in the watering system, a problem which occurred 3 years ago.

Site preparation, by rotovating, has been completed for the planned Casuarina and Melaleuca July planting. Weed control measures will be applied to increase the chances of successful establishment. We will decide in the next few weeks whether we want to restart Melaleuca seedlings now and attempt a fall planting in September.

TASK 6: WATER AND NUTRIENT USE

- Objectives:
1. Evaluate water and nutrient requirements of fuel farm forests.
 2. Assess environmental and site impact of fuel farm silvicultural practices.

Results and discussion:

A. Chipola Forest: Sand pine

The data of figure 1 do not show a difference in soil water content due to planting densities. The drainage data are highly variable between replicates (e.g. 126% coefficient of variation) as may be expected from the soil hydraulic properties and the sensitivity of measurement. Even so, the high density plantation consistently shows more drainage than the medium-density and low-density plots respectively. Vegetation cover of all three plots is very similar at

MELALEUCA COPPICE BIOMASS

<u>Plct</u> ^{1/}	<u>Original Stand</u>			<u>Coppice Stand Biomass</u>		
	<u>Mean DBH</u>	<u>Stems/ha</u>	<u>Dry Biomass</u>	<u>First Year</u>	<u>Second Year</u>	<u>MAI</u>
1	5.5 cm	23,600	112.3 mt/ha	4.4 mt/ha		4.4
2	6.6	20,000	119.2	5.3		5.3
3	7.0	11,600	71.0	2.0		2.0
4	5.4	29,200	112.0	4.4		4.4
5	10.4	11,200	199.8	3.6		3.6
11	6.6	12,000	93.8	2.2	6.5	3.3
12	6.0	16,000	94.7	2.4	3.3	1.7
13	2.0	158,000	45.0	0.6	1.1	0.6
14	6.0	36,800	158.4	8.1	13.8	6.9
15	6.2	25,200	132.7	0.6	2.8	1.4

^{1/} Plots 1-5 are in Lee Co., plots 11-15 are in Dade Co.

Figure 1. Chipola Forest Lysimetry.

this stage of development. This drainage pattern between plots is opposite to what could be expected and may be due to soil differences. Average drainage amounts to about 4% of rainfall, suggesting considerably more loss to ET than expected. These anomalous observations have prompted the exploration of watershed research potential with the Northwest Florida Water Management District to better evaluate ET. Water chemistry of the drainage water show relatively high levels of nitrogen (1.5 ± 0.8 ppm TKN) and phosphorus (0.6 ± 1.0 ppm TP).

B. Austin Cary Forest: Slash pine and Eucalyptus viminalis.

The data of figure 2 have been calculated from the mass conservation equation:

$$\Delta C = I - (ET - L)$$

where ΔC = change in stored water content.
 I = rainfall input.
 ET = evapotranspiration.
 L = leakage.

The term (ET-L) is the output value plotted in the figures and calculated from rainfall minus changes in water content. Changes in watertable depth and soil specific water yield constants have been used to calculate changes in stored water. Assuming no leakage the data would represent patterns of evapotranspiration. Observed variability is apparently masking any trends due to tree species or planting density at this stage of development. Tests for leakage are under way by adding a known watertable rise above that of the exterior during the dry season, and by subtracting below that of the outside watertable during the wet season.

A masters thesis synthesizing the data is in preparation and will be due fall 1981.

C. La Belle Forest: Eucalyptus grandis, Melaleuca quinquenervia and Casuarina equisetifolia.

The data of figure 3 show a consistent differentiation in soil moisture content with soil depth as may be expected. Casuarina plots failed to establish a tree cover and the data may be used as a control reference. Comparison with Eucalyptus soil water content data suggests a significantly higher water content developing in the low-density plots at all depths of soil during the fall and winter months.

The extended drought conditions lowered the watertable below the rooting zone. Analysis of daily watertable fluctuations for ET calculation has therefore been halted. The research has resulted in the development of an electronic watertable recorder which is presently being tested in field conditions.

TASK 7: PROJECT SYNTHESIS-ENERGY EXPENDITURES

A model for calculating before tax capitalized land values for alternative management regimes has been developed and tested using production functions developed by Bowersox and Ward¹. The model is listed below. It assumes one

¹Bowersox, T.W. and W.W. Ward. 1976. Economic analysis of a short rotation fiber production system for hybrid poplar. Jour. Forestry. 74:11. p 750-753.

Figure 2. Austin Cary Forest Lysimetric Plots

Figure 3. La Belle Forest Lysimetric Plots

rotation from seedlings (cuttings) followed by one coppice rotation.

$$CLV = [(Y1*P) (1+i)^n + (Y2*P) - CP (1+i)^{(n+m)}] / [(1+i)^{(n+m)} - 1]$$

In this equation:

- CLV= Capitalized land value per acre.
- P= price/ton, dry weight, of biomass on the stump.
- Y1= yield in dry tons/acre, seedling rotation.
- Y2= yield in dry tons/acre, coppice rotation.
- i= interest (capitalization) rate, expressed as a decimal.
- n= length in years, coppice rotation.
- m= length in years, seedling rotation.
- CP= regeneration cost, dollars per acre, seedling rotation; vary with growing space in square feet per tree.

This model is designed to identify optimum rotation length as being that which maximizes CLV, and in this form does not include variables, property taxes for example, which might reasonably be expected not to vary with rotation length. In its present form, that is, the model does not identify the profitability of any particular regime but rather the regime of maximum profitability or minimum loss.

The model was first run using a price of \$60/ton dry weight of yield, the yields derived using the Bowersox and Ward production function (for clone NE 388)². Planting costs were taken³ to vary with growing space per tree:

$$CP = 144.3213 + X^{-0.4982}$$

CP= planting costs per acre

X= growing space per tree, square feet.

Optimum financial rotation lengths tested coincided with rotations that produced maximum total dry mass. Price per ton had no effect over the price range tested, \$60 to \$100 per ton. Inclusion of planting costs varying with spacing did not change the rotations indicated by the maximum total dry mass production. Nor did inclusion of a six percent interest charge change the optimum financial rotation from the one of maximum total physical output; doubling the rate to twelve percent did not change the optimum rotation.

Optimum rotation lengths were the same --three years for the first rotation, four years for coppice-- for all tree spacing except the one square foot spacing which was optimum at a rotation combination of 3-2 years. For the 3-4 year rotation combinations, a growing space of five square feet was optimum.

²Work cited.

³From studies of planting cost data on a conventional pulpwood-growing operation.

Currently we have no data on the impact of harvesting costs on price paid for biomass on the stump. If this impact is in the direction of a higher price for more closely spaced trees, there is an indication that rotations might be shortened somewhat.

PUBLICATIONS:

Rockwood, D.L., R.F. Fisher, L.F. Conde, and J.B. Huffman. Australian Pines (Casuarina spp.). Submitted for inclusion in revised Silvics of Forest Trees of the United States.

Rockwood, D.L., R.F. Fisher, and L.F. Conde. August 25, 1981. Production potential of Eucalyptus grandis grown in short-rotation, close-spacing systems. Proc. 13th Inter. Bot. Cong. (abstract).

PRESENTATIONS:

Rockwood, D.L. 3/4/81. Increasing alcohol production from wood by utilizing genetic variation in wood characteristics. TAPPI Annual Meeting, Chicago.

Rockwood, D.L. 4/1/81. Woody biomass production research-results and future plans. U. Fla.-Industry Cooperative Forest Genetics Research Program Advisory Council Meeting, Gainesville.

Rockwood, D.L. 3/24/81. Woody biomass production research in Florida-presentation and field trip. Fla. County Ext. Agents Biomass In-Service Training Session, Gainesville.

Rockwood, D.L., R.F. Fisher, K.C. Ewel, H. Riekerk, and S. Wang. 4/29/81. Woody biomass production-presentations on species selection, silviculture, energy balances, environmental impact, and biomass characteristics and field trip. Training in Alternative Energy Technologies for Developing Countries (36 representatives from 21 countries), Gainesville.

Rockwood, D.L. 5/1/81. Woody biomass production research. Institute of International Education, Gainesville.

Rockwood, D.L. 5/27/81. Genetic, spacing, and genotype x spacing factors for growth of Eucalyptus grandis in south Florida. 16th S. For. Tree Imp. Conf., Blacksburg, Va.

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PROJECT TECHNICAL STATUS REPORT

Date: April 1, 1981

Period: January 1 - through March 31, 1981

PROJECT:

Title: Increasing the biomass production of short rotation coppice forestry.

CONTRACT:

Basic Agreement No. 7860; Project Authorization No. X02

Start Date: 11/15/80

Completion: 11/14/81

This project is a continuation of a project started 10/1/77; with completion date of 9/30/82.

Old project number: DE-AS09-77ET0006

Contractor: University of Georgia
School of Forest Resources
University of Georgia
Research Foundation
Athens, GA 30602

1.0 CONTRACT OBJECTIVE

The purpose of this research is to determine ways of increasing the biomass production of shortrotation hardwood forests. Procedures which will be employed involve screening a variety of hardwood species on such soils as might be available for energy production; evaluating intensive cultural practices such as cultivation, mechanical and chemical weed control, fertilization and irrigation; selection of superior individuals and geographic seed sources of promising species; development of tissue culture techniques for mass cloning of hardwoods; determination of the biomass production of nitrogen-fixing woody species in pure and mixed stands; assessment of changes in soil fertility and organic matter status under pure and mixed stands; and education of students in hardwood silviculture.

2.0 CONTRACT TASKS

Task 1 Maintain plantations

The plantations required no work during the dormant season. Dry weather and low soil temperatures have delayed weed growth. Fertilizer applications scheduled for April.

Task 2 Monitor Plantations

Seasonal measurements completed; this data in process of analysis and interpretation.

Task 3 Genetic improvement

This winter's activities included (a) establishment of new progeny tests of sweetgum and sycamore, (b) extracting, cleaning, counting and testing germination of newly collected sweetgum seedlots, and (c) germination tests of old sycamore collections.

A progeny test of sycamore and one of sweetgum were installed at the B. F. Grant Forest in Eatonton, Ga. this February. The sweetgum test consisted of 104 families from 28 stands, replicated four times. The sycamore test involved 123 families from 43 stands. Eight replications were installed.

In fall 1980 seed from 168 sweetgum mother trees in Georgia and adjacent states were collected for progeny testing. This seed was extracted and cleaned. The number of sound seed per boll varied from about 5 to nearly 100. Since it was not possible to completely separate the sound from the hollow seed, germination tests were run to determine nursery sowing rates. Sowing will be done in April.

Germination tests of sycamore seed collected in past years were also conducted. After two years in dry, cool storage there has been no loss in germination vigor or rate. Sycamore will be sown again this April.

Tests started on response of various clones or selections of sycamore to regeneration by cuttings of various size and location in parent plants.

The laboratory technicians spent the month of January setting up several thousand cultures using an improved method for producing plantlets of sweetgum in agar culture. Approximately 100 Chinese elm cultures from shoot and callus tissue are being rooted on agar media. A number of sweetgum plantlets were transferred to a potting medium in the greenhouse where they will be grown until ready for field planting in the fall of 1981.

Problems with heat and humidity control interfered with the scheduled hardening off of plantlets. It was necessary to try various antibiotics to control internal infection of buds caused by bacteria and fungi in tissue used for plantlet formation, especially in sweetgum. Obtaining and maintaining sterile conditions necessary in pure culture studies and has necessitated efforts to trace sources of contamination and ways to control it.

Task 4 Nursery techniques

The nursery has been prepared for spring planting; weather permitting seeding will take place in April. Dry weather and cold night temperatures have retarded plant growth in the Athens area up to April 1.

Task 5 Cooperation

Steinbeck cooperated with the Public Broadcasting System through local Station WGTV in filming a program on Alternate Energy Sources in the South.

On February 25 a World Bank Forester visited Athens to discuss biomass research and its possible applications in developing nations.

An interview with a reporter from the Atlanta Journal resulted in a newspaper article entitled "UGA Cloning Trees to Add to Resources".

Steinbeck participated in a USFS meeting concerned with a problem analysis of "Silviculture of Piedmont Hardwoods", March 12, 1981 at Statesboro, N.C.

Sommers and Brown attended a meeting in Atlanta at which Dr. Brown presented a paper at the Biomass Energy Symposium. (Feb.)

Task 6 Harvesting plantations

The harvesting equipment arrived and has been tested on plantings on the Whitehall Forest.

Task 7 Energy balance

Records have been maintained on fuel input on various operations and as soon as sufficient data have been accumulated analysis will be made and conclusions reported.

Task 8 Storage of chips

The harvesting performed under Task 6 did not produce enough chips for meaningful storage tests.

Task 9 Slit fertilizer trials

An additional planting, this one of 3 acres in Putnam County, has been established to further test the methods and fertilizer formulations used in 1980 on the planting made on the Savannah River Project.

Task 10 Graduate education

The student working on organogenesis research concentrated his time during the winter quarter on biochemistry courses essential to his research.

3.0 TECHNICAL APPROACH OR WORK PLAN CHANGES

None

4.0 VARIANCE/PROBELMS

Rate of expenditures somewhat below that originally planned. Since it is possible that the larger harvesting and chipping operations may involve unforeseen expenses later in the season, it appears prudent to keep funds back for emergencies.

5.0 OPEN ITEMS

None

6.0 RECENT AND PLANNED ACHIEVEMENTS

Dr. D. I. Dickman from Michigan State University arrived in March for a 6 month sabattic during which time he will work on leaf area development of sycamore and black locust.

Klaus Steinbeck
Claud Brown
Principal Investigators
School of Forest Resources
University of Georgia Research Foundation
Athens, GA 30602

Attachments:

Contract Management
Summary Report

PROJECT TECHNICAL STATUS REPORT

Date: July 10, 1981

Period: April 1 - through June 30, 1981

PROJECT:

Title: Increasing the biomass production of short rotation coppice forestry.

CONTRACT:

Basic Agreement No. 7860; Project Authorization No. X02

Start Date: 11/15/80

Completion: 11/14/81

This project is a continuation of a project started 10/1/77; with completion date of 9/30/82.

Old project number: DE-AS09-77ET0006

Contractor: University of Georgia
School of Forest Resources
University of Georgia
Research Foundation
Athens, GA 30602

1.0 CONTRACT OBJECTIVE

The purpose of this research is to determine ways of increasing the biomass production of short rotation hardwood forests. Procedures which will be employed involve screening a variety of hardwood species on such soils as might be available for energy production; evaluating intensive cultural practices such as cultivation, mechanical and chemical weed control, fertilization and irrigation; selection of superior individuals and geographic seed sources of promising species; development of tissue culture techniques for mass cloning of hardwoods; determination of the biomass production of nitrogen-fixing woody species in pure and mixed stands; assessment of changes in soil fertility and organic matter status under pure and mixed stands; and education of students in hardwood silviculture.

2.0 CONTRACT TASKSTask 1 Maintain plantations

The slit fertilizer test in Putnam County was harrowed in May and again in June. The Savannah River planting was harrowed and fertilized in June. For competition control it was necessary to bush-hog both the Tattnall and the Putnam County plantings.

The progeny tests on both the B. F. Grant Forest and the Savannah River location were cultivated and fertilized with 10-10-10 fertilizer at the rate of 500 pounds per acre.

Task 2 Monitor plantations

Growth and soil nutrient data have accumulated to the point that meaningful analyses can be made and summaries prepared.

Tattnall and Putnam County Plantations

1. Height and Diameter data collected in January of 1981 were recorded on coding forms and subsequently stored on punched cards.
2. Data analysis of height and diameter measurements included calculation of means of various plantings and species combinations as well as testing for significant effects of cultural treatments such as extra fertilization and irrigation.

3. Growth analysis was begun to monitor the progress of height and diameter increment as well as survival rate under various species combinations and treatments.
4. Construction of summary tables covering the current as well as earlier measurements was begun. These tables are stored as a permanent data set in disk-storage in the computer.
5. Completed data on soil nutrients from samples taken during the summer of 1980 were received from the lab. This data was recorded on coding forms and punched onto data cards. Analysis was begun to determine levels of nutrients, pH and percent organic matter among various species combinations and cultural treatments. Correlation analysis was performed to determine correlations between nutrients and soil factors and species composition.

Savannah River Plant Plantation

1. Height and Diameter data collected in November of 1980 was recorded on coding forms and stored on punched cards.
2. Data analysis consisted of calculations of means for diameter and height of the various species and analysis of variance between species and fertilizer treatment.
3. Summary tables were prepared listing mean height, diameter and percent survival.

Seasonal Harvesting Study - Pure Sycamore Plots

Wilkes County Plantings

Determination of Caloric values of various tissues

1. Samples of leaf, bark, stemwood, and branches taken from April 1979 to January 1980 were analyzed for caloric value.
2. Complete data on caloric values from all sampling dates were assembled and recorded on coding forms.
3. An analysis of variance was performed to test the effect of cutting season and to test for differences between tissues.

Whitehall Plantings

1. An experiment for testing the growth dynamics of pure sycamore plots under various thinning regimes was initiated during the latter part of June.
2. An experimental design was constructed and plots were laid out for the various treatments.
3. Three levels of thinning were included in the design as well as a control. The three levels are:
 1. Thin to one sprout per stool.
 2. Thin to two sprouts per stool.
 3. Thin to four sprouts per stool.
4. The plots were thinned and sample trees selected for growth data. Measurements of sample trees included the number of dominant sprouts, total number of sprouts and height and diameter of dominant sprouts. Material thinned from sample trees was collected for determination of dry weight of biomass removed.

Task 3 Genetic improvement

First year survival of progeny tests was assessed and found to be nearly 100% in both the B. F. Grant and the Savannah River plantings.

Additional progeny test material was sown in the nursery. 223 1/2 - sib families of sycamore and 168 of sweetgum were sown in 5 and 4 nursery replicates, respectively. Maintenance of these beds has been a major effort.

Planting sites for the seedlings now are being prepared.

Tissue culture research

Shoot tip culture experiments were continued on practical ways to multiply shoots of the same clone in from 8 to 12 weeks. Means of cloning older trees by the use of shoot tips have been tested on sweetgum, red maple, black locust, and European Alder.

Once plantlets form from root tips they must be transferred to soil-peat media and hardened off for field survival. This transference to field conditions has been difficult to achieve without excessive mortality. Hence experiments with light, humidity and nutrients continue in order to achieve more successful bridging of the gap between the laboratory and the field.

Scanning electronmicroscope studies have been made to determine the relationship between wax formation and distribution of stomates in young plantlets in culture and those transferred to soil in successive stages of acclimatization.

Inasmuch as genetic characters needed for preservation appear or can be recognized more readily in older material, studies have concentrated on rooting response of material from older trees. One approach has been to rejuvenate material and then use the rejuvenated material as the source of mass clonings. Although the initial response of older material to rooting is rather low only a few rejuvenated plants are needed to furnish additional material for cloning.

A check of black locust plantlets outplanted in December 1979 showed that 96% of 25 were alive in April 1981. Forty-nine Paulownia plantlets were outplanted at the sametime; 94% survived.

Task 4 Nursery Techniques

- a. Efforts were made this spring to improve nursery germination of sycamore. Last years germination percentage was less than satisfactory probably because puddling on the soil surface prevented seedling emergence. This year the seeds were sown in depressions filled with sand. Sand was then used to cover the seed. Germination was much better this year than last.

Task 5 Cooperation

In April a film crew from the German Educational Television came to Athens and filmed a project research dealing with renewable energy sources.

The project cooperated with the Greensboro (Ga.) Lumber Company in obtaining energy input-out data related to the fuel consumption rates per ton of wood chips.

Dr. Boulay from AFROCEL France visited the tissue culture laboratory at the School of Forest Resources in April 1971 for the exchange of information on techniques. Boulay found the laboratory and equipment impressive and viewed the program as outstanding, Boulay had been a month in the US visiting other laboratories interested in tissue culture such as Weyerhaeuser, Oregon State, the Institute of Paper Chemistry and commercial labs in Florida and North Carolina.

Sinclair and Steinbeck attended the Southeastern Hardwood Forestry group meeting at Clemson, S. C., April 30 - May 1, reviewing hardwood management problems.

On May 1 T.V. Station 11 in Atlanta arranged for a news and taping session on field research on short rotation forestry.

Sommers attended a session at Beltsville, Md., May 17-21 dealing with Strategies in Plant Reproduction. He is one of four authors on a paper entitled "Strategies in Tissue Culture Propagation." Approximately 250 attended mostly from the United States but with speakers also from England, Wales and the Netherlands.

Sommers and Bongarten attended the 16th Southern Forest Tree Improvement Conference at VPI on May 25-29. Approximately 200 people were in attendance.

Steinbeck addressed Middle School and High School teachers in an energy forum conducted by the College of Education at the University of Georgia.

Task 6 Harvesting plantations

Nothing scheduled during this period except the testing of the newly acquired harvesting equipment.

Task 7 Energy balance

Records are being maintained on the amount and kinds of fuels used on the various operations in tractors, trucks, etc. so that comparisons can be made later on the amount of energy used in relation to the energy value of wood produced in the different experimental plantings.

Task 8 Storage of chips

No activity during this period. It is apparent that the planned harvesting operations may not provide enough material for any meaningful study on the conditions needed for maintenance of chips in piles over a period of time.

Task 9 Slit fertilizer trials

The 3 acre planting in Putnam County has gone through the establishment period successfully with reasonable survival. Maintenance operations for this planting have been reported under Task 1.

Task 10 Graduate education

Michael H. Renfroe, the graduate student working on organogenesis of sweetgum withdrew from the University in June.

3.0 TECHNICAL APPROACH OR WORK PLAN CHANGES

None other than that connected with Renfroe's dropping his research and course work supported by the project.

4.0 VARIANCE PROBLEMS

Manpower on the project continues at the scheduled rate; expenditures still show below the planned rate mainly because equipment costs reflect slowness of purchases and resulting delay in accounting.

5.0 OPEN ITEMS

None

6.0 RECENT AND PLANNED ACHIEVEMENTS

Dr. D. I. Dickman from Michigan State University has made good progress on his leaf area development study on sycamore and black locust. Trees of both species were harvested in late May from pure and mixed stands growing in Putnam County, Georgia. Determinations are being made of species differences in leaf area development and leaf area index. Data collection will be completed by late summer and analysis of results scheduled for later in the year.

Klaus Steinbeck
Claud L. Brown
Principal Investigators
School of Forest Resources
University of Georgia Research
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Athens, GA 30602

Attachments:
Contract Management
Summary Report

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FUELS FROM WOODY BIOMASS

-- Quarterly Report --

NAME: Joe R. Cowles and H. W. Scheld

INSTITUTION: University of Houston

PROJECT TITLE: Cultural and Management Practices for the Chinese
Tallow Tree as a Biomass Fuel Source

REPORTING PERIOD: April 1 - June 30, 1981

GENERAL PROGRESS

Progress in the various tasks has been good. Several tasks begun in the previous reporting period were completed, and several new projects not called for in original plans but now considered important to the overall development of the tallow tree system were initiated. Specifically, these were (1) a study of flowering patterns of the tallow tree, which is important to the development of seed sources for direct planting as well as for planning of future tree improvement studies, and (2) an evaluation of the usefulness of bees in pollination and the economics of honey production in tallow stands.

The growing season thus far has been unusually good. Rains have been frequent and heavy. A total of 18 inches accumulated within one 6-day period, resulting in heavy flooding of all experimental plots. This appeared not to have any deleterious effects upon tallow tree growth. Flowering and seed production have been the best in our experience with the tallow tree.

Described below are the activities undertaken and the results obtained.

TASK I. Biomass increase in established stands.

The only activity in this task was general observations and maintenance of plot access trails.

TASK II. Growth rate under coppice management.

Two stands are now under study. Activity in the originally treated stand (Spring 1978) was limited to general observations and access trail maintenance. In the second stand, cut in 1980, treatment was begun in the previous reporting period and completed in this period. Treatments were as follows:

- A. Thinning of sprouts to an average spacing of 2 ft
- B. Thinning of sprouts to an average spacing of 4 ft
- C. Harvest of alternate 5-ft strips every year
- D. Harvest of alternate 5-ft strips every 2 yr
- E. Control untreated

TASK III. Growth rate in planted stands.

The only activity in this task consisted of cutting (6" stumps) and removing the 3-year-old trees in a 30' x 30' block from the corner of each 2' x 2' plot. This initiates a sub-experiment on coppicing in stands of known spacing after 3 growing seasons. The new sprouts are now approaching heights of up to 4 feet.

TASK IV. Growth and properties of superior trees.

A number of the fastest-growing trees in the planted 2' x 2' plots have been treated to stimulate juvenile sprouts. These will be used in preparation of cuttings for future planting.

TASK V. Economical establishment of stands.

In order to understand the factors affecting seed production, a study was carried out to characterize the flowering patterns of the tallow trees growing on the UH Coastal Center. This consisted of continuous observation of a large number of trees and of bagging studies to assess the mode of pollen transfer. The results thus far are very interesting in a basic biological sense. The following are the salient points:

- A. Flowers are of two basic types, resulting in seed cluster configurations termed "grape" and "eagle-claw."
- B. Opening of stigmata and/or pollen maturation within individuals of the population begins in mid-May and continues to the last week of June.
- C. Male and female flowers on the same tree never mature at the same time.
- D. Male flowers of the eagle-claw type mature and produce pollen first and at the same time the female flowers of the grape type are receptive on different trees.
- E. Male flowers of the grape type subsequently mature at the same time the female flowers of the eagle-claw type become receptive.

- F. This provides an outcrossing mechanism which forces eagle-claw tree flowers to pollenate grape tree flowers and grape tree flowers to pollenate eagle-claw tree flowers.
- G. Wind is the major mechanism of pollen transfer in dense stands such as those on the Coastal Center.

WOODY BIOMASS PRODUCTION THROUGH SOLAR ENERGY CONVERSION

ET-78-C-01-3067

Gary L. Rolfe

University of Illinois

Quarterly Report

March 1 - June 1, 1981

Task 3.2 1980 Herbicide Trials

Data compilation and analysis was completed and reported in the 1980-81 Annual Report.

Task 3.3 Procurement of 1981 Planting Stock

All stock has been received.

Task 3.4 Harvest I - 1980

Harvest I was completed in January 1981.

Task 3.5 Planting III - 1981

Planting III - 1981 is essentially complete at all three sites. Late spring rains have postponed planting of two tenth-acre plots at Site C and one fortieth-acre plot at Site B. All herbicides have been applied.

Task 3.6 Irrigation

Construction of a new irrigation pond for Sites A and B was completed in the fall of 1980. Late spring rains have filled the pond to capacity (24 acre feet). Prime lines have been installed and work continues on field installations of other irrigation equipment.

Publications

1. White, T. A., G. L. Rolfe and D. R. Bluhm. 1981. Yield of six woody biomass species during a two-year establishment rotation in southern Illinois. Ill. Agr. Exp. Sta. DSAC 9:(in press).
2. White, T. A., G. L. Rolfe and D. R. Bluhm. 1981. (Establishment of woody biomass plantations in the Midwest - 1980 herbicide trials. Ill. Agr. Exp. Sta. DSAC 9:(in press).
3. White, T. A., G. L. Rolfe and D. R. Bluhm. 1981. The establishment rotation energy balance of intensively cultured autumn olive (*Elaeagnas umbellata* Thunb.). Ill. Agr. Exp. Sta. DSAC 9:(in press).

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FUELS AND CHEMICALS
FROM WOODY BIOMASS PROGRAMS
QUARTERLY REPORT

NAME: Wayne A. Geyer
INSTITUTION: Kansas State University, Forestry Department
PROJECT TITLE: Great Plains Energy Forest
REPORTING PERIOD: 4-81 to 5-31-81 No. 6
USB CONTRACT NO.: 7934 Union Carbide Corp.

GENERAL COMMENTS:

Plantation measurements have been completed at all sites and subsequent growth calculations are being made. Growth appears to be less than that expected in any one year.

Three new plantations have been installed on the high plains topography of western Kansas. Drought during the last 9 months appears to have been moderated with ample precipitation during May. A coppice study has been initiated on 5-year-old silver maple to determine the effects of cultural treatments on 2nd growth.

TASK: Determine productivity

Three additional sites were planted this spring in far western Kansas for a total of 14 individual planting tests. These new sites are located in NW Kansas at Logan, far west at Tribune on the Colorado border and SW at Garden City. The first is on alluvial sandy loam, the second on upland silt loam, while the latter is on upland sandy loam soils. All sites received approximately 20-22" precipitation a year. To date survival has been good,

but a late May frost damaged the trees on all planted sites, which should be quickly overcome.

Siberian elm, black locust and honeylocust 1:0 seedlings were planted on all 3 sites. The usual weed control treatments of cultivation, Casoron or Ronstar herbicides were used.

Maintenance of the other plantations has begun--weed control the first two years, followed with occasional mowing during subsequent years.

Three additional sites have been located for our final planting during the spring of 1982.

Measurements of survival, ground line diameter, and total height have been completed at all sites. Preliminary calculations are being made and single tree biomass weights will be related to D^2H for yield comparisons starting with 3rd-year data.

Forty additional silver maple (trees larger than previously measured) have been cut for OVD weight and D^2H graphs.

Fourteen hundred 5-year-old silver maple were harvested this winter for a coppice yield study. The trees were planted in 1976 in eastern Kansas at Lawrence at a 4x4 ft. spacing. Two experiments were established, one to test the effects of soil ammendments and another the effect of stump treatments on subsequent sprout growth. We are testing fertilization, weed control, stump height and sprout inhibitors.

TASK: Determine production costs

No further work has been conducted on our first approximation effort as reported in the latest annual report.

TASK: Evaluate herbicide effectiveness

Detailed analysis of herbicide field studies have not been finished. Ronstar is not being sold in the WP formulation which makes future use in the granular form more expensive than desired. Substitute herbicides should be tried. Both tried herbicides need to be applied during the previous fall or winter after the 1st growing season to insure adequate activation.

PRESENTATIONS: None

PUBLICATIONS:

Geyer, W. A. 1981. Growth, yield and woody biomass characteristics of seven short-rotation hardwoods. Wood Science 13(4).

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FUELS FROM WOODY BIOMASS

QUARTERLY REPORT

Name: Robert L. Sajdak, Project Leader

Institution: Michigan Technological University

Project Title: Application of Sugar Maple and Black Locust to the Biomass/Energy Plantation Concept

Reporting Period March 1 - June 1, 1981

1) Plantation Establishment and Evaluation

Measurements of sprout growth for the 1980 growing season were completed. Soil and litter samples were taken to quantify the amounts of fertilizer remaining on the sites. A complete analysis of last year's soil data will be done before beginning analysis of these samples.

2) Growth Potential of Locust

There is no change in this phase of the project since the annual report. Evaluation of survival and growth of locust will begin at leafout.

3) Nitrogen Fixation

Cultural studies of the Rhizobium have been completed. The results of this testing have been used to choose organisms for the next phase of the study. Preparations are currently being made for the testing of the effectiveness of the Rhizobium when in symbiotic association with Black locust under conditions of low pH, low P concentrations, and in the presence of aluminum.

4) Biomass of Young Natural Stand

Analysis is proceeding on the biomass estimator equations which have been developed. Of significance at this time is the fact that height does not appear to perform as well as diameter in the estimation of sprout biomass.

Sites have been selected for the establishment of the Alder (Alnus rugosa) biomass study. The same method developed above will be used. Work is being planned to estimate nitrogen additions in this phase of the study.

5) Characterization of Biomass

Characterization of northern hardwood sprouts by the conventional physical and chemical methods is complete for sugar and red maples, and is continued for other species including, red oak, white ash, aspen, white birch and black locust.

Comparison of the actual cold water extractives with the loss of these extractives during specific gravity determination has provided some interesting observations. For the bark samples of young sprouts, nearly 100 percent of the extractives was dissolved during the soaking period of specific gravity measurements. However, the extractive loss is substantially less for old bark and wood samples.

Presentations: None

Publications: None

FUELS AND CHEMICALS FROM
WOODY BIOMASS PROGRAM

Quarterly Report June 1, 1981

Title: "Use of Wetlands for Production of Woody Plants for Fuels and Petrochemical Substitutes"

Institution: University of Minnesota
Soil Science Department

Period: March 1 - May 31, 1981

Principal Investigator: Professor Rouse S. Farnham

D.O.E. grant No. ET-78-G-01-3082

I. NATURAL STANDS EVALUATION

Biomass estimations of tall shrubs in wetland areas and its relationship to some edaphic factors

M.S. thesis to be completed summer 1981 (by Sept. 1)

March 1 - June 30, 1981

- task 1 A review of the literature and description of the methods has been completed
- task 2 Age determinations of each stand has been completed.
- task 3 A discussion of the methods used to generate the biomass estimation equations has been completed.
- task 4 A statistical analysis and disucssion of this analysis is nearing completion. A one-way analysis of variance was generated via SPSS for comparing biomass estimations between stands and for comparing soil and water analytical results between organic soils stands. A one-way ANOVA was generated for following:
1. Shrub biomass estimations were compared by stand
 2. Shrub biomass estimations were compared on mineral and organic soils.
 3. Shrub biomass estimations were compared on mineral, saprist, hemist and fibrist soils.
 - 4a. Shrub biomass estimations were compared on saprist, hemist, fibrist organic soils.
 - 4b. Soil and water analytical results were compared on saprist, hemist, fibrist organic soils.
 - 5a. Shrub biomass estimations were compared on terric and typic groups of organic soils.
 - 5b. Soil and water analytical results were compared on terric and typic groups of organic soils.
 - 6a. Shrub biomass estimations were compared on high base status (euic) and low base status (dysic) groups of organic soils.
 - 6b. Soil and water analytical results were compared on euic and dysic groups of organic soils.
- Linear regression analysis of mean stand shrub biomass on soil and water chemical characteristics.

June 1 - Sept. 1

- Task 1 In progress is the multiple regression analysis of mean stand biomass on soil and water chemical characteristics.
- Task 2 Complete results and discussion portion of M.S. thesis with a synthesisation of the data.
- 2 papers will be published:
1. Biomass Estimation Equations - published in a North Central Forest Experiment Station Bulletin
 2. Biomass: Soil Relationships - journal not known yet.

II. Propagation Work

Continued vegetative propagation of the ten imported clones of Salix has produced approximately 10,000 plants. The target of 1100 for each clone will be reached for all but one of these selections by the end of May 1981. (See following Salix inventory) The one exceptional clone, (S. smithiana Q666) has been susceptible to disease and has been the most difficult to root of the imported Salix.

The *Alnus* selections for field planting were seeded into plots containing peat/vermiculite/perlite mix and germinated under mist in rented commercial greenhouse space. Five thousand seedlings of each of three species A. glutinosa, A. rubra and A. crispa will be grown to the three to four true leaf stage when a portion of each species will be inoculated with symbiotic nitrogen fixing organism Frankia alnii. The cultures of Frankia which were obtained indirectly from Dr. Torrey in New England have been increased by subculture in fresh media every four to six weeks.

The experiments designed to investigate nutrient effects on macro and microporpagation in Salix are complete. However, the analysis of the data is dependent upon the leaf tissue nutrient content. The samples of leaf tissue have been sent to the analytical laboratory.

III. Preparation for Field Work

A. Collection of Cuttings

Four natural stands of Salix interior were selected as a source of hardwood cuttings based on age and uniformity. These cuttings were harvested in five foot lengths and placed in cold storage. Presently we are cutting this material into 6" lengths for planting within the next month.

Those natural stands selected were as follows:

Henderson site: south central Minnesota, enough material for 20,000 6" cuttings were obtained for use in the variety and spacing study as well as in the demonstration energy forest.

Riverview site: south central Minnesota, enough material for 5,000 6" cuttings to be planted in the variety and spacing study was harvested.

Wabasha site: southeastern Minnesota, material cut for variety and spacing study.

Alma site: west central Wisconsin, material cut for variety and spacing study.

B. Equipment Purchased (Funds provided by Minn. Agr. Expt. Sta.)

1. Plastic covered greenhouse - This facility is presently being erected by our staff at the Wilderness Valley Farms Peat Research Station. This greenhouse is 30 feet wide by 144 feet long and is equipped with fans, heaters and a mist system. The stock plants of Salix will be transferred to the Wilderness Valley Farms site and propagated in this facility to provide a sufficient amount of planting material for the field studies.
2. Transplanter - this two row transplanter will be used to plant both rooted softwood cuttings and non-rooted hardwood cuttings.
3. Fertilizer, Herbicide - Necessary fertilizer and herbicides were purchased to prepare fields for 1981 planting.

C. Rhinelander Trip

On March 25th, we toured the North Central Forest Experiment Station at Rhinelander, Wisconsin. Drs. Ed Hansen, Jerry Zavitzkowski and Howard Phipps showed us both the propagation and field work. Valuable information on weed control, field equipment, plot design and data collection was gained from this visit. Additional clones of poplar were requested by us but insufficient quantities of cuttings was a problem for them at this time. Contact between our staff and theirs will be maintained in order to exchange information on propagation and management techniques and clonal selections.

IV. Wetlands Inventory

The inventory of Minnesota wetlands has been completed as to the location and distribution of the areas.

In cooperation with the Center for Urban and Regional Affairs (CURA) at the University, the data has been compiled and is stored in the Minnesota Land Management Information Systems data bank.

Information for each 40 acre cell is available for soil type, percent land use, vegetation type, geological information, ownership, and suitability ratings for biomass production. We have produced a test matrix model for Aitkin Co. Minn. including all parameters related to availability and suitability for biomass production which is based on edaphic factors and external factors limiting land use. A computer print-out of this information is being tested for Aitkin Co.

SALIX INVENTORY

<u>CULTIVAR</u>	<u>1/27</u> <u>QUANTITY</u>	<u>2/27</u> <u>QUANTITY</u>	<u>4/2</u> <u>QUANTITY</u>	<u>4/27</u> <u>QUANTITY</u>	<u>% GOAL</u>
056	91	949	834	1021	98.2
075	29	712	660	783	71.2
077	705	530	730	1040	94.5
082	967	883	760	973	88.4
083	583	428	1012	1044	94.9
Q683	1367	1220	1048	950	77.2
Q699	1954	1596	1527	1431	100.0
Q802	770	534	470	1000	90.9
Q803	330	281	390	1200	100.0
Q666	68	56	55	444	40.4
SInt	0	134	123	NA	NA
TOTAL	6864	7324	7654	9898	

FUELS FROM WOODY BIOMASS

QUARTERLY REPORT

JUNE 1, 1981

Name: Dr. Douglas J. Frederick, Project Leader
Dr. Robert C. Kellison, Co-Project Leader
Mr. William E. Gardner, Co-Project Leader

Institution: North Carolina State University
School of Forest Resources
Hardwood Research Cooperative
Raleigh, NC 27650

Project Title: Species Selection and Silvicultural Systems
for Producing Fuels from Woody Biomass in the
Southeastern United States

Reporting Period: 3/01/81 - 6/01/81 Contract Number: DE-FG01-78CS-84006
(formerly ET-78-G-01-3038)

Task 1.1: To review and summarize approximately 50 species-site tests established by the N. C. State Hardwood Research Cooperative and determine nutrient levels in trees and soils. (Note: This task is not in the original proposal but was added as Supplement to Volume 1 - Technical Proposal.)

Major summarization of progress on this task was included in the annual report dated March 4, 1981. Analysis of foliar samples for nutrient concentrations in plantation grown sycamore continues, designed to refine the resolution of nutritional differences between sites and fertilizer treatments. It is anticipated that the comparison of foliar nutrient concentrations to soil nutrient levels will be completed this year, so that recommendations for sycamore plantation amendments may be simplified.

Optimum sampling points have been determined for nutrient distribution and content among component parts of trees of several hardwood species by Graduate Student Michael G. Messina. This progress has allowed analysis to proceed with many additional species already sampled, in order to determine stand nutrient distributions as well as the impact of changing utilization standards and management techniques upon long term site fertility.

Task 1.2: To screen and identify tree species and genetic sources most suitable for intensively managed, short-rotation biomass production.

Survival of the species-site trial in Wayne County, North Carolina, near Goldsboro, is marginal because of the prolonged drought conditions (see Table 1). The study is currently being maintained by disking and will be re-evaluated later this growing season for retention or abandonment. Species established earlier in Granville County, North Carolina have withstood the dry conditions much better, and would presently respond to growing season rainfall (Table 2).

Table 1 - Average Height and Survival of Species in the Goldsboro Species-Site Test.

Species	Height (Feet)	Survival Percent
Ailanthus	0.53	30
Red Maple	1.14	33
Loblolly Pine	1.47	47
Cottonwood	1.59	6
Ligustrum	1.71	78
Sweetgum	1.90	59

Table 2 - Average Height and Survival in the Granville County Species-Site Test.

Species	Height (Feet)	Survival Percent
Water-Willow Oak	1.45	76
Virginia Pine	1.74	75
White Ash	2.69	100

Task 1.3: To identify the optimum level of plantation site preparation, stand establishment, and management of the most promising species identified for potential use in energy plantations.

The Piedmont upland site in Granville County, North Carolina is presently being disked to reduce weed competition. In spite of some recent rainfall, soil conditions are extremely hard, making cultivation difficult.

The red river bottom site along the Roanoke River in Bertie County, North Carolina has been given its initial cultivation for 1981 and growth this season is particularly impressive for sycamore, water-willow oak and green ash.

A third energy plantation, established in 1980 near Riceboro, Georgia has maintained generally good survival although this first year's growth was affected by the 1980 drought (Table 3). This study has already been given one cultivation in Spring 1981.

Table 3 - Average Height and Survival of Species in the Riceboro, Georgia. Energy Plantation, evaluated April 15, 1981.

Species	Height (Feet)	Survival Percent
Green Ash	1.5	97
Sweetgum	2.5	90
Water-Willow Oak	1.3	88
Loblolly Pine	1.5	85
Sycamore	2.5	55
<u>Eucalyptus</u> <u>macarthurii</u>	3.0	80
<u>Eucalyptus</u> <u>viminalis</u>	3.5	75

Task 1.4: To employ present and refined genetics breeding programs to locate and/or develop suitable trees to be grown for fuel.

Field sampling was recently completed for Graduate Student Barbara McCutchan, whose project is relating previously evaluated parameters of graded superior sycamore trees and their progeny to energy production. Additional work in selection and evaluation of select trees of some 25 indigenous hardwood species continues.

PRESENTATIONS AND PUBLICATIONS:

Gardner, W. E. 1981. Effect of tract size on the cost of reforestation. M.S. Thesis, School of Forest Resources, North Carolina State University, Raleigh, North Carolina. 44 pp.

Kellison, R. C. 1981. Characteristics affecting quality of timber from plantations, their determination and scope for modification. Invited paper, IUFRO XVII World Congress, Kyoto, Japan. 11 pp.

Kellison, R. C., D. J. Frederick and W. E. Gardner. 1981. A guide for regenerating and managing natural stands of southern hardwoods. Sta. Bull. No. 463, Agric. Res. Ser., N. C. State University, Raleigh. North Carolina. 28 pp.

Kellison, R. C. and J. Sprague. 1981. Forest genetics for tomorrow's southern pine forests. In Press. Pulp and Paper. 16 pp.

Paschke, J. L., G. R. Johnson and W. E. Gardner. 1981. Genetic aspects of nursery management for sweetgum seedling uniformity. 16th Southern Forest Tree Improvement Conference, Virginia Polytechnical Institute and State University, Blacksburg, Virginia. 9 pp.

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ESTABLISHMENT OF POPULUS ENERGY PLANTATIONS^{1/}

Quarterly Progress Report
for the Period

March 1, 1981 - May 31, 1981

David H. Dawson
Principal Investigator

Work Performed Under
Interagency Agreement #DE-AI05-800R20763

^{1/} Registered Trademark Intertechnology Solar Corp.

INTRODUCTION

The period of this report, i.e., of March 1 to May 31, is what could be defined as the planting season. Nearly all new field studies are initiated during this period and it is in fact the busiest time of the year.

The weather conditions this spring were such that planting activities were accomplished in the optimum time frame and adequate moisture toward the last part of the period should insure excellent establishment.

PLANTING ACTIVITIES

The following studies were planted at the Harshaw Forestry Research Farm:

1. A 6-acre block was planted to make further comparative tests between a rolling cultivator, rotary hoe, coil tine harrow and some pre-emergent herbicides. Also weed control at wider tree spacings is being tested.
2. Yields from different spacing-rotation combinations of three Populus clones under irrigated and non-irrigated plantations.
3. Third year of a study to define the spring planting season for unrooted hardwood cuttings.
4. Comparison of three propagation systems for extending the late spring planting season.
5. Comparison of five site preparation methods with and w/o pre-emergent herbicide on Populus establishment.
6. Herbicide screening trials.
7. Clonal screening trials of original 20 clones.

8. Planted 67 new clones for second stage screening trials.
9. Comparison of unrooted hardwood cutting length and planting depth on survival and early growth.
10. Outplanting of cuttings collected at different fall dates and stored over winter at various temperatures.
11. Expansion of the clonal orchard.

The establishment of these studies brought to about 80 acres of test plantations established since 1975 on the Harshaw Forestry Research Farm. About 20 acres of plantations have been removed due to completion of some studies.

SEASONAL PROGRAM TRENDS

I. Planting and Establishment Research

Based on two years data, spring planting was centered in mid-May rather than in April as has been done traditionally in this climate. Results have shown that the earliest planting times are not necessarily the best. The planting season for unrooted hardwood cuttings appears to extend from mid-April to mid-June. The best time may be mid- to late-May because of the additional time permitted to control weeds prior to planting and the warmer soil temperatures that result in rapid early growth.

II. Insect and Disease Research

Frank Sapio, a graduate student with Michigan State University, will be evaluating the plantations to determine the agent or agents causing the necrotic gall injury on young hybrid cottonwoods, to assess and characterize the gall injury on stems and branches of susceptible

cottonwood clones, and to research and recommend direct or indirect suppression measures for responsible gall-forming agents.

III. Other Research

We have again hired Dr. Richard Verch, a biologist with Northland College, to evaluate the effects of intensively cultured plantations on non-game bird species. Dr. Verch will be examining intensively cultured plantations at the Harshaw Forestry Research Farm and also on lands of our industrial cooperators to determine the usage of plantations for nesting, feed and cover by song birds.

Richard McLaughlin, a graduate student from Purdue University, is studying nitrogen cycling in young energy plantations. Emphasis is on nitrogen inputs from N-fixing cover crops and losses in soil water leachate.

PUBLICATIONS RELEASED THIS QUARTER BY THE R&D PROGRAM

Burk, T. 1981. Crown architecture of intensively cultured Populus:

Analysis and modeling. Unpublished Ph.D. Thesis. Dept. of Forestry, Univ. of Minnesota, St. Paul.

Dawson, David H., Jaroslav Zavitkovski, and J. G. Isebrands. 1980.

Managing forests for maximum biomass production. American Institute of Chemical Engineers Symposium Series, Vol. 76 (#195):36-42., George R. Lightsey, editor.

Dawson, Jeffrey O., David Funk, Robert Fulton, and George Gertner. 1981.

Seasonal changes in leaf nitrogen concentration of Alnus glutinosa, A. rugosa and A. serrulata. In Proceedings Third Central Hardwood Conference, University of Mo., Columbia, MO.

- Dickmann, Donald, Howard Phipps and Dan Netzer. 1980. Cutting diameter influences early survival and growth of several Populus clones. USDA Forest Service, North Cent. Forest Experiment Station Research Note, NC-261. 4 pp.
- Ek, Alan R. 1980. Mensurational and biomass relations for Populus 'Tristis #1' under intensive culture. USDA Forest Service, North Central Forest Exp. Station Research Note, NC-260. 4 pp.
- Hansen, Edward A. and Howard Phipps. 1981. How to Grow Hybrid Poplars. USDA Forest Service, North Central Forest Exp. Sta. HT 49.
- Hutchinson, Jay G. 1981. Fast-growing young poplars make good panels, study says. For. Ind. 198(4):58-59.
- Nelson, Neil D., Thomas Burk, and J. G. Isebrands. 1981. Crown architecture of short-rotation, intensively cultured Populus. I. Effects of clone and spacing on first-order branch characteristics. Can. J. For. Res. 11(1):73-81.
- Pallardy, S. G. and T. T. Kozlowski. 1981. Water relations of Populus clones. Ecology 62(1), pp 159-169. Ecol. Soc. of America.
- Phelps, J. E. and E. A. McGinnes, Jr. 1980. Discolorations and streaks in black walnut - A microscopic evaluation. In Proc. IUFRO Working Party S.5.01-02, All Division 5 Conference, Oxford, UK, April 8-16, 1980. Edited by J. Bauch.
- Phelps, J. E. and E. A. McGinnes, Jr. 1980. Color of black walnut - Macroscopic and microscopic studies. In Proc. IUFRO Working Party S.5.01-02, All Division 5 Conference, Oxford, UK, April 8-16, 1980. Edited by J. Bauch.

PRESENTATIONS AND CONFERENCES
REGARDING WOOD FOR BIOMASS

- Isebrands, J. G. 1981. Invited seminar. University of Minnesota Plant Physiology Interdepartmental Seminar, St. Paul, MN Photosynthesis and translocation in hybrid poplar. 2-19-81.
- Isebrands, J. G. 1981. Invited paper. R&D Session Annual Meeting TAPPI, Chicago, IL 3-3-81.
- Isebrands, J. G., D. W. Einspahr, J. E. Phelps and J. B. Crist. 1981. Wood and kraft pulping properties of juvenile hybrid larch grown under intensive culture. Proc. 1981 Tappi Annual Meeting. Chicago, IL. March 2-5, 1981. (Abs.) p. 21.
- Isebrands, J. G. 1981. Invited presentation. Midwest Section, For. Prod. Res. Society, Moline, IL. Short rotation tree crops on small tracts for wood and energy. 3-26-81.
- Isebrands, J. G. and R. A. Parham. 1981. Reaction wood anatomy and its effect on kraft paper from short rotation intensively cultured trees. IAWA Bulletin. 2(2/3)57. Also Proc. 13th Int. Bot. Congress. Int. Assoc. Wood Anat. Symp., Sydney, Australia. Aug. 21-38, 1981 (Abs.). In press.
- Nelson, N. D. 1981. Invited Reviewer. DOE Fuels and Chemicals from Woody Biomass Program annual technical review of projects, Atlanta, GA. 3-17-81.
- Nelson, N. D. 1981. Presentation - Joint Am. Soc. Plant Phys./Can. Soc. Plant Physiol. Ste. Foy, Quebec. June 14-18, 1981.
- Nelson, N. D., and P. Ehlers. 1981. Comparative photosynthesis within two poplar clones grown in growth room, greenhouse, and field. Plant Physiol. Annual Meeting Supplement 67 (Abs.) p. 93.

Phelps, J. E. 1981. Presentation - 1981 Annual Meeting, For. Prod. Research Society, St. Paul, MN. June 22-25, 1981.

Phelps, J. E., D. W. Einspahr, J. G. Isebrands and J. B. Crist. 1981. Short rotation intensively cultured hybrid larch as a potential source of kraft pulp. Proc. 1981 Annual Meeting, Forest Products Research Society. St. Paul, MN. June 22-25, 1981. (Abs.) p. 41-42.

Zavitkovski, J. 1981. Participated in a Workshop on plant canopy structure. Sponsored by U.S. Army Research at Oakridge, TN.

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FUELS AND CHEMICALS FROM WOODY BIOMASS PROGRAM

NAME: P. R. Blankenhorn, T. W. Bowersox and C. H. Strauss
INSTITUTION: The Pennsylvania State University
PROJECT TITLE: Net Energy and Economic Analyses for Producing
Populus Hybrid Under Four Management Strategies
REPORTING PERIOD: March 1 - May 31, 1981

The energy and financial analyses for this project will consider the inputs for producing, harvesting, transporting, and processing forest biomass. Subsequently these inputs will be balanced against the recoverable energy from forest biomass, taking into account the conversion efficiencies of the energy recovery system. Comparisons within both the energy and financial analyses will establish the sensitivity and relative significance of the various inputs and energy recovery systems. Since these inputs are related to the outputs and these input/output factors are created during different annual periods, the analytical framework for this model will also incorporate a time dimension.

The objectives of this study are to establish and analyze: 1) energy and economic inputs for producing short-rotation hybrid poplar using four management strategies (control, irrigation, fertilization, and combined irrigation/fertilization), 2) production yields as a function of management strategy, 3) wood properties related to use as a source of fuel or chemicals as a function of management strategy, 4) energy and economic analyses of selected conversion strategies (direct incineration, pyrolysis, gasification, and liquefaction) for each of the management strategies, 5) sensitivity analyses of the selected conversion strategies to energy inputs for each selected management strategy, 6) a comparison of the energy and economic analyses for selected management and conversion strategies, and 7) recommendations of the most advantageous combination of management and conversion strategies in light of energy and economic considerations.

TASK 1 - ESTABLISH PLANTATION

This task is concerned with measuring the energy and economic inputs needed to establish the short-rotation plantation under four management strategies (control, irrigation, fertilization, and fertilization/irrigation). Plantations have been established on two sites with either favorable (Basher silt loam soil) or unfavorable (Morrison sandy loam) inherent conditions for high yields. Each plantation site (1.2 ha) consists of six replications (0.2 ha each) with three replications planted in the spring of 1980 and 1981 respectively. Each replication consisted of four treatment units (0.05 ha each for control, irrigation, fertilization, and fertilization/irrigation). Populus hybrid NE-388 cuttings were planted in rows 0.8 meters apart and 0.6 meters between trees in a row for a 0.48m^2 of growing space per tree. In each treatment unit, trees were designated for annual destructive sampling and continuous inventory over a four year period.

Fertilization of designated treatment units has been completed. The irrigation equipment has been purchased and is presently being installed. We expect our plantations to be fully operational by the beginning of June.

Plantation establishment operations have been evaluated on an energy basis. Cost analysis for these operations has started. We expect these analyses to be finalized in the next year.

TASK 2 - PLANTATION BIOMASS PRODUCTION

This task is concerned with obtaining the energy and economic inputs needed to operate and maintain the plantations under the selected management strategies. In addition, biomass production yields, growth rates, and biomass properties related to its use as a fuel or chemical feedstock will be measured.

Biomass production yield and growth rate data for the 1980 plantation first growing season have been collected. These data when combined with the 1981 plantation first growing season results will be statistically analyzed and reported. Yield values will be presented on both a green weight and oven-dry weight basis. Integration of the yield values with the chemical and energy values will be helpful in estimating the harvesting and processing energy and financial requirements to achieve usable energy and chemical outputs.

Selected physical and chemical properties, related to the use of Populus hybrids as a source of fuel or chemicals, will be analyzed for variations associated with the different cultural strategies. Specific gravity, moisture content, gross heat of combustion, ash content, extractive content, and macronutrient content data have been collected for wood, bark, and wood/bark composite specimens from the 1980 plantation treatment units. Holocellulose, alpha-cellulose and Klason lignin data will be obtained this summer.

TASK 3 - ANALYSIS OF BIOMASS ENERGY AND ECONOMIC DATA

This task is concerned with analyzing and comparing the energy and economic data for the selected management/conversion scenarios. Energy and cost analyses will be performed on each of the selected management strategies for each conversion strategy. Data collected on the project will be compared with published research for the analyses. Biomass production yields, growth rate, and properties will be used to standardize the data. Linear programming will be used to analyze the various input requirements, associated constraints, and outputs for the combinations of the various production/conversion scenarios. This would permit an evaluation of the production/conversion scenarios that would maximize net energy flows, net value flows, and the sensitivity of change in any variable to the resultant outputs. It is anticipated that a range in values will be used for the variables. Coupling the management and conversion energy and economic data base will provide the opportunity to recommend a management strategy for each conversion strategy with the most favorable energy and economic consideration.

A prototype for the linear programming model has been established. This model will include the various input/output requirements with associated

constraints. Ranges in the input and output values will establish the sensitivity of net energy and financial analyses to the various input and output values. Conversion efficiencies, plantation size, and plantation establishment cost values from a literature review have been summarized as a first step in establishing the values needed for incorporation into the linear programming model. Refinement of the values developed will continue throughout the project.

Plantation establishment field operations and energy inputs for the operations have been analyzed. We are presently refining these estimates and establishing cost values to these operations. Energy and cost values will be used as the data base to the linear programming model.

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QUARTERLY REPORT

NAME: William E. Sopper, Principal Investigator

David R. DeWalle, Co-Investigator

Sonja N. Kerr, Research Assistant

INSTITUTION: The Pennsylvania State University

PROJECT TITLE: Feasibility of Using Municipal Wastewater and
Waste Heat to Maximize Biomass Production in
Energy Plantations

REPORTING PERIOD: January 1, 1981 to May 31, 1981

CONTRACT NO: ET-78-G-01-3066

TASK NO. 1: Evaluate the effect of municipal wastewater irrigation biomass
production in a hybrid poplar plantation.

Weekly wastewater irrigation treatments were begun May 15 for the summer in all three hybrid poplar energy plantations. Tree height and diameter growth measurements for 1980 were statistically evaluated. Foliar biomass for 1980 was calculated and separate foliar samples that were collected for chemical analyses were digested and analysed for trace metals and nutrients. Nutrient and trace metal uptake and budgets for the vegetative cover are being calculated.

At the present time we are undergoing a massive infestation of gypsy moths in the County. This has necessitated frequent spraying to control the caterpillars. However, frequent rain has delayed spraying and has reduced the effectiveness of the spray. All hybrid poplar plantations have been invaded by the caterpillars. The problem is expected to last a few more weeks when the caterpillars will pupate. The extent of damage will not be known until July. It is expected that the annual biomass production will be reduced as a result of the insect invasion.

TASK NO. 2: Evaluate the efficiency of the energy plantations to renovate the wastewater.

Monthly samples of soil water percolate were collected from suction lysimeters installed at the 120 cm depth in each growing space subplot of both the wastewater irrigated and control plantations. Samples were analyzed for selected nutrients and trace metals. Monthly and annual averages, based on the results of these analyses, were calculated. Results of the analyses of soil percolate water collected from the control plantations were used in comparison to the results obtained from the wastewater irrigated soil percolate samples to determine the renovation efficiency of the energy plantations.

TASK NO. 3: Evaluate the use of municipal wastewater as a commercial fertilizer substitute.

Samples of the wastewater were collected during each irrigation period. These samples were analyzed to determine the total amount of nutrients applied on each spacing plot in 1980.

TASK NO. 4: Evaluate the effect of municipal wastewater and waste heat on biomass production.

Tree growth and development data for the 1978-1980 period are being further analyzed and compiled for a journal article to be submitted to Forest Science.

TASK No. 5: Evaluate the energy budgets and economic implications.

As indicated for Task 4, data from past growing seasons are being incorporated into a paper in preparation.

Quarterly Report

April 01, 1981-May 31, 1981

CULTURAL TREATMENT OF SELECTED SPECIES
FOR WOODY BIOMASS PROJECT

Linda Sutliff Dolan
Biomass Project Manager
Seattle City Light
1015 Third Avenue
Seattle, WA 98104

Dr. Peter Schiess
Principal Investigator
University of Washington

Continuing work under
U.S. Department of Energy
Grant #DE-FG01-78ET20593-A002

Cultural Treatment of Selected Species
for Woody Biomass Project

Quarterly Report
April-May 1981
SEATTLE CITY LIGHT

Administrative Activities:

Contract revision signed between University of Washington and Seattle City Light following delayed receipt of NOGA from U.S. Department of Energy. Contract includes research studies funded by Seattle City Light to study fuel characteristics of plantation-grown biomass and a field test for a whole tree baler developed at Virginia Poly-Technical Institute.

After hiring of the field supervisor and technical contracts specialist, Seattle City Light staff performed field reviews of research operations to date. This resulted in a list of negligent and problem areas on the plantations and a schedule of activities to correct and adjust field work (see attached).

Fourth year contract negotiations with DOE have been complicated, in part by negative comments of technical reviewers, and budget negotiations continue. Seattle City Light has proceeded with developmental work for fourth year contracting.

RFP has been issued for an assessment of plantation operational costs. Expected contract dates are July 01 to December 31, 1981. (See attached Scope of Work.)

Seattle City Light formally approved 1981 R&D funds for Biomass Project totaling \$51,475 -- \$16,000 for baler test; \$10,975 for fuel characterization; and \$24,500 for portions of the economic assessment that supplement \$10,800 of Department of Energy funds.

Technical Activities:

The sample design is being reworked for both sites with a statistician's assistance. The modified treatment layout for the Lee site is complete, and treatment activities are operating on schedule. The cultivation schedule at the Cedar River site is under review, awaiting final decision on treatment plot arrangement. New data analysis will be made using last season's measurements and the new treatment plot designs. The analysis will appear in the 1980-81 Final Report.

Irrigation repairs are completed at Cedar River site and plans for system operation are being refined. System repairs have been completed at Lee site, but the system will not be operated this season under the revised treatment design.

Fertilizer application is completed for this growing season.

The lysimeter system, to be used in analysis of nutrient cycling, was totally destroyed by vandals just prior to final installation. The activity has been cancelled.

Publications:

Smith, David Hugh, "Wood Gains Points as an Industrial Fuel," Christian Science Monitor, May 20, 1981

Activities Next Quarter:

Final negotiations on Fourth Year budget with Department of Energy and development of Fourth Year subcontracts, including subcontract for a professional forestry crew to perform maintenance tasks at experimental plantations (by July 31).

Panel of Northwest hardwood researchers to comment and recommend on research design and plantation O&M activities (by July 31).

Completion of remedial work at plantations by University of Washington (see attached field schedule for completion dates).

Plantation cost assessment begins under subcontract (July 01-December 31).

Graphic display of plantation research for "Wood Energy Conference and Trade Show" in Seattle, June 03-07, which includes a two-day public wood energy show. Display also to be sent to California State University at Fullerton, "Biomass Energy Short Course" for two weeks' use in June.

Personnel Changes:

The field supervisor and technical contracts specialist were hired at Seattle City Light to supervise site work and to write technical papers and contracts, respectively.

No changes with University of Washington technical staff. Hiring of summer labor underway.

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7.0 HARVEST, COLLECTION, TRANSPORTATION, AND STORAGE REPORT

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Virginia Polytechnic Institute and State University

W. B. Stuart and T. A. Walbridge

DOE Quarterly Report

February 1, 1981 - April 30, 1981

Development Work on the Baler

United States Steel Company, Packaging Systems Division was the only active response that we received to our questionnaire asking for assistance on tying systems for the baler. In early February, 1981, two engineers- Don Baldwin, Manager of Equipment and Services, and Frank Kratochvil, Manager of Engineering Services, visited the campus for two days to observe a demonstration of the baler and discuss potential tying systems. Their analysis of the unit was that we are still one to two prototypes away from the point which U.S. Steel could afford to take an active interest in the research and development of automatic tying systems. They did provide us with ideas on how to construct an automatic wire feed system and provided us with a research set of high tensile, galvanized steel wire and hand splicing systems for experimental application. An automatic wire feed system had been designed incorporating many of their ideas. This unit will be constructed.

Time studies and force analyses on the baler infeed at the beginning of the quarter were delayed because the engine on the unit blew a head gasket. The engine was repaired and the studies completed during the first week of March, 1981. The results of both of these studies are summarized in Tables 1, 2, and 3.

TABLE 1

Hydraulic Pressures Developed Baling Forest Residues

Hydraulic Circuit	Position of Cylinder	Hydraulic Pressure (psi)	
		Range	Average
Grapple	Extend	1000-2400	2000
	Retract	250-400	305
Carriage	Extend	250-350	280
	Retract	400-1500	570
Plunger	Extend		
	Closure	300-1000	450
	Hold	900-1300	1160
	Shear	900-2500	1850
	Compact	2100-2500	2160
	Retract	250-400	380
Back Door	Extend	1200-1550	1375
	Retract	1200-2100	1750

TABLE 2

**Projected Baler Production Rates with Increased Pump
Capacity**

Baler Time Study

<u>Baler Elements</u>	<u>Average Elapsed Time (min.)</u>	
	<u>Current System</u>	<u>100 gpm System</u>
Carriage In	.109	.070
Extension of Plunger to hold material	.197	.101
Reposition Carriage	.103	.055
Shear and Compact	.191	.146
Retract Plunger	.226	.113
Total Cycle Time	.826	.485
Number of Cycles per Bale	13	13
Total Bale Time	10.7 min.	6.3 min.
Total Strapping Time	6.8 min.	6.8 min.
Total Time	17.5 min./bale	13.1 min./bale

TABLE 3

Projected Baler Production with Improved Shear and Strapping Mechanism

Baler Time Study

<u>Baler Elements</u>	<u>Average Elapsed Time (min.)</u>	
	<u>Current System</u>	<u>100 gpm System</u>
Total Cycle Time	.826	.485
Number of Cycles per Bale	10	10
Total Bale Time	0.26	4.85
Total Strapping Time	2.0	2.0
Total Time	10.26 min./bale	6.85 min./bale

Baling Tests on Conventional Residues

Tests of the feasibility of compacting crushed forest residues were conducted in cooperation with K.C. Jones and Associates, a consulting engineering firm from Ottawa, Ontario, under contract with the Forest Engineering Research Institute of Canada.

Keith has been in charge of the FERIC project, analyzing the potential of crushing residues using heavy duty roll chippers. He has been working with an experimental roll crusher constructed by TVA in the early 1970's and currently under loan to the University of Massachusetts. Approximately 10,000 pounds of material which has been crushed using this unit were shipped from Massachusetts to Blacksburg for baling tests. The species involved were hemlock, spruce, white birch, quaking aspen, red maple, and red oak. This material, which had been crushed between 1 and 3 months previously and had been in outside storage at Massachusetts, was again put into outside storage when it arrived at our shop in Blacksburg. The moisture content of the material ranged from 72% to 130% with the three softwood species and the aspen all having moisture contents greater than 100%. The moisture content of red maple and red oak samples was below 80%. The test batches were small, and whenever possible, an attempt was made to form a bale of individual species. This proved impossible in some instances and mixed species bales had to be constructed.

The results of these baling tests are included in Table 4 attached. The bale weight of the crushed material averaged slightly over 500 kilograms or 1100 pounds. Some problems were experienced in forming the bales because the material was of a different form than that previously handled and it took

TABLE 4
BALING ROLL SPLIT WOOD
Data Summary

DATE: March 15, 1981

No.	Species Composition	Weight Green	Dimensions			Volume	M.C. (Dry)	S.G.	Density Green	Density Dry	Solid Volume	Notes
	(%)	(Kg)	L (M)	W (M)	H (M)	(M ³)	(%)		(Kg/m ³)	(Kg/m ³)	(%)	
CASE NO. 1: PLATTEN PRESSURE 6.43 Kg/cm ² (91 psi)												
1	Hemlock	365	0.94	1.63	0.85	1.30	130	0.43	434	170	44	- One wire broken - Rounded shape - Poor bale
2	Spruce and Pine (50% - 50%)	413	0.92	1.44	0.84	1.12	120	0.34	369	170	50	- Satisfactory bale - Corners slightly rounded
3	Red Maple	479	0.93	1.37	0.83	1.06	79	0.53	452	252	48	- Satisfactory bale - Good corners
AVERAGE		485	0.93	1.48	0.84	1.16	110	0.43	413	204	47.0	
CASE NO. 2: PLATTEN PRESSURE 10.4 Kg/cm ² (147 psi)												
4		580	0.91	1.36	0.84	1.04	72	0.58	557	323	56	- Tight surface - Square corners - Good bale
5	Oak - 40 Hem - 30 Pine - 30	543	0.94	1.39	0.84	1.04	113	0.43	522	245	57	- Satisfactory bale
6	Birch 50% Red Maple 50%	572	0.94	1.30	0.86	1.21	97	0.54	555	281	52	- Poor bale - One rounded corner
7	Aspen	543	0.94	1.39	0.81	1.06	120	0.45	512	232	52	- Excellent bale - Square corners - Very tight
8	Hemlock 50% Red Maple 50%	570	0.93	1.49	0.84	1.16	104	0.48	491	240	50	- Satisfactory bale - Tight - Good corners
AVERAGE		561	0.93	1.43	0.84	1.1	101	0.50	527	264	53.4	
CASE NO. 3: ROLL CRUSHED SLASH PLATTEN PRESSURE 10.4 Kg/cm ² (147 psi)												
9	Roll crushed slash; Hardwood mix - Dogwood - Red Maple - Oak (Var) - Mostly "Hard" Hardwood	361	0.91	1.36	0.81	1.00	16	.50	361	311	62	- Excellent bale - Sharp corners - Very tight surfaces

* Taken from Roll Splitting and Baling Harvesting Residues-by K.C. Jones

the team a short period of time to develop a feed strategy which would assure adequate bale formation.

Short Rotation Material

A second portion of this cooperative project involved experimental work with both crushing and baling short rotation plantation material. Since no short rotation material was at hand surrogate materials, in the form of a random mix of sprout, red maple, dogwood, oak and other mixed hardwoods, ranging from hickory through sassafras were used. The week before the tests were conducted, a crew had gone out and harvested stems ranging between 1/2" and 1" in diameter and formed these into 100 to 150 pound bundles, approximately 5 meters long. This material was cut just at the time of bud break, consequently the moisture content of the wood was at or near the maximum which could be expected under growing conditions. This material was then brought to the Prices Fork farm at Virginia Tech where we had gotten permission to use a sugar cane test mill that had been maintained as part of a sorghum yield test study in the Department of Agronomy. This test mill, built in the middle to late 19th century, is rather crude by current crusher technology. It is powered by a 5 horsepower, 3 phase electric motor through belt and gear drive reductions. One advantage of this mill was that the gap between the front and back rolls on the top roll could be adjusted independently. During the test a gap between the top and front bottom roll was set at 1/2". The gap was set at 1/4" between the top and the rear bottom roll.

The test material was brought in from the field, the bundles were weighed and then broken. The material was then fed into the crusher for

primary breakdown. Although the stems had to be fed one at a time, crusher speed was such that the individual pieces could be overlapped so that 3 to 4 stems were moving through the unit at one time. After leaving the mill the slash was loosely piled on a trailer and transported to the shop facility for the baling test. A drip pan was placed below the rollers to collect any water squeezed from the material by the crushing operation. Surprisingly, the crushing of this small material yielded insufficient quantities of sap and moisture for any subsequent analysis.

A total of 17,060 pounds of material was processed through the mill. The results of the crushing tests are shown in Table 5 attached.

It was found that the average machine energy required for the crushing test was 62.1 megajoules per oven dried ton. This is considerably higher than that required for roll splitting of roundwood slivers in the Amherst test (20-30 MJ/ODT) and that required for whole tree chipping (16-20 MJ/ODT) per oven dried ton. Part of this high energy demand is attributed to the flat belt and finger tooth gear drives used on the crusher unit. It was estimated that with a more efficient type drive the crusher would be brought into the same consumption levels of that of the TVA fiberizing concept used in the Amherst tests.

Perhaps one of the most surprising portions of the research involved moisture content reduction. Very little water was squeezed from the stem during crushing even though the initial moisture content of the coppice was 100+% prior to the tests. It was found, however, that this material had dried to an 18% moisture content after being left in loose 60 centimeter

TABLE 5
Roll Crushing Wood Using a
Sourgum Mill
Data Summary and Test Results

Bundle No.	Weight Green	Energy Consumed	Time	No Load Power	Dry Weight	Machine Energy	Cycle Energy
	(Kg)	(MJoules)	(min)	(MJ/min)	(Kg)	(MJ/ODT)	(MJ/ODT)
1	38.2	1.528	6.87	.092	18.9	47.5	80.8
2	27.7	1.104	5.45	.092	13.7	43.9	80.5
3	18.2	.934	4.26	.1045	9.0	54.3	103.1
4	27.7	1.934	8.83	.1045	13.7	73.8	141.7
5	37.7	1.042	5.62	.104	18.6	24.5	56.3
6	50.0	2.139	9.33	.104	24.7	47.1	86.5
7	43.6	2.491	10.55	.100	21.6	66.5	115.3
8	43.6	1.901	6.96	.098	21.6	56.4	88.0
9	27.3	1.279	6.50	.100	13.5	46.6	94.7
10	16.4	1.605	8.30	.0998	8.2	95.0	195.7
11	46.3	2.268	11.80	.098	22.9	48.5	99.4
12	48.2	3.920	20.15	.098	23.9	81.4	164.0
13	40.5	2.965	6.06	.098	20.1	117.9	147.5
14	51.4	3.784	16.12	.098	25.4	86.8	148.9
15	70.0	2.542	14.03	.099	34.7	33.2	73.2
16	40.0	2.255	13.05	.097	19.8	49.9	113.9
17	31.8	1.866	9.00	.099	15.7	62.1	118.9
18	41.0	2.761	13.03	.096	20.3	74.4	136.0
19	38.2	2.596	13.96	.097	18.9	65.7	137.0
20	30.9	2.224	13.45	.098	15.3	59.2	145.0
21	31.8	1.836	10.78	.096	15.7	51.0	116.9
Total	800.5	-	214.1	-	396.2	-	-
Mean	38.1	2.140	10.20	.098	18.8	62.1	116.3
ST.DV	12.1	.800	4.07	.003	5.9	21.5	31.3
Max.	70.0	2.964	20.15	.104	34.7	117.8	164.0
Min.	16.4	0.934	4.26	.096	8.2	24.5	56.3

* Taken from Roll Splitting and Baling Harvesting Residues-by K.C. Jones

high piles for the 3 days between the crushing test and the baling test.

The weather during the storage period was not particularly beneficial for drying. This was typical Appalachian spring weather, temperatures ranged from below freezing to approximately 65° Fahrenheit. One light rain fell during the period, however, the weather was quite windy. This moisture loss was far greater than any of those involved in the test had anticipated. The conclusions from this test were that the roll crushing with smooth surface rolls could reduce cross-sectional dimensions of a stem by a factor of 4, with a machine energy requirement of 40-60 megajoules per ton, therefore it is an effective way of reducing the loose volume of slash by a factor of at least 2. Roll crushing encourages natural drying, because of exposing the grain in two directions and breaking the fibers, thereby reducing the hydrostatic pressure for moisture movement.

Because it is unlikely the energy requirements can be reduced below 40 megajoules per ton crushing, it will require approximately twice the machine energy of chipping to point 1" chips and half that of hogging wood to a 1" nominal size. The FERIC report concludes that while machine energy is higher than chipping, the simplicity and rugged nature of the machinery make it in some aspects, a more desirable device for harvesting residues.

There was only sufficient crushed material to form one full bale weighing approximately 800 pounds. This bale had the highest solid volume content of any of the experimental bales formed during the trial. The crushing caused the coppice to become very flexible and easy to form into

a rectangular cube. The bale had extremely tight surfaces, sharp corners and excellent form and would be a very desirable unit for materials handling in nearly any system. The only problem encountered with this bale occurred the week following the tests. A 4" wet snowfall fell on the bale and was followed by a warm clear day while it was in outside storage. The bale reabsorbed sufficient moisture from the melting snowfall to allow pressures to build up in the material, breaking 2 of the 3 bands which had been used to tie it off. This experience indicates that if bales of this type are to be formed from the material that is both dried and evenly distributed through the bale cross section, banding materials with tensile strength in excess of 1500 pounds will have to be used to assure stability.