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Short Rotation Woody Crops Program

Quarterly Progress Report for the Period June 1 to August 31, 1985

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R. D. Perlack
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Environmental Sciences Division
Publication No. 2624

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ENVIRONMENTAL SCIENCES DIVISION

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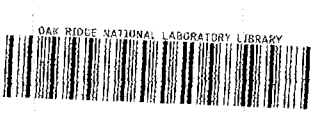

EXECUTIVE SUMMARY

This report covers the progress of the Short Rotation Woody Crops Program (SRWCP) during the third quarter of fiscal year 1985. The SRWCP is sponsored by the U.S. Department of Energy's Biofuels and Municipal Waste Technology Division (DOE/BMWT) and is managed by Oak Ridge National Laboratory (ORNL). This report summarizes ORNL management activities, technical activities at ORNL and subcontract institutions, and the technology transfer that is occurring as a result of subcontractor and ORNL activities. Highlights of these activities are listed below.

MANAGEMENT ACTIVITIES

- The annual contractors' workshop was held in Hilo, Hawaii, August 20-23.
- A revised draft Annual Operating Plan and the draft Field Task Proposal/Agreement were submitted to DOE for approval.
- The SRWCP Annual Progress Report for 1984 was published as an ORNL report (ORNL-6160).
- A briefing was presented to visiting staff from DOE headquarters.
- Two presentations were made by SRWCP staff at national meetings.

TECHNICAL ACTIVITIES

- Progeny tests of European black alder were established at four sites in Iowa.
- Species/site relationships have been identified for candidate SRIC species in the Southeast.
- Three species have been identified as best candidates for Short Rotation Intensive Culture (SRIC) use in the Northeast.
- A final report entitled "Available Harvesting Equipment for Woody Biomass" was submitted to SRWCP staff by TVA.
- Species screening trials were established at four sites in the Southwest.

- Progeny tests were planted in south Florida to assess the performance of five superior red gum (Eucalyptus grandis) families.

- Seven provenances of black cottonwood (Populus trichocarpa) which could tolerate the severe winters of Wisconsin were identified .

- A synthesis of production, harvest, and conversion costs for a biofuel energy supply system was evaluated by Pennsylvania State University.

- Results of two herbicide trials were reported by Kansas State University.

TECHNOLOGY TRANSFER

- Thirteen research papers were published.

- Sixteen presentations were made by managers and researchers of the SRWCP.

- Four institutions (BioEnergy Development Corporation, University of Florida, Iowa State University and Oak Ridge National Laboratory) hosted tours.

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INTRODUCTION

The Short Rotation Woody Crops Program (SRWCP) was initiated by the U.S. Department of Energy (DOE) in 1978 to address concerns about an adequate supply of biomass for energy use. It is the first and only comprehensive, nationwide program investigating short-rotation intensive culture (SRIC) of trees as a means of supplying energy needs. The goal, objectives, and organization of the SRWCP are summarized below.

Program Goal

The goal of the SRWCP is to provide to the private sector an information base that will include the following types:

1. Methods and materials required to obtain high rates of wood (energy) productivity for selected species.

2. Recommendations for producing wood at costs competitive with those of other energy and wood feedstocks for selected site types.

Program Objectives

The desired information base is being obtained by funding research projects that propose to meet the objectives listed below:

1. To identify and improve high-productivity woody species which respond well to intensive cultivation on unused and marginal agricultural land.

2. To identify and improve cost-effective cultural techniques that maximize productivity rates and minimize risks and losses associated with SRIC.

3. To identify the current major economic constraints on producing wood-energy feedstocks by using SRIC and to demonstrate how these constraints can be minimized.

4. To identify the major environmental problems associated with SRIC and to propose methods for successfully ameliorating those problems.

Program Organization

The general organization of the SRWCP is presented in Fig. 1. The institutions performing work for the SRWCP under interagency agreements

SHORT ROTATION WOODY CROPS PROGRAM
ORGANIZATION CHART

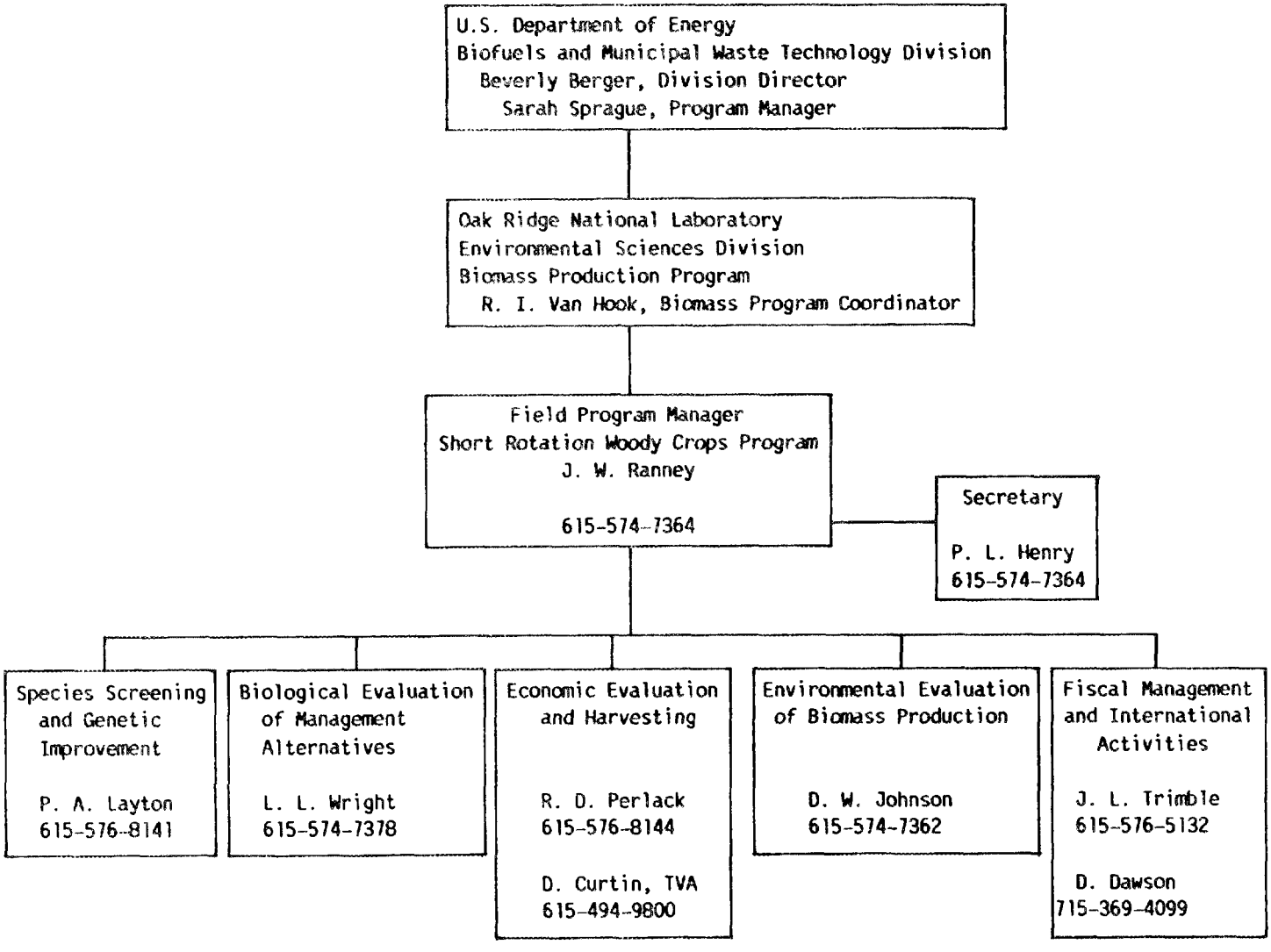

Fig. 1. Organization chart for Short Rotation Woody Crops Program.

or under subcontract during the fourth quarter of FY 1985 are listed in Table 1. The genetic improvement and cultural management objectives are being met through field and laboratory research subcontracted to institutions throughout the United States. The economic objective is being met largely through sensitivity analysis and modeling conducted by investigators at Pennsylvania State University and Oak Ridge National Laboratory (ORNL) and through literature evaluations conducted by the Tennessee Valley Authority (TVA). The environmental evaluation objective is being met through field research and data synthesis performed at ORNL.

Report Format

The following six sections briefly summarize activities of the SRWCP field-management office at ORNL, research accomplishments of the program, and technology-transfer activities in the program. The section entitled "Quarterly Highlight" discusses in depth one research or analysis activity conducted by the SRWCP. The Appendix presents reports on research progress at all institutions under subcontract to the SRWCP.

Table 1. Institutions and principal investigators who received research funding through the Short Rotation Woody Crops Program during the third quarter of FY 1985

Institution	Investigator(s)	Contract number
BioEnergy Development Corporation	T. B. Crabb	Subcontract 19X-09061C
Energy/Development Inter.	S. Hale, Jr.	Subcontract 19X-89640C
University of Florida	D. L. Rockwood	Subcontract 19X-09050C
University of Georgia	H. E. Sommer	Subcontract 19B-07860C-X02
Iowa State University	R. B. Hall	Subcontract 19X-43391C
Kansas State University	W. A. Geyer	Subcontract 19X-07394C
Michigan State University	J. W. Hanover	Subcontract 19X-09053C
North Carolina State University	D. J. Frederick R. C. Kellison R. Lea	Subcontract 19X-09054C
Pennsylvania State University	P. R. Blankenhorn T. W. Bowersox C. H. Strauss	Subcontract 19X-07928C
Plant Resources Institute	C. M. McKell	Subcontract 19X-89638C
Texas A&I University	P. Felker	Subcontract 19X-09066C
USDA Forest Service, North Central Forest Experiment Station	E. A. Hansen H. Nienstaedt	Interagency Agreement DE-AI05-80OR20763
USDA Forest Service, Pacific Northwest Forest and Range Experiment Station	D. S. DeBell	Interagency Agreement DE-AI05-81OR20914
University of Vermont	F. M. Laing	Subcontract 19X-09060C
Virginia State University	M. S. Joshua	Subcontract 19X-43389C
University of Washington	P. E. Heilman R. F. Stettler	Subcontract 19X-43382C

ACCOMPLISHMENTS

This section includes a brief list of accomplishments of the SRWCP management staff at ORNL as well as significant accomplishments reported by SRWCP subcontractors or ORNL research staff during the fourth quarter of FY 1985. Further details of the subcontractor research results can be obtained by referring to the subcontractor reports in the Appendix.

Major Event/Activity Accomplishment

The SRWCP held its annual contractors' meeting in Hilo, Hawaii, August 20-23. Approximately 50 people attended, including, besides all program managers and principal investigators, 20 guests specializing in various aspects of biomass energy. The program was organized to encourage active participation from all present in assisting SRWCP managers to determine future direction for the program. Presentations explained why the various types of current research were being pursued, and panel discussions addressed the topics of which issues need further evaluation and research. A key point echoed by several presentations and the panel discussions was that a need exists for advancing the genetic improvement of SRIC species based on a physiological understanding of tree growth. Because options for physiological research are extensive, recommendations were that (a) only a few species should be selected for detailed study, (b) only traits involved in the most important physiological aspects of growth should be examined, and (c) studies should be strictly linked to enhancing the production of wood energy under SRIC conditions. Field trips planned by the meeting host, the Bioenergy Development Corporation, demonstrated the broad range of silvicultural, genetic and physiological studies being pursued of eucalypts in Hawaii.

Management Accomplishments

1. A revised draft Annual Operating Plan (AOP) was submitted to DOE for final approval.

   The revised AOP was forwarded to DOE on July 23, 1985. This document describes in detail the management and technical milestones and accomplishments expected during the period October 1, 1985, through September 30, 1986, assuming a total program funding level of $4.2 million.

2. A draft Field Task Proposal/Agreement was submitted to DOE in mid-August.

   This document is the contractual agreement between DOE and Martin Marietta Energy Systems which specifies the management

milestones that must be met by ORNL, Environmental Sciences Division with respect to the SRWCP.

3. Five project-site visits were conducted.
   J. W. Ranney visited the Pacific Northwest Forest and Range Experiment Station of the USDA Forest Service, P. A. Layton visited Iowa State University, J. L. Trimble visited Pennsylvania State University and the North Central Forest Experiment Station of the USDA Forest Service, and L. L. Wright visited Kansas State University.

4. A briefing was presented to visiting staff from DOE headquarters.
   R. L. San Martin (Deputy Assistant Secretary for Renewable Energy) and R. R. Loose (Director, Office of Renewable Technology) were briefed on program activities by Herbaceous Energy Crops Program (HECP) and SRWCP staff.

5. A presentation was made by L. L. Wright to the Poplar Council of the United States.
   The presentation entitled "Need for standardization in SRIC research" summarized the standards that the SRWCP now expects of its subcontractors and discussed areas where standards need to be developed.

6. A presentation was made by R. D. Perlack to the Seventh Southern Forest Biomass Workshop in June 1985.
   Dr. Perlack gave a brief overview of the current activities of SRWCP and presented a paper entitled "The economic evaluation of SRIC energy plantations."

7. The SRWCP Annual Progress Report for 1984 was published as an ORNL report (ORNL-6160) and the progress report for the third quarter of FY 1985 was published as an ORNL technical manuscript (ORNL/TM-9698).

Technical Accomplishments

1. Progeny tests were planted in south Florida to assess the performance of five superior red gum (*Eucalyptus grandis*) families.
   Two new studies were established to provide information about the effects of spacing, time of year of harvest, rotation length, and soil type on the families. They were planted as bulked seedlots, row plots and block pure plots. In addition, several other families of red gum and other eucalypt species were planted in row plots for comparison.

2. Energy Development International established species-screening trials in the Southwest.

   Fifty-eight different species or families within species were planted. Each was established in at least one of four tests plots planted in July and August. Initial survivals appear good.

3. Seven provenances of black cottonwood (Populus trichocarpa) were selected for cold tolerance for use in Wisconsin and other areas.

   Results of the analysis of last winter's cold damage to clones indicated a significant correlation between survival and latitude of origin. Poor survival results from lack of adaptation to severe winter cold. Seven provenances from British Columbia and eastern Washington have been identified as cold-hardy and applicable for further testing in Wisconsin.

4. Hybridization between two species of alders (Alnus) was proven to be successful.

   Eleven hybrid seedlings resulting from the breeding of European black alder (A. glutinosa)x red alder (A. rubra) have grown to 1 m in height in the greenhouse and may now be used in a cloning program. This cross may be more disease and insect resistant than European black alder and more drought and cold tolerant than red alder.

5. A synthesis of production, harvest, and conversion costs for a biofuel energy supply system was evaluated by Pennsylvania State University.

   Harvest, chip, and transit costs ranged from $19.08/dry Mg (dry Megagram) for a prototype feller-buncher system to $33.30/dry Mg for a commercially available chip-harvester system. The combination of a fertilizer-strategy production system and the less expensive feller-buncher harvest system would provide delivered wood chips at the plant site for $59.57/dry Mg. The final conversion of this biomass to ethanol via hydrolysis developed a total output cost of $.48/l ($1.83/gal). Within this particular scenario, plantation production costs contributed 32.8% to total output cost, harvest-chip-transit added another 15.6%, with the remaining 51.6% tied to the final conversion stage.

6. Results of two herbicide trials were reported by Kansas State University.

   Three years of study indicate that individual and combination treatments of the preemergent herbicides Devrinol, Casoron, and Enide provide adequate weed control on sandy and silty sites and do not inhibit the growth of honeylocust (Gleditsia triacanthos), black locust (Robinia pseudoacacia), silver maple (Acer saccharinum), Siberian elm (Ulmus pumila), and cottonwood (Populus deltoides).

Tank-mix treatments of preemergent and postemergent herbicides provided good weed control, and no trees suffered visual toxicity symptoms when oversprayed at prebudbreak. However, a variety of visual symptoms were observed following postbudbreak applications. Siberian elm, silver maple, and green ash (Fraxinus pennsylvanica) showed the most sensitivity. The herbicides tested were Surflan (a preemergent) mixed individually with Poast, Goal, and Fusilade 4E.

7. Important information was gained by the USDA Forest Service Forest Science Laboratory in the Pacific Northwest regarding factors which affect the survival and growth of poplar clones.

   Initial sprouting and growth of four clones of hybrid cottonwoods and black cottonwoods varied substantially in tests conducted this spring in Washington. Successful sprouting was correlated with the presence of healthy buds on the cutting at time of planting. Tests containing clones with numerous "spent" buds (i.e. where sylleptic branching occurred) failed due to poor sprouting. These clones needed to form adventitious buds after planting, but the unusual frosts and drought conditions occurring after planting probably inhibited formation of such buds. Dean Debell concludes that the tendency towards profuse sylleptic branching in some of the clones and hybrids of black cottonwood may create problems in production of cuttings not encountered with eastern cottonwood.

8. Results of genetic tests at the University of Washington clearly document the importance and effectiveness of selection in F_1 progenies at the family and individual levels.

   Much variation in growth, vigor, and susceptibility to Melampsora rust was observed among the 474 new hybrids produced in the spring of 1984. Of 20 families, there were three in which all progeny showed high rust incidence. All three families had the same male parent, which did not occur in any other crosses. Six families showed various degrees of rust infection and eleven families showed no signs of rust. The male parent which was the primary source of the rust will be excluded from all future breeding.

Planned Events/Accomplishments for First Quarter FY 1986

1. The draft annual report of the SRWCP will be submitted to DOE.

2. Three solicitations for new work in the SRWCP will be prepared for release by December 1, 1985.

3. Site visits are planned to the University of Florida and the Energy/Development International project in the Southwest.

4. The North Central Forest Experiment Station of the USDA Forest Service will host a harvesting workshop in October.

5. Project Summaries will be prepared for all SRWCP projects.

6. A SRWCP staff member will attend one or two days of the Tucson, Arizona conference "Arid Lands: Today and Tomorrow" in connection with a site visit in the Southwest.

7. One or more SRWCP staff members will attend sessions of the IUFRO symposium on whole-plant physiology in Knoxville, Tennessee, October 6-11. The meeting is entitled "Coupling of Carbon, Water, and Nutrient Interactions in Woody Plant Soil Systems."

MILESTONES

The milestones listed below were identified in the Annual Operating Plan of the SRWCP as major tasks which would be initiated or completed during FY 1985. Figure 2 lists the milestones briefly and shows the expected completion date. The following text also lists the milestones and describes the status of the work.

Task 1 - Species Screening and Genetic Improvement

1. Identify drought-tolerant F_1 hybrids of *Populus trichocarpa* x *Populus deltoides* (March 1985).
   Milestone met in second quarter FY 1985. Results previously reported in ORNL/TM-9698.

2. Report seedling-rotation productivity of 2-year-old mesquite (March 1985).
   Milestone met in second quarter FY 1985. Results previously reported in ORNL/TM-9698.

3. Start full-scale European black alder progeny tests in several locations (May 1985).
   This milestone was met in July 1985. Four progeny tests were established in late June and July. Floodplain and ridgetop sites (two each) were planted with containerized seedlings. With two exceptions, all families were planted on all sites. Early survival ranged from 36 to 71%. Because of poor survival, these tests have little value for long-term genetic use; however, the survival information is important.

4. Start clonal tests of new collections of poplar species (May 1985).
   Stool beds for 200 clones of black cottonwood were established last fall at Harshaw Farm in Rhinelander, Wisconsin, and in East Lansing, Michigan, in cooperation with Michigan State University. New collections of eastern cottonwood (96 open-pollinated families) were outplanted this spring, and new collections of balsam poplar (200 clones) were established in stool beds. Damage to the black cottonwood clones as a result of severe winter cold has been evaluated.

5. Summarize species/site relationships in the Southeast (July 1985).
   Species/site relationships for candidate SRIC species in the Southeast have been identified by North Carolina State University. Sweetgum (*Liquidambar styraciflua*) is recommended for upland sites and for clay bottomlands. Sycamore (*Platanus occidentalis*), which outperforms sweetgum initially, is recommended only for coarse textured bottomland sites. In general, after 5 years sweetgum growth surpasses that of sycamore on most sites.

FY 1985 MILESTONES

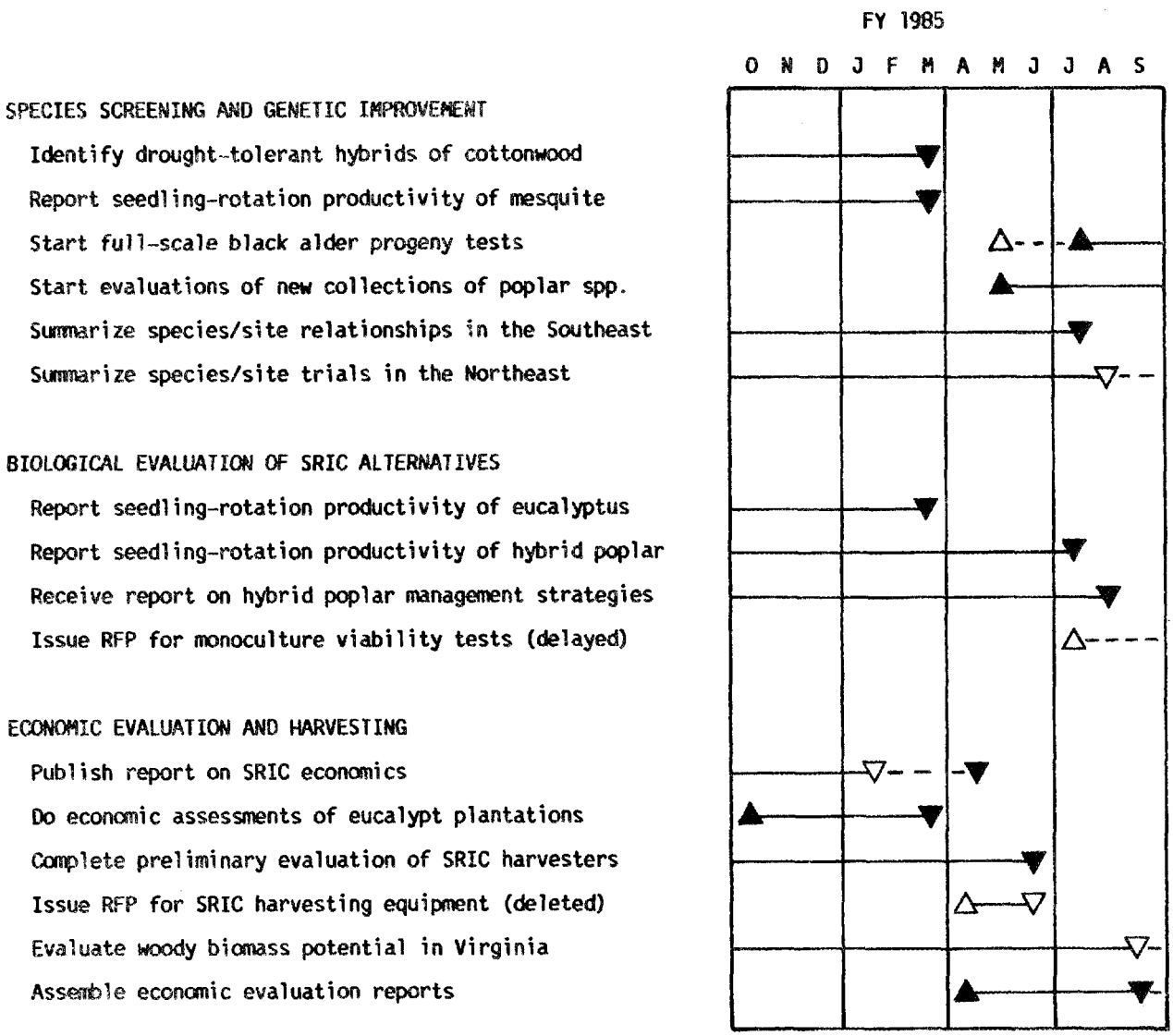

Fig. 2. Milestone chart for FY 1985.

FY 1985 MILESTONES (continued)

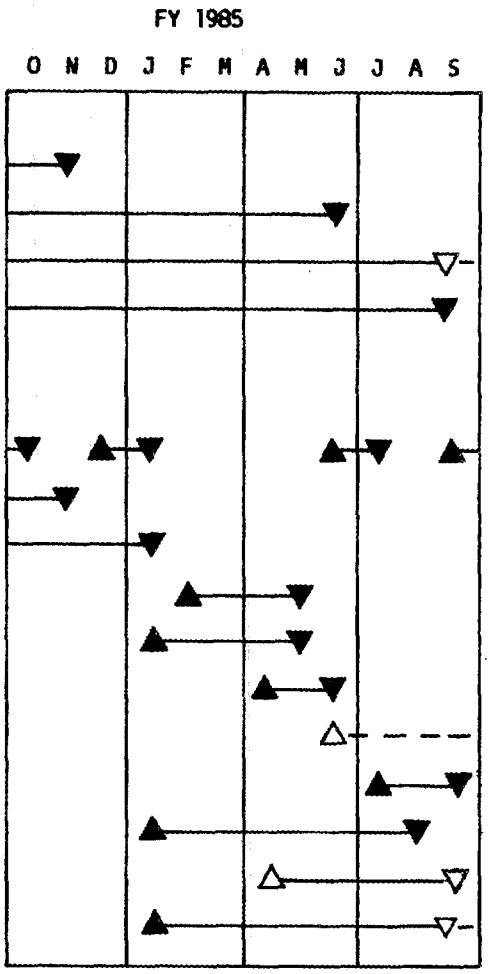

Fig. 2. (continued).

6. Summarize species/site trials in the Northeast (August 1985).
   The draft final report identified three species for use in this area. They are poplar species and their hybrids, black locust and silver maple. Poplar hybrids are susceptible to disease and may be restricted to a particular type of site. Further research is needed on poplar clones. Silver maple is recommended for bottomland sites and black locust for a wide variety of sites. The milestone will be met in December 1985 when the final report is submitted. .

Task 2 - Biological Evaluation of Management Alternatives

7. Report seedling-rotation productivity of eucalyptus (March 1985).
   Milestone met second quarter FY 1985. Results were reported in ORNL/TM-9698.

8. Determine seedling-rotation productivity of hybrid poplar in central Pennsylvania (July 1985).
   Seedling rotation productivity rates varied from 4.8 dry $Mg \cdot ha^{-1} \cdot year^{-1}$ to 10.7 dry $Mg \cdot ha^{-1} \cdot year^{-1}$ in hybrid poplar plantings in central Pennsylvania.

9. Receive final report comparing four hybrid poplar management strategies (August 1985).
   In trials comparing two sites, four management strategies, and two planting years, the highest productivity rates were consistently achieved with the fertilizer and irrigation treatment. However, productivity from this combined treatment was only slightly higher than that from the fertilization treatment alone. For the four comparisons available (two planting years and two sites), the productivity achieved by fertilization plus irrigation averaged only 0.7 dry $Mg \cdot ha^{-1} \cdot year^{-1}$ higher than that of plots receiving fertilization alone. These results indicate that irrigation contributes very little to the increased productivity of the combined treatment.

10. Issue request for proposal (RFP) for initiation of monoculture viability tests (delayed).
    No RFP will be released in FY 1985 due to the reduced FY 1985 budget. Plans are being made to release an RFP for this work in 1986, pending appropriate budget levels.

Task 3. - Economic Evaluation of Management Alternatives

11. Publish report on preliminary evaluations of SRIC economics (January 1985).

    A comparative economic assessment of seven SRIC systems was made in a paper presented by R. D. Perlack at the Institute of Gas Technology Symposium in January 1985. That paper is currently "in press." Similar information is contained in the SRWCP 1984 Annual Progress Report (ORNL-6160) published in August 1985.

12. Perform economic assessments of Hawaiian eucalypt plantations (March 1985).

    This milestone was met in second quarter FY 1985. Results were reported in ORNL/TM-9698.

13. Complete report providing a preliminary evaluation of innovative SRIC harvesting equipment (June 1985).

    This milestone was met from submission of a report entitled "Available Harvesting Equipment for Woody Biomass" by D. T. Curtin and P. Barnett. The report describes forest biomass harvesting systems, equipment, and costs. Current developments in equipment specifically designed for harvesting of SRIC plantations are also discussed.

14. Issue a request for proposals (RFP) for SRIC harvesting equipment (deleted).

    No Request for Proposal was released in FY 1985 for this category of work because of budget constraints.

15. Complete evaluation of woody biomass potential in Virginia (rescheduled).

    This milestone has been rescheduled to December 1985. Additional data collection is required by the researchers following an unexpectedly low response to a survey of nonindustrial landowners in Virginia.

16. Assemble economic-evaluation reports from field projects (September 1985).

    Beginning September 1985, ORNL will update the evaluation of SRIC economics in anticipation of the key milestone planned for February 1986. At that time, ORNL plans to have completed a national integrated economic evaluation of SRIC production.

Task 4. - Environmental Evaluation

17. Present five-year results from aboveground whole-tree harvest sites (November 1984).
    Milestone was completed in the first quarter of FY 1985. A brief summary was reported in ORNL/TM-9540.

18. Identify regrowth species on whole-tree harvest sites (July 1985).
    Milestone completed in third quarter of FY 1985. A brief summary was reported in ORNL/TM-9698. A manuscript for publication is currently in review.

19. Publish report on environmental effects of whole-tree harvesting (delayed).
    Publication of this report has been rescheduled as an FY 1986 milestone.

20. Determine nutrient drain of SRIC biomass via uptake (September 1985).
    Estimation of biomass and nutrient content of trees was completed for the second growing season. These data are reported on page 27 of this report.

Task 5. - Program Management

21. Submit Quarterly Reports to DOE (October 31, 1984; January 31, 1985; and July 31, 1985).
    Completed.

22. Submit draft Annual Technical Progress Report to DOE (November 15, 1984).
    Completed.

23. Submit draft Technical Information Dissemination Plan to DOE (January 5, 1985).
    Completed.

24. Perform technical review of renewal proposals (April 30, 1985).
    Completed.

25. Submit draft Multiyear Plan (MYP) to DOE (March 1985).
    Completed.

26. Submit draft Annual Operating Plan (AOP) to DOE (June 1, 1985).
    The AOP, which is a detailed planning document describing specific programmatic and subcontractor milestones and accomplishments for FY 1986, has been submitted to DOE for approval.

27. Submit project summary sheets to DOE (July 1, 1985).
    Project summary sheets will be prepared when requested by DOE.

28. Submit draft Field Task Proposal/Agreement to DOE (August 1, 1985).
    This agreement, which outlines the specific research and management milestones that will be tracked by DOE for the following fiscal year, was forwarded to DOE by the end of September.

29. Hold Annual Contractors' Meeting (August 1985).
    The BioEnergy Development Corporation hosted an excellent meeting in Hilo, Hawaii, on August 20-23, 1985. All subcontractors and 20 additional guests attended the sessions.

30. Perform technical review of new proposals (deleted).
    No formal reviews of new proposals will occur during FY 1985 since no solicitations for proposals have been released. Unsolicited proposals will not be reviewed.

31. Complete renewals of subcontracts and interagency agreements.
    Most renewals have been completed; refer to Table 2 for additional information.

Table 2. Procurement status for the FY 1985 Short Rotation Woody Crops Program

Title	Contractor	Estimated amount (dollars)	Type procurement	Procurement date Planned/actual
Eucalyptus Plantations for Energy Production in Hawaii	BioEnergy Development Corporation	276,965	Renewal	Aug 1/
Tree Species and Management Strategies for the Lake States	Michigan State University	50,000	Renewal	Jun 1/May 22
Species Selection and Silvicultural Systems for Producing Fuels from Woody Biomass in the Southeastern United States	North Carolina State University	70,300	Renewal	Jun 1/May 21
Breeding Alnus for Intensive Culture of Biomass for Energy	Iowa State University	50,000	Renewal	Jun 15/May 28
Tissue Culture of Elite Biotypes of Atriplex canescens as a Short Rotation Woody Biomass Crop	Plant Resources Institute	60,000	Renewal	Jun 1/Jun 3
Improvement of Woody Species for Energy Production in the Southwest	Energy/Development International	55,000	Renewal	Jun 1/May 30
Net Energy and Economic Analyses for Producing Populus Hybrid Under Four Management Strategies	Pennsylvania State University	136,000	Renewal	Jul 1/Jun 3
Production of Woody Biofuels from Mesquite (Prosopis spp.)	Texas A&I University	54,000	Renewal	Jul 1/Jun 19
Establishment of Populus Energy Plantations	USDA Forest Service, North Central For. Exp. Sta.	153,000	Renewal	Sep 1/
Increasing the Biomass Production of Alder Plantations in the Pacific Northwest	USDA Forest Service, PNW For. and Range Exp. Sta.	150,000	Renewal	Sep 1/
Biomass Harvesting and Field Handling	Tennessee Valley Authority	90,000	Renewal	Oct 1/
Eucalyptus for Biomass Production in Florida	University of Florida	160,000	Renewal	Sep 1/
Great Plains Energy Forest	Kansas State University	70,000	Renewal	Sep 1/Jul 25
Evaluation and Genetic Improvement of Black Cottonwood for Short-Rotation Coppice Culture	University of Washington	140,000	Renewal	Sep 1/Aug 19
Crown Zellerbach's Short-Rotation Intensive Culture Fiber Program	Crown Zellerbach Corp.	135,000	Sole-source	Nov/

PROCUREMENT STATUS

Procurements that have been or will be initiated during FY 1985 are shown in Table 2. Placement of procurements started in late April following the technical review and DOE's approval of ORNL's funding recommendations. As of August 31, nine of the procurements were "in place" as scheduled, and three of the procurements were awaiting concurrence by the subcontracting institution. Those awaiting concurrence are expected to be in place by October 1, 1985. The renewal contract for the University of Florida project was mailed out for their concurrence on September 11, 1985. The procurement of BioEnergy Development Corporation's renewal contract was delayed while Martin Marietta Purchasing Division audited the contract. Regardless of delays caused by audits or other reviews, the "effective renewal dates" will be the same as the planned renewal dates shown in Table 2. A new sole-source contract using recently allocated FY 1985 money was initiated in late September and is expected to be "in place" by early November.

INTERNATIONAL ACTIVITIES

David H. Dawson serves as technical coordinator for the United States in International Energy Agency (IEA) activities related to SRIC research. Dr. Dawson attended an IEA meeting in Malmo, Sweden, in September 1985. The purpose of the meeting was to revise a program plan for IEA activities in Annex I, Improvement of Biomass Growth and Technology in Short-Rotation Forestry (formerly Working Group B, Forest Growth and Production) for 1986-1989. In general, the subject areas for research activities in the new Annex are: genetic improvement and biotechnology, production biology, and operations. The major plant genera to be emphasized are alder (Alnus), poplar (Populus), and willow (Salix). The new program plan includes fewer, more integrated research activities that directly complement research in the SRWCP. The revised program plan will be submitted for comment to the IEA Executive Committee in October 1985.

TECHNOLOGY TRANSFER

This section summarizes technology transfer that occurred or was reported during the quarter by ORNL Short Rotation Woody Crops Program staff and by subcontractors to the program.

BioEnergy Development Corporation

Contacts and Tours

The BioEnergy Development Corporation did an excellent job of hosting the annual contractors' workshop. In addition to SRWCP contractors, there were several visitors to the workshop who participated in the field tours. Some of the visitors were personnel from sugarcane companies in Hawaii searching for alternative uses of their land.

University of Florida

Contacts and Tours

Two scientists from the Forestry Administration and the Forest Research Institute, Seoul, Korea, visited during June 24-25, 1985. Three scientists from Cia. Melhoramentos de Sao Paulo Industries de Papel and Cia. Suzano de Papel e Cellulose, Sal Paulo, Brazil, visited on June 27, 1985. Also visiting the University of Florida during June were: a scientist from the National Botanical Research Institute of India and a scientist from the Forestry Division, Agricultural Research Organization of Israel. A review of the biomass research projects was presented to the 40 scientists attending the Seventh Southern Forest Biomass Working Group Workshop on June 13, 1985. On June 19, 1985, a Food and Agriculture Organization (FAO) scientist from India also visited to discuss biomass research.

Publications

Rockwood, D. L., D. R. Dippon and C. W. Comer. 1985. Potential of *Eucalyptus grandis* for biomass production in Florida. *Bio-Energy* 84:86-93.

Presentations

Dippon, D. R. 1985. Slash and sand pine intensive short-rotation culture: Economic energy feedstock? Paper presented at the Seventh Southern Forest Biomass Working Group Workshop, Gainesville, Florida, June 11-14, 1985.

Reighard, G. L. and D. L. Rockwood. 1985. Plot subsampling in intensively cultured slash and sand pine tests. Paper presented at Seventh Southern Forest Biomass Working Group Workshop, Gainesville, Florida, June 11-14, 1985.

Iowa State University

Contacts and Tours

The research program at Iowa State University was presented to a coordination meeting hosted by the Iowa Energy Policy Council on June 19, 1985. Research on and applications of biomass energy around the state were reviewed and plans were formulated for continued information exchange. On July 31, 1985, a representative of the Iowa Energy Policy Council toured the Rhodes research plots.

Kansas State University

Contacts and Tours

Attendees of the 22nd Annual Poplar Council Meeting held in Lawrence toured the research plots in conjunction with this meeting in June. An Association for International Development (AID) graduate short-course was taught in July for foreign foresters attending The University of Tennessee.

Presentations

Geyer, W. A. 1985. Forestry practices in Italy. Paper presented at the Seventh Southern Forest Biomass Workshop, Gainesville, Florida, June 11-14, 1985.

Geyer, W. A. 1985. Coppicing: A centuries-old practice crucial to SRIC forestry. Paper presented at the 22nd Annual Poplar Council Meeting, Lawrence, Kansas, June 1985.

Naughton, G. G. 1985. Production and harvesting costs of an 8-year-old energy plantation. Paper presented at the 22nd Annual Poplar Council Meeting, Lawrence, Kansas, June 1985.

Meetings Attended

Geyer, W. A. July 1985. Ninth World Forestry Congress, Mexico.

Michigan State University

Presentations

Hanover, J. W. and R. O. Miller. 1985. Progress in tree improvement of biomass species. Paper presented at the North Central Tree Improvement Association Conference, East Lansing, Michigan, August 12-14, 1985.

North Carolina State University

Publications

Clark, A., D. R. Phillips, and D. J. Frederick. 1985. Weight, volume, and physical properties of major hardwood species in the Gulf and Atlantic Coastal Plains. Southeastern Forest Experiment Station Res. Paper SE-250. USDA Forest Service. 66 pp.

Gower, S. T., R. Lea, and D. J. Frederick. 1985. Aboveground energy production and distribution of southeastern hardwood swamp forests. Biomass 7:185-197.

Kellison, R. C. and R. G. Hitchings. 1985. Harvesting more young southern pines will require pulpmill changes. Pulp & Paper 59(7): 53-56.

Mroz, G. D., D. J. Frederick, and M. F. Jurgensen. 1985. Site and fertilizer effects on northern hardwood stump sprouting. Can. J. For. Res. 15: 535-543.

Presentations

Kellison, R. C. 1985. Forest resource technology and transfer in developing countries. Paper presented at the International Forestry Working Session, Society of American Foresters Annual Convention, Fort Collins, Colorado, July 29-31, 1985. 5 pp.

Kellison, R. C. 1985. Seed procurement and nursery management of the southern pines in the People's Republic of China. Paper presented at International Symposium on Nursery Management Practices for the Southern Pines, Auburn, Alabama, August 4-9, 1985. 5 pp.

Lea, R. 1985. Aboveground biomass, nutrient, energy, and growth and yield of bottomland hardwood forests. Paper presented at symposium: Characterization of Bottomland Hardwood Forests, St. Francisville, Louisiana. 16 pp.

USDA North Central

Publications

McLaughlin, R. A., P. E. Pope, and E. A. Hansen. 1985. Nitrogen fertilization and ground cover in a hybrid poplar plantation: Effects on nitrate leaching. J. Environ. Qual. 14(2):241-245.

Michael, D. A., D. E. Dickman, K. W. Gottschalk, N. D. Nelson, and J. G. Isebrands. 1985. Determining photosynthesis of tree leaves in the field using a portable 14-CO_2 apparatus: Procedures and problems. Photosynthetica 19(1):98-108.

Nelson, N. D. 1985. Woody plants are not inherently low in photosynthetic capacity. Photosynthetica 18(4):600-605.

University of Washington

Publications

Schulte, P. J. and T. M. Hinckley. 1985. Stomatal aperture and guard cell water relationships in Populus (abstract). Plant Physiol. (Suppl.) 77:142.

Van Volkenburgh, E., C. Ridge, and T. M. Hinckley. 1985. Limits to poplar leaf growth (abstract). Plant Physiol. (Suppl.) 77:136.

Presentations

Hinckley, T. M. 1985. Short-rotation intensive culture of Populus: The role of physiology. Paper presented to the Interdisciplinary Plant Group, University of Missouri, Columbia, August 23, 1985.

Schulte, P. J. and T. M. Hinckley. 1985. Stomatal aperture and guard cell water potential relationships in Populus. Presented to Annual Meeting of the American Society of Plant Physiologists, Brown University, June 23-28, 1985.

Van Volkenburgh, E., C. Ridge, and T. M. Hinckley. 1985. Limits to Poplar Leaf Growth. Paper presented at the Annual Meting of the American Society of Plant Physiologists, Brown University, June 23-28, 1985.

Oak Ridge National Laboratory

Contacts and Tours

Jim Woodman, Director of Research for Champion International, was briefed on the SRWCP on June 13, 1985, at ORNL.

Two tour groups from The University of Tennessee Governor's School for the Sciences and the Executive Seminar Center's Science Technology and Public Policy class were given presentations and tours at ORNL by J. L. Trimble.

P. A. Layton and L. L. Wright visited the plantings established by the USDA Forest Service Southeastern Forest Experiment Station in South Carolina to study the effects of root grading on the survival and early growth of sweetgum. Species trials previously established by the University of Georgia were also visited to evaluate the condition of the stands and the potential for obtaining additional data on coppice growth and nutrient dynamics.

J. W. Ranney visited the Crown Zellerbach Company in the Northwest and toured two of their large poplar plantings. The potential for cooperation between Crown Zellerbach and the SRWCP was discussed.

Publications

Schutt, J. R., H. H. Shugart, Jr., and J. W. Ranney. 1985. Crown geometry of plantation-grown American sycamore and its simulation. ORNL/TM-9721. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 269 pp.

Ranney, J. W., L. L. Wright, J. L. Trimble, R. D. Perlack, D. H. Dawson, C. R. Wenzel, and D. T. Curtin. 1985. Short Rotation Woody Crops Program: Annual progress report for 1984. ORNL-6160. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 74 pp.

Wright, L. L., R. D. Perlack, C. R. Wenzel, J. L. Trimble, and J. W. Ranney. 1985. Short rotation woody crops program, quarterly progress report for the period March 1 to May 31, 1985. ORNL/TM-9698. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 41 pp.

Presentations

Johnson, D. W. 1985. Fertilization in short-rotation woody crops plantations: Research at ORNL. Paper presented at the SRWCP Annual Subcontractors' Meeting, Hilo, Hawaii, August 19-23, 1985.

Mann, L. K., D. W. Johnson, and D. E. Todd. 1985. Nutrient content and natural regeneration after whole-tree and sawlog harvest. Paper presented at the Ecological Society of America Annual Meeting, University of Minnesota, Minneapolis, June 17-21, 1985.

Perlack, R. D., S. Das, and J. W. Ranney. 1985. The economic evaluation of SRIC energy plantations. Paper presented at the Seventh Southern Biomass Workshop, Gainesville, Florida, June 11-14, 1985.

Wright, L. L. 1985. Need for standardization in SRIC research. Paper presented to the Poplar Council of the United States Meeting, Lawrence, Kansas, June 25-27, 1985.

ORNL RESEARCH AND PROGRAM SYNTHESIS ACTIVITY REPORTS

Nutrient Utilization Study (D. W. Johnson)

Studies of the effects of two fertilizer regimes on nitrification and nitrate leaching in SRWC plantations of loblolly pine (Pinus taeda) and yellow-poplar (Liriodendron tulipifera) have been conducted since the winter of 1982 at ORNL. Beginning in March of 1982, one set of three plots was fertilized annually with urea^{-N} at 100 kg$\cdot$ha$^{-1}\cdot$year^{-1}, another set was fertilized quarterly with urea^{-N} at 25 kg$\cdot$ha$^{-1}\cdot$year^{-1}, and a third unfertilized set of three plots was a control.

Soil solution nitrate concentrations remained elevated in the spring of 1985, even though fertilization was discontinued in 1984 (for a total of 300 kg/ha of urea-N in both quarterly and annual applications). Soil solution concentrations exceeded the 10 ppm nitrate-N drinking water standard in some of the quarterly fertilized plots. The one-time urea application resulted in soil solution nitrate-N concentrations of nearly 30 ppm immediately after application, whereas equivalent applications of melamine (a slow-release nitrogen fertilizer) resulted in soil solution nitrate levels of less than 10 ppm. Nitrate concentrations are declining rapidly in both treatments, however, and longer-term effects remain to be seen.

Estimations of biomass and nutrient contents of trees in the summer of 1984 (second growing season) are now complete (Table 3). It is obvious that loblolly pine outgrew yellow-poplar on this poor site, and it is also obvious that quarterly fertilization produced virtually no growth response or increased nitrogen content in relation to untreated plots. Nutrient drains by harvest at this stage would be minimal primarily because biomass is still low. Biomass and nutrient contents will be estimated again in the fall of 1985.

Quarterly and, to a lesser extent, annual fertilization reduced foliar phosphorus levels in both yellow-poplar and loblolly pine (Table 4). In the case of loblolly pine, the quarterly fertilizations have apparently induced a phosphorus deficiency in that foliar phosphorus levels have dropped below the level thought to be indicative of phosphorus deficiency (0.1%). Foliar samples were taken in the summer of 1985 and soil available phosphorus levels will be checked in the fall-winter of 1985.

Whole-Tree Harvesting (D. C. West)

Work on this project is currently in the phase of final data synthesis and document preparation. All subcontracts have ended except one Interagency Agreement with the Forest Service in the Southeast. All

Table 3. Biomass and Nutrient Content of Yellow-poplar and loblolly pine (age 2) fertilized with 100 kg•ha^{-1}•yr urea-nitrogen annually (March) and quarterly (25 kg•ha^{-1} per application)

	Biomass	N	P	K	Ca	Mg
			kg•ha^{-1}			
Yellow-poplar						
Control	950±194	8.0±1.9	0.6±0.07	4.8±0.8	5.0±1.4	1.1±0.20
Annually	1170±153	14.5±1.2	0.9±0.30	7.5±0.3	5.3±2.5	1.8±0.30
Quarterly	860±121	8.3±1.8	0.5±0.01	3.8±0.5	4.1±1.1	1.1±0.09
Loblolly Pine						
Control	3480± 817	24.2±6.2	2.2±0.7	11.9±2.3	5.5±1.0	2.1±0.4
Annually	5340±1205	38.6±8.4	2.7±0.6	19.3±4.4	8.8±1.5	3.4±0.8
Quarterly	3850± 745	25.9±6.3	1.4±0.2	11.0±2.5	5.2±0.9	2.0±0.3

Table 4. Foliar nutrient concentrations in yellow-poplar and loblolly pine (age 2) fertilized with 100 kg•ha^{-1}•yr^{-1} annually (March) and quarterly (25 kg•ha^{-1} per application)

	N	P	K	Ca	Mg
			%		
Yellow-poplar					
Control	1.93±0.19	0.13±0.09	0.67±0.07	1.17±0.33	0.23±0.03
Annually	2.40±0.30	0.11±0.04	0.78±0.08	0.72±0.48	0.25±0.01
Quarterly	2.07±0.18	0.12±0.007	0.70±0.14	1.12±0.38	0.26±0.04
Loblolly Pine					
New Foliage					
Control	1.83±0.09	0.13±0.01	0.67±0.08	0.23±0.05	0.10±0.02
Annually	1.93±0.07	0.11±0.006	0.62±0.009	0.2 ±0.01	0.09±0.0006
Quarterly	2.05±0.05	0.08±0.00	0.71±0.08	0.18±0.005	0.10±0.0005
Old Foliage					
Control	1.20±0.00	0.09±0.01	0.36±0.003	0.37±0.02	0.08±0.009
Annually	1.50±0.10	0.08±0.005	0.47±0.02	0.40±0.06	0.08±0.002
Quarterly	1.77±0.19	0.07±0.01	0.34±0.03	0.31±0.02	0.07±0.007

subcontractors are continuing to cooperate informally in the preparation of the final synthesis document. Work at ORNL is concentrating on the preparation of manuscripts. A summary of final conclusions was given in a previous quarterly report, ORNL/TM-9540.

Evaluation of SRIC Harvesting Equipment (D. T. Curtin)

A final report that identifies and documents the existing prototypes of SRIC harvesting equipment has been submitted to ORNL. A brief summary of the conclusions and recommendations of that report is included as the Quarterly Highlight on pages 31 - 39.

SRWCP Technical Data Base (L. L. Wright)

Major revisions of the SRWCP technical data base design were undertaken and completed. Complete documentation of the design of the data base was written and will soon be published as an ORNL technical manuscript.

Revision of the data base design slowed the process of adding new data since detailed checks on all previously input data tables were required. Nevertheless, information from Kansas State University, University of Washington, and University of Georgia was entered, bringing the number of projects with some information entered to a total of seven. There are currently more than 500 records in the files containing productivity information. .

QUARTERLY HIGHLIGHT

The quarterly highlight aims to focus attention either on research being performed by the SRWCP or on analysis of the economic potential of the SRIC concept. This section presents the information in a format similar to that of a journal article. The highlight this quarter focuses on research being conducted at ORNL.

Equipment for Harvesting Short-Rotation Intensive Culture (SRIC) Woody Biomass Plantations

Paul Barnett
Dennis Curtin

Introduction

The lack of information on harvesting costs for SRIC biomass plantations is a major concern of many private enterprises that might otherwise find SRIC plantations a viable, optional source of fuel. Current estimates are that one-third of the total cost of SRIC biomass to the user will be a result of the harvesting function (Fig. 3) (Ranney et al. 1985). In order to obtain more information on costs using current equipment, a survey was conducted to identify available harvesting equipment which might have application in SRIC plantations. Three types of equipment are identified: conventional forest harvesting equipment, land clearing/biomass recovery machines, and prototype SRIC harvesting machines.

Methods and Results

Existing conventional forest harvesting machinery was evaluated first to determine what concepts in current use might be applied to SRIC harvesting. It soon became evident that existing machinery is so highly specialized that application in SRIC harvesting is not economically feasible for three reasons: (1) Such machinery is built to withstand extremely rugged use and terrain, thus, is expensive to own and operate. Since SRIC harvesting occurs during limited parts of the year (assuming coppice is desirable), it is uneconomical to carry the large investment in a machine that cannot be used year-round. (2) Conventional forest harvesting equipment is not designed to sever stems without damaging the stump, nor does it have the ability to harvest multiple coppice stems. (3) Most conventional forest harvesters are designed to harvest trees with a stem diameter of 25 cm (~10") or greater. Whether comparing volume per tree with diameter (Fig. 4) or number of trees required to produce a volume of wood with diameter (Fig. 5), the relationships are inverse geometric functions.

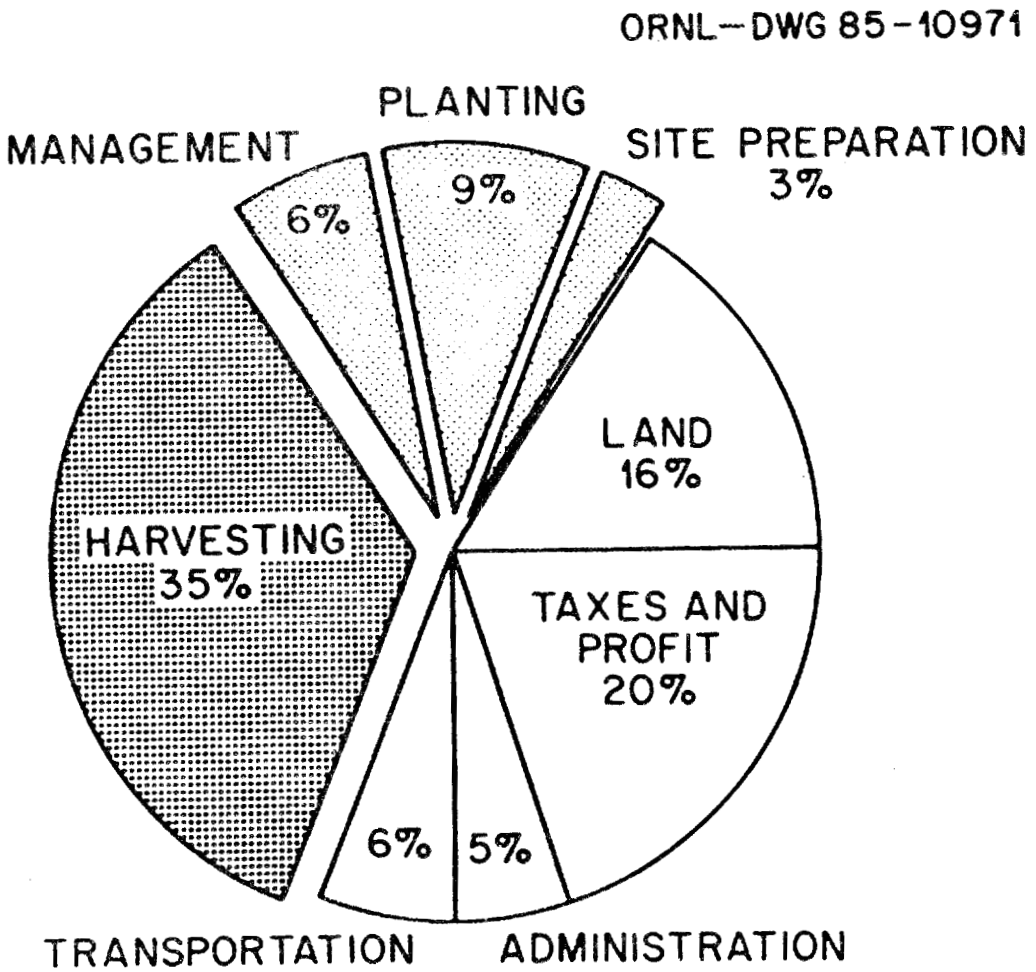

Fig. 3. Major cost components of short-rotation intensive culture biomass production (average of 7 research projects) (Ranney et al. 1985).

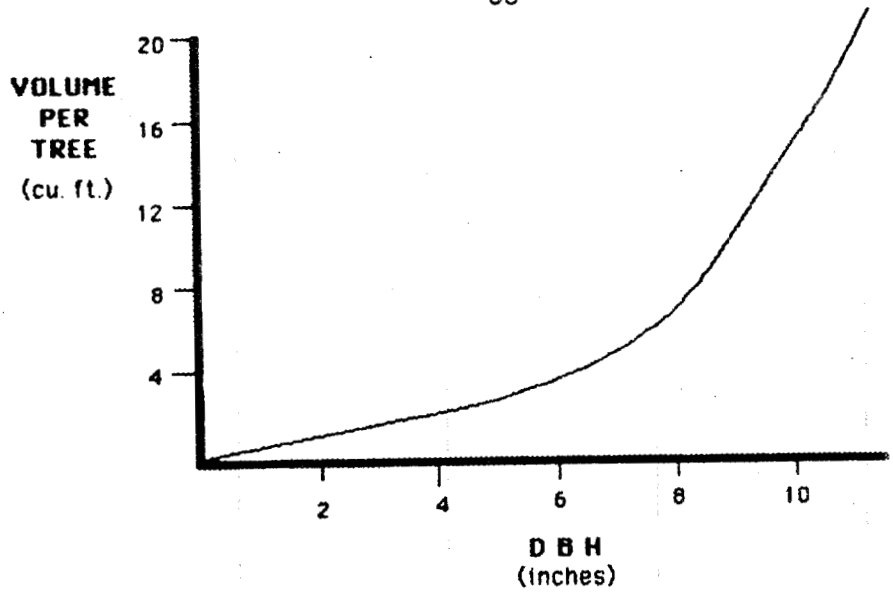

Fig. 4. Volume per tree versus diameter.
Source: Lanford, B. L., and G. F. Haver. 1973. Production and time study manual, production tables study. Vol. 4, American Pulpwood Association, Washington, D. C.
Metric conversion: 1 inch = 2.54 cm , 1 cu. ft. = 0.028 cu. meter.

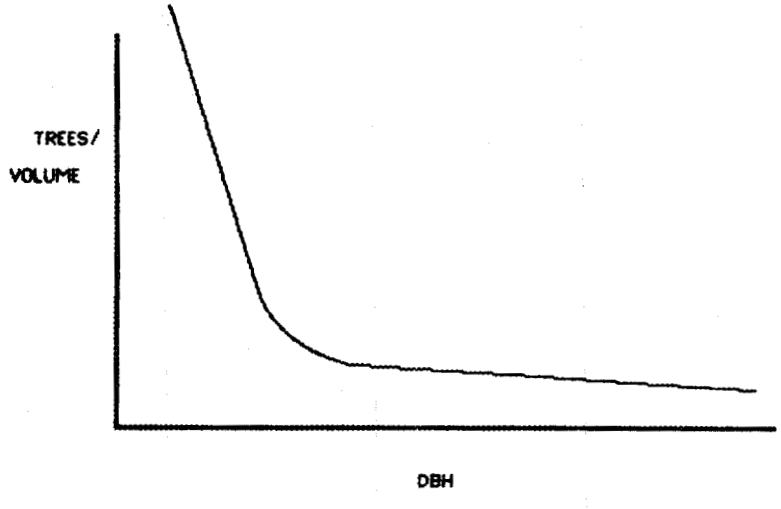

Fig. 5. Number of trees/unit volume versus diameter.
Source: McCraw, W. I., and C. R. Silversides. 1970. Analysis of tree harvesting machines and systems - A methodology. Canadian Forestry Service, Department of Fisheries and Forestry. Forest Management Institute, Information Report FRM-X-17. July.

Therefore, as the diameter of trees being harvested decreases (as it obviously must in SRIC) productivity (stems/hour) must increase geometrically if production (tonnes/hour) is to remain nearly constant. Lanford (1983) found that as stem DBH dropped from 25.4 cm (10") to 10 cm (4"), the cost of harvesting with a feller buncher increased by a factor of seven.

Land clearing/biomass recovery equipment initially showed promise since it utilizes a continuous swath rather than an individual tree approach. However, further evaluating disclosed several problems in application to SRIC harvesting. The most significant problem these machines exhibit is the damage to stumps of harvested material, thus discouraging coppice regrowth and stump preservation. Examples are the Georgia-Pacific Biomass Harvester (O'Dair and Smith 1980) and the Nicholson-Koch Mobile Harvester (Koch and Savage 1980). One machine in this category that does not severely damage stumps is the A-Line Swather, constructed cooperatively by forest industry and the Forest Engineering Research Institute of Canada (FERIC) (Heidersdorf 1982). This machine, however, was designed to harvest larger trees (up to 20 cm or 8" DBH) in natural stands and represents an excessive investment (in terms of money and horsepower) for use less than year-round.

Several prototypes of machinery specifically designed for SRIC biomass harvesting are in the construction and/or testing stages. In the United States, three machines were noted: (1) the VPI/DOE Harvester (Teel 1983) was designed to harvest multiple stems in coppice stands. The prototype involved 102 kW (136 hp) and achieved a rate of 10 to 15 stools (4 to 15 stems/stool) per minute or 8 to 19 tonnes (megagrams) per productive machine hour (t/pmh). (2) The USFS Short Rotation Harvester (Mattson 1983, Wehr 1985) utilizes a unique 0.6 m (2') milling cutter for severance and bunches stems for further handling. It has not undergone extensive testing to date. (3) The Swath Harvester (Scott 1985) is a high-speed (3,000 m/min or 10,000 ft/min) chain saw attachment for a farm tractor, designed to fell extremely dense (40,000 to 200,000 stems per hectare) stands of woody biomass.

The National Research Council of Canada (NRCC) is currently involved in construction and testing of four prototype SRIC biomass harvesters: (1) the NRCC Coppice Harvester (Voss 1985) is designed to harvest coppice material in rows one meter apart, using a reciprocating saw for severance; (2) the NRCC FB12 (Jasinski 1985), a relatively large machine, is designed to harvest material to 30 cm (12") in diameter using a single circular saw; (3) the NRCC FB2 (Jasinski 1985), also designed for coppice harvesting, uses a bandsaw for severance and ties the material in bundles; and (4) the NRCC FB7 (Stokes 1985), which has achieved production rates of 850 to 1,050 stems pmh in tests. This rate compares favorably with the geometric increase necessary for small stems discussed earlier. Figure 6 compares productivity of a conventional feller buncher over a range of stem sizes with productivity of the FB7.

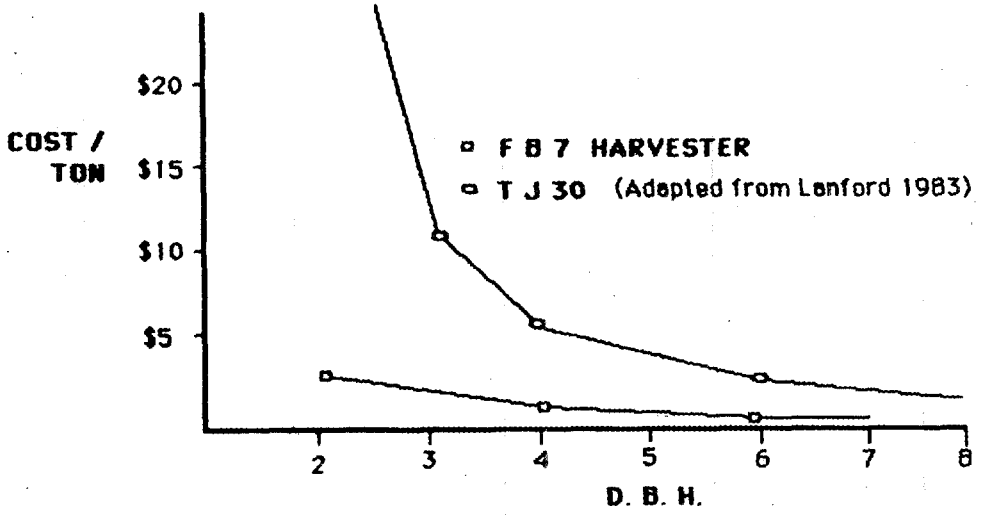

Fig. 6. Comparison of productivity of the NRCC FB7 with a conventional feller buncher over a range of stem sizes.
Source: Stokes, B. 1985. Short rotational biomass harvesting system evaluation. Unpublished manuscript. USDA Forest Service, Southern Forest Experiment Station, Auburn, Alabama.
Metric Conversion: $1 per ton = $0.91 per metric ton (Megagram)

Two European countries have evaluated several possible machine configurations that could become effective SRIC plantation harvesters. Sweden has constructed and tested two machines: (1) the K12, which is an attachment for a 100-kW (135 hp) farm tractor and produces manually tied bundles and (2) the Brunn AIB, which is a much larger machine capable of accumulating loads of 7,000 kg (15,000 lbs). The Brunn AIB is a single-purpose, expensive machine. Both the K12 and the Brunn AIB are discussed by Gilliussan (1984). Two experimental machines constructed and tested for harvesting willow coppice stands in Ireland are: (1) the Bord na Mona (Keville 1982), designed to be pulled by a 90 kW (120 hp) farm tractor and produce 15 cm (6") billets accumulated in a 7 m^3 container and (2) the Loughry harvester (McLain 1984), which mounts directly on a 44 kW (58 hp) farm tractor and produces 30 kg (66 lb) bundles.

Summary

As a result of the survey and analysis carried out in this project, a synopsis of the various components of existing SRIC harvesting equipment was prepared (Table 5). In addition, a relative rating of the components that make up biomass harvesting systems (i.e., severing, conveying, processing) and their relative efficiency based upon use and success of harvesters to date was prepared and will be included in a final report.

Recommendations

In order to achieve development of cost-effective harvesting and field processing equipment for SRIC biomass plantations, the following are recommended.

1. Harvester development activities should be directed toward industries with vested interests (e.g., equipment markets) in similar or related fields (e.g., right-of-way maintenance, precommercial thinning, pulpwood, and fuelwood harvesting).

2. Encourage the use of lessons learned in prototypes already tested.

    A. Use continuous harvesting principles.

    B. Use saws as severance mechanisms.

    C. Minimize power requirements in the field (e.g., avoid chipping).

Table 5. SRIC biomass harvesters and their components

SRIC harvester	Gathering	Severing	Conveying	Processing
Canada				
NRCC coppice harvester	Fingers	Reciprocating saw	Fingers	Directional felling
NRCC FB2	Fingers	Bandsaw	Fingers Arms	Bundling
NRCC FB7	-	2 circular saws	Arms	Bunching
NRCC FB12	Arms	1 circular saw	Arms	Bunching
Ireland				
Bord na Mona	Headers	2 circular saws	Horizontal belt and rolls	Billeting
Loughry	Headers and counter-rotating augers	1 circular saw	Arms, 2 sets	Bundling
Sweden				
Brunn AIB	Headers and opposing belts	2 circular saws	Opposing belts and counter-rotating augers	Bunching and transporting
K12	Headers	2 circular saws	Opposing belts	Bundling
USA				
USFS	Arms	Auger	-	Bunching
VPI-DOE	Headers and opposing belts	2 circular saws	Reels and opposing belts	Crushing
Swath	-	Chain saw	-	Directional felling

D. Direct development efforts toward attachments for existing carriers.

E. Utilize the field as a drying location to take advantage of direct solar energy and natural airflow to dissipate moisture.

F. Produce bundles or bales of sufficient size and orientation to result in efficient handling and processing of subsequent functions (e.g., transportation).

G. Minimize frequency and level of traffic on production site (field).

H. Utilize areas adjacent to production site for inventory and drying of bundled stems.

Literature Cited

Gilliusson, Rolf. 1984. The IEA Forestry Energy Agreement Area "Harvesting, on-site processing and transported." IN Review 1984 Swedish University of Agricultural Sciences, Garpenberg, Sweden. 47 pp.

Heidersdorf, E. 1982. Evaluation of the preproduction A-line Swather VII. Technical Note TN-55, Forest Engineering Research Institute of Canada, Pointe Claire, Quebec, Canada. 24 pp.

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Keville, B. J. 1982. Short-rotation forestry harvester chipper. pp. 83-89. IN Energy from Biomass: Proceedings of the EC Contractors' Meeting, Brussels. May.

Koch, P., and T. E.Savage. 1980. Development of the swath-felling mobile chipper. J. For. 78:17-21.

Lanford, B. L. 1983. Productivity and costs of the Timberjack 30 feller buncher. For. Prod. J. 22:61-66.

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O'Dair, J. R., and F. M. Smith. 1980. A biomass harvester. pp. 391-400. IN The Proceedings of 1980 Annual Technical Association of Pulp and Paper Institutions Meeting.

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Scott, L. A. 1985. Omark Industries, Oregon Saw Chain Division, Portland, Oregon. Personal communication to Paul Barnett, Tennessee Valley Authority, Norris, Tennessee. February.

Teel, J. B. 1983. The design and development of a prototype short rotation harvesting system. MA thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. June.

Voss, Doug. 1985. J. D. Reed Machine Ltd., Brantford, Ontario, Canada. Personal communication to Paul Barnett, Tennessee Valley Authority, Norris, Tennessee. March.

Wehr, M. A. 1985. USDA Forest Service, North Central Forest Experiment Station, Houghton, Michigan. Personal communication to Paul Barnett, Tennessee Valley Authority, Norris, Tennessee. February.

APPENDIX: SUBCONTRACTED RESEARCH REPORTS

EUCALYPTUS PLANTATIONS FOR ENERGY PRODUCTION

Quarterly Report for the Period

June 1 to August 31, 1985

Thomas B. Crabb
Thomas H. Schubert

September 1, 1985

Report prepared by

Thomas B. Crabb
Thomas H. Schubert
BioEnergy Development Corporation
888 Kalanianaole Avenue
Hilo, Hawaii 96720

under

Subcontract 19X-09061C

for

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
operated by
Martin Marietta Energy Systems, Inc.
for the
U.S. Department of Energy
Contract No. DE-AC05-84OR21400

Current Activities

Research activities were concentrated on scheduled remeasurements of existing experiments. In terms of research objectives, these included:

1. Increase biomass production: Species Trials at Amauulu, Onomea, Pepeekeo F69B, Chin Chuck F30B, and Kamae F26B and F27C; E. saligna/E. grandis Provenance Trial and E. globulus Progeny Trial at Chin Chuck F30A; Mimosa scabrella Provenance Trial at Chin Chuck F30B; E. urophylla Seed Source Trial at Kamae F26C; and Brazilian Hybrid Eucalyptus cuttings at Pepeekeo F69B.

2. Determine optimal cultural requirements: Spacing X Rotation Study at Amauulu; Species Admixture Trial at Onomea; NP Trial and Number of Fertilizer Applications Trial at Akaka; Euc/Legume Ratio Test at Chin Chuck F30A and Liming Trial at Chin Chuck F30B; Nitrogen Fertilization of Older Trees at Kamae F25A and Comparison of Fertilizers Trial at Kamae F26A; and E. saligna Spacing/Fertilizer Study at Kamae F26B and F27C.

Coppicing was measured on the stumps of the 3-year old trees felled at Amauulu in September, 1984. Crop-logging was done in open field stands at Akaka and Kamae.

A draft multi-year plan for the Project was prepared and submitted.

In preparation for the Annual Biomass Contractors' meeting, weeding and general clean-up were done in areas at Amauulu, Pepeekeo, Akaka, Chin Chuck, Kamae, and Ka'u that were scheduled for field tours. The meeting was attended by T. Crabb, C. Whitesell, and T. Schubert.

Summary of Research Results

No particular changes from past trends were noted. Eucalyptus saligna and E. grandis continue to be the two best species overall, although at Pepeekeo E. urophylla, E. camaldulensis, and E. globulus have grown faster up to 18 months. In the provenance, progeny, and seed source trials, there has been little change from previous rankings. The general deterioration of the trees in the Mimosa scabrella trial continues. In the hybrid eucalyptus trial after 6 months, survival of 8 of the 10 clones is 100%, and height growth averages 1.0 to 1.7m.

The fertilizer, euc/legume admixture, and spacing trials also continue previous trends. The medium level of applied nitrogen with some added phosphorus is best, and multiple applications of nitrogen are better than at planting only. No results are yet apparent from fertilizing the older trees, which was done only six months ago. The benefits of mixing leguminous trees with the eucalyptus continue to be evident, and the widest spacings have the largest diameter trees.

Coppicing at Amauulu has been disappointing overall, although it is quite good in some places. The higher stumps seem to have produced more and larger coppice, and coppicing appears to be somewhat better in the narrower spacings than in the wider ones.

Publications/Presentations

DeBell, Dean S., Whitesell, Craig D., and Schubert, Thomas H., 1985."Mixed Plantations of Eucalyptus and Leguminous Trees Enhance Biomass Production". USDA Forest Service Pacific Southwest Forest and Range Experiment Station Research Paper PSW-175, 6p.

Schubert, Thomas H., and Whitesell, Craig D., 1985. "Species Trials for Biomass Plantations in Hawaii: a first appraisal". USDA Forest Service Pacific Southwest Forest and Range Experiment Station Research Paper PSW-176, 13p.

"Six and a Half Years Later - The BDC Story" was presented by Thomas B. Crabb at the Energy Symposium and International Exposition in Anaheim. 6/5/85

One hundred fifty copies of our 1984 Annual Report were distributed to interested and related cooperators/individuals.

Thomas B. Crabb made a presentation at the County of Kauai Energy Conference.

Other Activities

The highlight of the past three months was the Contractors' Annual Short Rotation Woody Biomass Workshop here in Hilo, at which, copies of the above two publications were distributed to all participants. Fifty participants from the U. S. Mainland, New Zealand and Scotland attended.

BioEnergy Development Corporation is assisting and participating in a State funded alternate biomass research project with Hawaii Sugar Planters' Association, principal contractor. Research trials will be installed on five islands comparing grasses, cane and trees.

Tom Schubert participated in a tree improvement workshop sponsored and coordinated by the State Resource Management forester.

SPECIES SCREENING AND GENETIC SELECTION AT SITES IN ARIZONA, NEW MEXICO, AND TEXAS

Quarterly Report for the Period

June 1 to August 31, 1985

Samuel Hale, Jr.

September 1, 1985

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QUARTERLY REPORT FOR THE PERIOD
JUNE 1, 1985 - AUGUST 31, 1985
FIRST QUARTER OF THE SECOND YEAR

TASK 1. Germplasm Acquisition:

Final selection and acquisition of germplasm was completed during the previous reporting period.

TASK 2. Development of Propagation Techniques and Production of Nursery Stock:

The nursery stock propagation was completed during this period at consortium members' nurseries. The species produced at each nursery are listed in Attachment 1. Both the commercial nurserymen and the university researchers involved with the project had difficulty with the plant bands that were used uniformly for all nursery stock. They have expressed the desire to use their own standard nursery pots in the future. This preference is to be expected because a nursery may spend years developing and improving upon its use of one specific system and it is difficult to make a rapid adjustment to a new system for a relatively small number of seedlings. These nurseries also identified cultural problems associated with the plant bands that were discussed in the previous report.

TASK 3. Establishment of Experimental Plots:

This period of reporting encompassed the planting season for all sites and planting was completed during this period. An experimental design and plot layout was prepared for each site. These involved a detailed map of each site and location of the plots. These maps are available upon request.

The Las Cruces planting, which is initially supported by NMERDI funding, was the first to be planted. The most efficient field layout and planting techniques were developed at this site in collaboration with the New Mexico State University Horticultural Department which is a consortium member on this project. Color coded flags were found to provide an efficient means for planting the proper species in the proper place using untrained labor. The labor at this site was provided by the State of New Mexico under a summer youth employment program. Prior to planting, the site had been deep plowed and irrigated and the weeds treated with the herbicide Roundup. The planting had been scheduled at this site for Wednesday, July 17th; however, the expected rains did not come and the site had dried up so that digging was prohibitively difficult. It was therefore decided to irrigate the site again and plant on July 22nd. Planting took one day with 14 people planting. A total of 4,096 seedlings of 50 species and varieties were planted in randomized complete blocks (8x8 and line plots) at this site. The species planted are listed in Attachment 2.

Glendale, Arizona was the second site to be planted. Although this site was well prepared (deep plowing, etc.) the rains in the previous week and subsequent drying had cemented the soil such that digging 15 inch holes was very difficult. There was no possibility to irrigate this site. A tractor driven augar was therefore used to dig the holes. This was a very slow process and the planting took three days to complete. This planting was completed on July 26, 1985. A drip irrigation system was installed at this site after planting. One seedling was found eaten by a rabbit so a low fence was installed to protect the planting against rabbits. A total of 1,482 seedlings of 12 species were planted in randomized complete blocks (8x8 and line array) at this site. A list of these species are given in Attachment 2.

The Alcalde, New Mexico site was planted during the week of August 12th. The 1,200 seedlings at this site were planted in randomized complete blocks with line plots.

The Premont, Texas site was planted on August 20th. The field layout (flagging) was completed on August 7th; however, due to the dryness of the season and intense heat, it was suggested that the seedlings be hardened-off two weeks before planting in order to assure better survival. The site had been deep-plowed and disked prior to planting and the weeds treated with Roundup. Planting took half a day with the help of 14 planters. The seedlings were watered-in with an overhead portable sprinkler system after planting. The seedlings were sprayed with 'Hinder', prior to being planted, for rabbit protection. A total of 1,632 seedlings of 11 species were planted in randomized complete blocks (8x8 and line plots) at this site. The species tested at this site are listed in Attachment 2.

Summary of Observations on Planting-Out in the Southwest:

1. The timing of planting in this arid zone is very critical. If it rains a day or two prior to the scheduled planting, planting will be delayed due to the difficulty of walking around in and digging holes in the muddy soil. If the soil dries too much due to delayed rains, it becomes too hard in most places to dig the holes. An augar was used to help dig the 15 inch holes required for the plant bands. The use of the augar also requires ideal soil conditions; not too dry nor too wet. If the soil is too dry, the hole is filled in by the loose soil after the augar is pulled out. The ideal situation would be to wait until the perfect soil moisture conditions are available for planting. If only one site were to be planted this would offer the best option. This project covers three states and long distances between sites and therefore, waiting for the ideal conditions would not prove practical. For individual tree farming, we would recommend that the farmer plant only when the soil moisture status is appropriate.

2. The 15 inch plant bands were greatly more difficult to plant than the shorter leach tubes. These plant bands may prove to provide better survival; however, it is doubtful that a private investor will want to invest in the additional cost to dig the extra-deep holes to plant these containers.

3. The movement of seedlings from the various nurseries in three states to the planting sites was costly and time-consuming. In one occasion, we were unable to move seedlings from Texas to Arizona because of state quarantine laws. In the future, all seedlings to be planted at a site should be propagated at that site in order to avoid these complications.

4. When a seedling is propagated at one site and planted at another, it is probably important for survival to harden-off those seedlings at the site of planting. A good rule of thumb is to place the seedling in a location that will allow it one half-day of sunlight each day for at least two weeks prior to planting.

5. The pre-emergence herbicide Surflan is providing good control of weeds without harm to the seedlings.

TASK 4. Management and Evaluation of Experimental Plots:

Data forms were designed that will facilitate a systematic collection of data on the growth, survival, and condition of the seedlings in the research plots. Copies of these forms are available upon request. The first data collection on the size of the seedlings was taken for each site immediately after planting. Also, representative seedlings of each major species in the selection trials were carefully examined for root development, nodulation, and general vigor, and then photo-documented. Individuals at the commercial nursery sites have been identified and trained for help with the periodic data collection.

A rain gauge and a maximum-minimum thermometer was purchased for each site. Data collection on rainfall and temperature will be recorded at periodic intervals at each site.

Data collection for sapling survival and damage has been completed for the Las Cruces and Glendale sites. Preliminary information from the first two sites planted indicate that seedling survival has been very good. Extra seedlings were left at each site for replanting the mortalities during the first three months only. An attempt to control weeds at the Las Cruces site with Roundup resulted in some seedling loss despite the great care to protect the seedling from direct exposure to this herbicide. In the future, only a pre-emergence will be used for post-planting treatment.

ATTACHMENT 1

Attachment 1

WHICH NURSERY PROPAGATED WHICH SPECIES

Nursery	Species
NMSU	Acacia abyssinica
	Acacia pennatula
	Casuarina equisetifolia
	Cupressus arizonica (Low)
	Leucaena diversifolia x leucocephala K743
	Leucaena leucocephala K636
	Pinus eldarica
	Sapium sebiferum
	Sambucus mexicana
	Leucaena leucocephala var Cunningham
	Leucaena leucocephala var Peru
	Leucaena leucocephala K8
	Leucaena leucocephala K132
	Leucaena leucocephala K28
	Leucaena leucocephala K67
	Leucaena leucocephala K6
	Leucaena leucocephala K62
	Leucaena leucocephala K500
	Leucaena leucocephala K341
	Leucaena leucocephala K29
	Leucaena leucocephala K156
	Leucaena leucocephala K340-D
	Prosopis juliflora
	Prosopis specifera
	Prosopis tamarugo
	Zizilphus jujuba
	Acacia arabica
	Acacia karoo
	Acacia tortilis
	Acacia victoriae
	Acacia senegal
	Acacia nylotica-Pakistan
	Albizia falcataria
	Albizia julibrissa
	Albizia lebbeck
	Dalbergia sissoo
	Eucalyptus gunnii
	Eucalyptus globulus
	Eucalyptus camaldulensis
	Eucalyptus torquata
	Casuarina cristata
	Casuarina glaca
	Melia azedarach

Attachment 1 (continued)

Nursery	Species
Plants of the Southwest	Ailanthus altissima Atriplex canescens (Var. Prov.) Chrysothamnus nauseosus Elaeagnus angustifolia Fraxinus velutina
Mountain States	Acacia minuta Eucalyptus microtheca Prosopis alba Prosopis chilensis Ziziphus spina-cristi
Storm Nursery	Quercus virginiana
Native Plants Inc.	Atriplex canescens (Utah Prov.)
Texas A&I	Prosopis alba clone B_2 V_{50}
NMSU-NMSERI	Cucurbita foetidissima -- Seed (Direct Seeded Herbaceous Perennial)

ATTACHMENT 2

Attachment 2

TREE AND SHRUB SPECIES BEING TESTED
FOR THE SRWC PROJECT OF THE SOUTHWEST REGION

Species	Test Site[1]	Nitrogen Fixation	Native or Exotic[2]
Acacia abyssinica	P, LC, G	Yes	E
Acacia minuta	P, LC, G, LL	Yes	N
Acacia nilotica	LC, LL	Yes	E
Acacia pennatula	LC, LL	Yes	E
Ailanthus altissima	AL		E/I
Atriplex canescens	AL, LL, LC		N
Casuarina equisetifolia	P, LC, LL	Yes	E
Chrysothamus nauseosus	AL		N
Cucurbita foetidissma	LL		N
Cupressus arizonica	AL, LC, G, LL		N
Dalbergia sisso	LC		E
Elaeagnus angustifolia	AL	Yes	E/I
Eucalyptus microtheca	LC, G, LL		E
Fraxinus velutina	AL		N
Leucaena diversifolia x leucocephala	G, P, LC	Yes	E
Leucaena leucocephala (K636)	G, P, LC	Yes	N
Leucaena pulveruenta x leucocephala	G, P	Yes	N
Pinus eldarica	G, P, LL, LC		E
Prosopis alba	G, P, LC, LL	Yes	E
Prosopis alba clone B_2V50	G, P, LC, LL	Yes	E
Prosopis chilensis	G, P, LC, LL	Yes	E
Quercus virginiana	P, LC		N
Robinia pseudoacacia	LL, LC	Yes	N
Sambucus mexicana	LC		N
Sapium sebiferum	LC		E
Ziziphus spina-cristi	LC		E
Leucaena leucocephala var Cunningham	LC	Yes	E
Leucaena leucocephala var Peru	LC	Yes	E
Leucaena leucocephala K8	LC	Yes	E
Leucaena leucocephala K132	LC	Yes	E
Leucaena leucocephala K28	LC	Yes	E
Leucaena leucocephala K67	LC	Yes	E
Leucaena leucocephala K6	LC	Yes	E
Leucaena leucocephala K62	LC	Yes	E
Leucaena leucocephala K500	LC	Yes	E
Leucaena leucocephala K341	LC	Yes	E
Leucaena leucocephala K29	LC	Yes	E
Leucaena leucocephala K156	LC	Yes	E
Prosopis juliflora	LC	Yes	E
Prosopis specifera	LC	Yes	E
Prosopis tamarugo	LC	Yes	E
Zizilphus jujuba	LC	Yes	E
Acacia arabica	LC	Yes	E
Acacia karoo	LC	Yes	E

Attachment 2 (continued)

Species	Test Site[1]	Nitrogen Fixation	Native or Exotic[2]
Acacia tortilis	LC	Yes	E
Acacia victoriae	LC	Yes	E
Acacia senegal	LC	Yes	E
Acacia nylotica-Pakistan	LC	Yes	E
Albizia falcataria	LC	Yes	E
Albizia julibrissa	LC	Yes	E
Albizia lebbeck	LC	Yes	E
Dalbergia sissoo	LC	Yes	E
Eucalyptus gunnii	LC	Yes	E
Eucalyptus globulus	LC	Yes	E
Eucalyptus camaldulensis	LC	Yes	E
Eucalyptus torquata	LC	Yes	E
Casuarina cristata	LC	Yes	E
Casuarina glaca	LC	Yes	E
Melia azedarach	LC	Yes	E

1. Test Sites: P = Premont, LC = Las Cruces, G = Glendale, AL = Alcalde, LL = Los Lunas

2. Native or Exotic: N = Native, E = Exotic, E/I = Exotic but introduced and naturalized

EUCALYPTUS FOR BIOMASS PRODUCTION IN FLORIDA

Quarterly Report for the Period

June 1 to August 31, 1985

Donald L. Rockwood

September 1, 1985

Report prepared by

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for

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I. Description of New Research Activities and Research Results.

Task A. Selection in the Current Base Population of Eucalyptus grandis.

Genetic gains were predicted at different selection strategies for converting Study 33 (GPOP77) into a seed orchard. For each strategy, the inbreeding coefficient (F) was established based on the relatedness among selected individuals. The predicted gains were adjusted for inbreeding, as well as for selfing, which is known to occur at higher rates in Eucalyptus grandis. Also, a selection index equation is being developed to aid in the selection for multiple traits involving growth, coppice performance, and frost resistance.

Data from controlled crosses in GPOP73 was obtained and the general and specific combining abilities of 10 parents were estimated. Similar analyses were done in GPOP77 involving parents common to both populations.

Task B. Screening of Eucalyptus Species for Frost Hardiness.

Eucalyptus amplifolia has proven to be the only species with frost resiliency. Selected progenies of this species are being established in Studies 35 and 36.

Task C. Eucalyptus Species in Coppice Stands.

In July 1985, bulk mixes of five selections of Eucalyptus grandis progenies superior in growth and survival were planted in Study 35 at Belle Glade on a "muck" soil site. Row and block plots of each of the five selected progenies were also planted. In addition, row plots of six E. amplifolia, five E. dunnii, 22 E. grandis and 16 E. robusta were planted to provide comparative measurements. A total of 5,310 trees were planted.

In September 1985, a comparative planting of the same Eucalyptus species in Study 35 will be established on a "palmetto prairie" site near LaBelle (Study 36). A total of 2,655 trees will be planted.

Studies 35 and 36 will provide information on three spacings, three harvest times during the year, two rotation lengths, and two soil types.

Soil samples collected from Eucalyptus grandis fertilizer tests in Study 7 (LaBelle) have been analyzed. Foliage samples for the same tests are scheduled to be analyzed.

Task D. Introduction of New Eucalyptus Sources.

Identification and selection of new sources based on source trials has been postponed until a new set of measurements can be completed in the first quarter of 1985-86.

Task E. Selection of Elite Eucalypts.

No work scheduled to be done.

Task F. Clonal Propagation and Testing of Eucalypts.

Clonal trials were measured in April 1985 and analyses are forthcoming from Mr. George Meskimen.

Task G. Economic Analyses of Eucalypts' Biomass Plantation.

Revised growth and yield equations for Eucalyptus, sand pine and slash pine were estimated as data was collected and compiled in our data base for existing plantings.

Task H. Systems Analysis for Biomass Production.

Systems model reformulation continued as the collection of new data and the evaluation of the current growth and yield equations dictated further model development.

Task I. Pilot-scale Planting of Eucalyptus grandis.

Measurement of the test plots has been delayed until the first quarter of 1985-86.

Task J. Fuel Characterization of Eucalyptus grandis.

Physiochemical analyses have been postponed until qualified personnel are available. All samples are ready for analysis.

Task K. Development of Other Species.

No activities were scheduled since Taxodium and Casuarina are no longer included in the Biomass study.

II. Technical Information Dissemination.

1. Presentations

Dippon, D. R. 06/11-14/85. Slash and sand pine intensive short rotation culture: Economic energy feedstock? Seventh Southern Forest Biomass Working Group Workshop Conference, Gainesville, Florida.

Reighard, G. L. 06/11-14/85. Plot subsampling in intensively cultured slash and sand pine tests. Seventh Southern Forest Biomass Working Group Workshop Conference, Gainesville, Florida.

Rockwood, D. L. 08/20/85. Genetic improvement of biomass species in Florida. Short Rotation Woody Crops Program Contractors Meeting, Hilo, Hawaii.

2. Visitors

Comer, C. W. - Woody biomass research in Florida.

06/24-26/85 - Two scientists from the Forestry Administration and the Forest Research Institute, Seoul, Korea, to visit and discuss biomass research projects.

06/27/85 - Three scientists from Cia. Melhoramentos de Sao Paulo Industrias de Papel and Cia. Suzano de Papel e Cellulose, Sao Paulo, Brazil, to visit and discuss Eucalyptus biomass research.

Dippon, D. R.- Woody biomass research in Florida.

06/25/85 - Two scientists from the Forestry Administration and the Forest Research Institute, Seoul, Korea, to visit and discuss biomass research projects.

07/19/85 - Dr. C. Chandrasekharan, a FAO Visiting scientist from India to discuss biomass research.

Rockwood, D. L., Comer, C. W., Reighard, G. L., and Dippon, D. R. - Woody biomass research in Florida.

06/13/85 - Forty (40) scientists attending the Seventh Southern Forest Biomass Working Group Workshop Conference reviewed biomass research projects.

Rockwood, D. L. - Woody biomass research in Florida.

06/11-18/85 - Dr. S. D. Khanduja, National Botanical Research Institute, Lucknow, India, discussed biomass research.

06/15-18/85 - Dr. Y. Zohar, Forestry Division, Agricultural Research Organization, Ilanot, Israel, discussed eucalypt research.

III. Publications

Dippon, D. R. 1985. Slash and sand pine intensive short-rotation culture: Economic energy feedstock? 7th S. Forest Biomass Workshop Proceedings, June 11-14, 1985. Gainesville, Florida. 6p. (accepted for publication)

Reighard, G. L. and D. L. Rockwood. 1985. Plot subsampling in intensively cultured slash and sand pine tests. Seventh Southern Forest Biomass Working Group Workshop Conference. Proceedings, June 11-14, 1985. Gainesville, Florida. 4p. (accepted for publication).

*Rockwood, D. L., D. R. Dipopn and C. W. Comer. 1985. Potential of Eucalyptus grandis for biomass production in Florida. Bio-Energy 84:86-93. (Draft copies sent with previous quarterly report.)

*(3 copies enclosed)

BREEDING *ALNUS* FOR INTENSIVE CULTURE OF BIOMASS FOR ENERGY

Quarterly Report for the Period

June 1 to August 31, 1985

Richard B. Hall

September 1, 1985

Report prepared by

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Progress on 1984-85 Work Plan

This is the final quarterly report to be made on the 1984-85 work plan. Any unfinished or continuing items will be reported on as part of the 1985-86 work plan in the next quarterly report.

The most significant activity during this quarter was the establishment of progeny tests at 4 locations.

Accomplishments this quarter and plans for the remaining work are listed categorically by work plan tasks/subtasks as follows:

Task 1. Breeding Program for Alder Species

Goal: Use the most promising selections available to breed for improved growth rate, climatic adaptability, and resistance to Phomopsis canker. With the aid of cooperators, test these progeny under a variety of site conditions.

Subtask 1a) Plant pilot-scale progeny test in June 1984 and establish guidelines for establishment of the full-scale progeny test.

We have begun collecting second year data on this test. Some additional mortality has occurred: the upland site went from 91 to 85% survival and the bottomland site fell from 74 to 62%. Budset observations were commenced in August. By the end of the month about 15% of the trees had appeared to set bud with more of this occurring on the upland site. This is probably due to the dry growing season we were having. Since the end of July precipitation has moved back to above normal levels and some of the trees that had not firmly set bud are reactivating.

Subtask 1b) Produce second cycle of crossings using selected parents in February - March 1985.

Strobili development appears to be progressing normally. A few losses of marginally healthy grafts/strobili have occurred over the summer but most are developing in good to excellent condition. Seed collection bags have been put over the strobili and the grafted trees have been moved outside for normal seed ripening. Only 1 graft has shown evidence of flowering next spring.

Subtask 1c) Harvest seed from first set of controlled crossings performed in 1983-84 using selected parents.

The sets of putative hybrids with A. rubra and A. incana have now grown to approximately 1 meter in height in the greenhouse. Analysis of comparative leaf and stem morphology confirms that we do have 11 hybrid A. glutinosa x A. rubra trees from 2 different females. Leave size is exceptionally large and growth of 10 of the plants is very vigorous. These trees will be clonally replicated and set out in test plots next spring. Analysis of the putative hybrids with A.incana is inconclusive. Since that material was derived from an open-pollinated A. incana selection surrounded by mostly A. glutinosa and a few A. incana plants it is not worth studying in great detail. Controlled

crosses of this hybrid were produced this year and will be available for study in a few months.

Subtask 1d) Start first full-scale progeny test in several field locations in May - June 1985.

Table 1 presents information on the 4 progeny test sites planted this year. The sites were chosen to be representative of the types of areas where alder might be planted in Iowa. The planting dates were 1-2 months later than desireable due to slow development of the planting stock.

Table 1. Planting sites and dates for 1985 progeny tests.

Site Name	Owner	Planting Date	Location Lat (N)	Location Long (W)	Topography	Soil-Description
Fick	Iowa State Univ.	6/17	41° 55'	93° 56'	Ridgetop	Hayden loam/silt loam, high sand
Hinds	Iowa State Univ.	7/1	41° 58'	93° 37'	Floodplain	Spillville-loam
Rhodes	Iowa State Univ.	7/25	41° 52'	93° 12'	Ridgetop	Downs well-drained silt loam
Amana	Amana Corp.	7/3	41° 45'	91° 55'	Floodplain	Bremer silty clay loam

Table 2 presents information on the trees planted at the 4 test sites including survival through the first week of August, 1985. Survival has been poorer than normal in all 4 locations. It has become clear that much larger planting stock will be needed and that the plantings must be put out much earlier in the growing season. Because of the small number of entries and the poor survival the long-term genetic usefulness of these tests will be minimal. However, they have demonstrated the problems associated with the various sites. The survival data itself is valuable. Most families and populations have been consistant in performance from site to site. The poor performance of our Alnus incana entry is consistant with last year's results with the same seed source, but probably not indicative of the general value of the species. Other sources will be incorporated in our future tests.

Table 2. Entries and early survival for 1985 progeny test planted on four sites in Iowa.

Female Parent		Male Parent	Number of trees planted/Number of trees surviving Aug. 1985 Location: Fick	Hinds	Rhodes	Amana	Overall	%	Source/comment
127-3-7	X	221-4-3	16/12	16/11	8/ 7	16/ 6	61/36	59	1983 Crosses, included in 1984 progeny tests
431-2-1	X	592-1-6	27/15	27/14	26/19	29/12	109/60	55	" " "
592-1-8	X	843-1-7	---	---	5/ 5	---	5/ 5	100	" " "
X61-3-5	X	172-3-8	21/ 8	40/19	---	20/ 7	81/34	42	1984 Crosses
511-4-8	X	172-3-S	29/20	27/22	16/10	26/14	98/66	67	"
591-3-3	X	221-4-3	15/10	15/13	16/ 8	15/ 3	61/34	56	"
638-3-7	X	172-3-8	21/18	21/17	22/19	21/ 6	85/60	71	"
127-1-2	X	Open Pollinated	21/14	18/10	24/19	20/10	83/53	64	1984 collections from trees moved to seed
591-3-5	X	Open Pollinated	28/19	21/15	31/30	21/ 5	101/69	68	orchard or gerplasm conservation orchard.
592-2-8	X	Open Pollinated	18/12	23/15	25/22	21/ 8	87/57	66	591-3-5 is also included in IEA index planting
5210			16/ 5	12/ 7	11/ 9	12/ 6	51/27	53	Polish seedlot included in 1979 provenance test and now in these tests and the IEA index plantings as a basis for comparison.
Alnus incana			21/ 5	7/ 1	42/12	26/ 3	96/21	22	Swiss seedlot included in 1984 progeny test and now in these tests as a species comparison.
		Overall	233/138	227/144	226/160	227/ 80	913/522		
		%	59	63	71	35		57	

Task 2. Analysis of Variation in Energy Traits

Goal: Use an existing provenance test of Alnus glutinosa to determine what traits contribute most to genetic variation in biomass energy content.

Subtask 2a) Continue collecting data on first year coppice growth over the 1984 growing season.

This item is complete and was summarized in the last quarterly report. Second year observations have been recorded when significant. Growth during the first part of the second season has appeared slower than the first year. Several reasons probably account for this. 1) Weed competition, which we thought would be controlled by the overlapping growth of the coppice, was stronger than anticipated. A herbicide application or mechanical control should have been used during the start of the second season. 2) A serious infestation of leaf miner (Fenusa dohrnii) has occurred. No significant level of resistance has yet been identified in our plantings. We do need to carry out impact assessments and study genetic resistance potential. 3) The dry weather during the 1st half of the growing season has probably accentuated the strong competition between the dense coppice sprouts. Growth has improved with the rains that began coming in late July.

Subtask 2b) Complete measurements of volume on best trees in Wisconsin and Illinois plantations by December 1984.

This activity is completed.

Subtask 2c) Determine caloric values and wood quality parameters for harvested trees. Complete by September 1984.

This subtask has been completed. An analysis of correlations between traits and among sources and individuals must now be done using this data and our earlier data on tree morphology, bark percentage, and specific gravity. That analysis will be completed by December.

Task 3. Improvement of Selection Base for Alder

Goal: Establish large (greater than 1000 trees) population plantings of the most promising sources of Alnus germplasm on a variety of sites to serve as the basis for future cycles of selection and breeding.

Subtask 3a) Grow first set of selected large populations in nursery over the 1984 growing season.

Ten of the 11 A. glutinosa seedlots sown are producing significant numbers of seedlings, but their size is small at this time. If they develop sufficient size by the end of the growing season, there will be over 8000 seedlings available. None of the 23 A. rubra seedlots is producing significant numbers of seedlings.

Task 4 Output of Improved Alder Stock

Goal: Provide the best available seed and clones of Alnus to other researchers for biomass studies and to applied tree growers for large-scale field use.

Subtask 4a) Begin cloning selected trees at Iowa plantation in June 1984 and make available a few limited clones.

We now have rooted cuttings of all 12 of the surviving selections in our Iowa test. These will be increased in the greenhouse over the winter and used for expanding the seed orchard and as entries in our future progeny tests as parental comparisons.

Subtask 4b) Maintain seed orchard established with selected trees from the Iowa provenance test.

No new developments have occurred. The surviving trees are slowly regaining crown and/or sprout stem growth. Several trees will produce flowers for next year.

Related Research

At the request of project reviewers we have been comparing the growth of A. glutinosa to other intensive culture species on our Iowa test site. Table 3 gives our results for the 1984 growing season. Alder's biomass potential continues to compare favorably with sycamore in terms of yield and height growth (height data not shown in table). Alder has been somewhat less productive than silver maple and is somewhat slower in height growth. Trials of alder/silver maple mixtures should be conducted to determine their actual compatability. Hybrid poplars have outgrown all the other species in height but have produced the least biomass in our tests because they produce fewer sprouts and have been preferrentially attacked by deer and beaver. The alder has been the most consistant in its coppice behavior.

Table 3. Comparative yields of four species grown under similar conditions at Rhodes, Iowa. Data are for 1-year coppice regrowth on 3-year-old roots in 1984.

Species	--------Dry Weight------- MG/HA	C.V. %
Silver maple	5.5	46.0
European alder	4.9	24.7
Sycamore	4.1	39.1
Hybrid Poplar	3.2	75.0

The results of a 3-year study on silver maple nursery selections have been compiled. In 1982, "super-seedlings" averaging 52% taller and 68% larger in caliper than nursery run stock were planted along with nursery controls. Apparantly due to transplant shock on the larger trees they exhibited no growth advantage the first year. The second year they grew only 8.2% better than the controls. However, when the trees were harvested at the end of 3

growing seasons the selected trees averaged 51% greater dryweight production. We feel that by also incorporating selection based on root morphology and/or cultural practices to reduce transplant shock we can substantially improve short rotation biomass yields for silver maple using early selection.

As part of our involvement in the International Energy Agency we helped identify seedlots of Alnus and clones of Populus and Salix that were included in an "index population" planting made by the IEA at 3 locations: St. Paul (Rosemount), MN; Eastern Ontario, Canada, and Uppsala, Sweden. Thirty entries of each genera were planted as a cross comparison of climate and genotypic performance. We grew the stock for the Minnesota plots and did the planting. We included 2 of our alder progeny test entries (see Table 2) in the IEA plantings and in the future we plan to use several of the IEA seedlots in our tests to provide an international linkage in our studies.

Technical Information Dissemenation

On June 19 Roger Hanna represented our program at a coordination meeting hosted by the Iowa Energy Policy Council. Research on and applications of biomass energy around the state were reviewed and plans were formulated for continued information exchange between groups. A second meeting of this group will be held in September.

On July 31 we hosted Mr. Mike Carleton of the Iowa Energy Policy Council on a tour of our Rhodes research plots. This was done in conjunction with Pat Layton's site visit.

GREAT PLAINS ENERGY FOREST

Quarterly Report for the Period

June 1 to August 31, 1985

Wayne A. Geyer

September 1, 1985

Report prepared by

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under

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for
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Oak Ridge, Tennessee 37831
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Contract No. DE-AC05-84OR21400

GENERAL COMMENTS

Growing conditions this year are much better than the extremely dry summers experienced in 1983 and 1984. Late July and August precipitation plus a cool summer have stimulated growth.

All planting sites are being maintained with mowing. Growth data are being evaluated, and technical information/transfer efforts have been increased.

TASK: DETERMINING PRODUCTIVITY POTENTIAL

Growth data from a 1968 SRF study with silver maple seedlings was reviewed in light of the recent popularity of the "woodgrass" concept. This preliminary study on SCS class I alluvial-loamy soil tested three spacings of 0.3, 0.45, and 0.6m. Plots were hand cultivated throughout the experiment. Trees were cut and weighed on 1- to 3-year cutting cycles for a period of eight growing seasons. The first cut was made at two or three years. Thereafter cutting was done annually.

At 0.3., 0.45, and 0.6m. spacings, mortality was substantial, notwithstanding the fact that silver maple is a shade-tolerant species (Figure 1). Reduction in the number of trees at the closest spacing was twice that of the greatest spacing. The longer the cutting cycle, the greater the annual rate, i.e., annual yield rate was greater for three years than for two years, and for two years than one-year coppice cuts. While yields varied with seasonal precipitation patterns, they remained relatively high (Figure 2).

Another study with silver maple on upland loamy sites (SCS Class III land) in eastern Kansas showed that mortality at wider spacings is not a factor in SRF biomass production. Survival remained above 90 percent for eight growing seasons in these uncut plots compared to 70 percent survival after three growing seasons with very close spacing in the previous study. The annual yield rate at three years of 8 dry tonnes/ha for 1.2m spacing was less than the annual yield rate of the "woodgrass" study of 11 t/ha). Biological maturity (maximazation of M.A.I.) apparently has not been reached on this eastern upland site.

A revised single-tree yield curve (sD2H) has been calculated, adding 30 larger black locust trees to our data. The new curve is similar to the previous one developed for smaller trees.

TASK: DETERMINE PRODUCTION COSTS.

Collaborative report is being developed with Oak Ridge staff for the Kansas growth data.

TASK: EVALUATE HERBICIDE EFFECTIVENESS

Studies to evaluate herbicides for use in short-rotation forestry operations are ongoing. Initial research tested the effect of numerous preemergent herbicides on weed control in sandy and silty soils. Results from these studies were used to determine herbicide treatments for

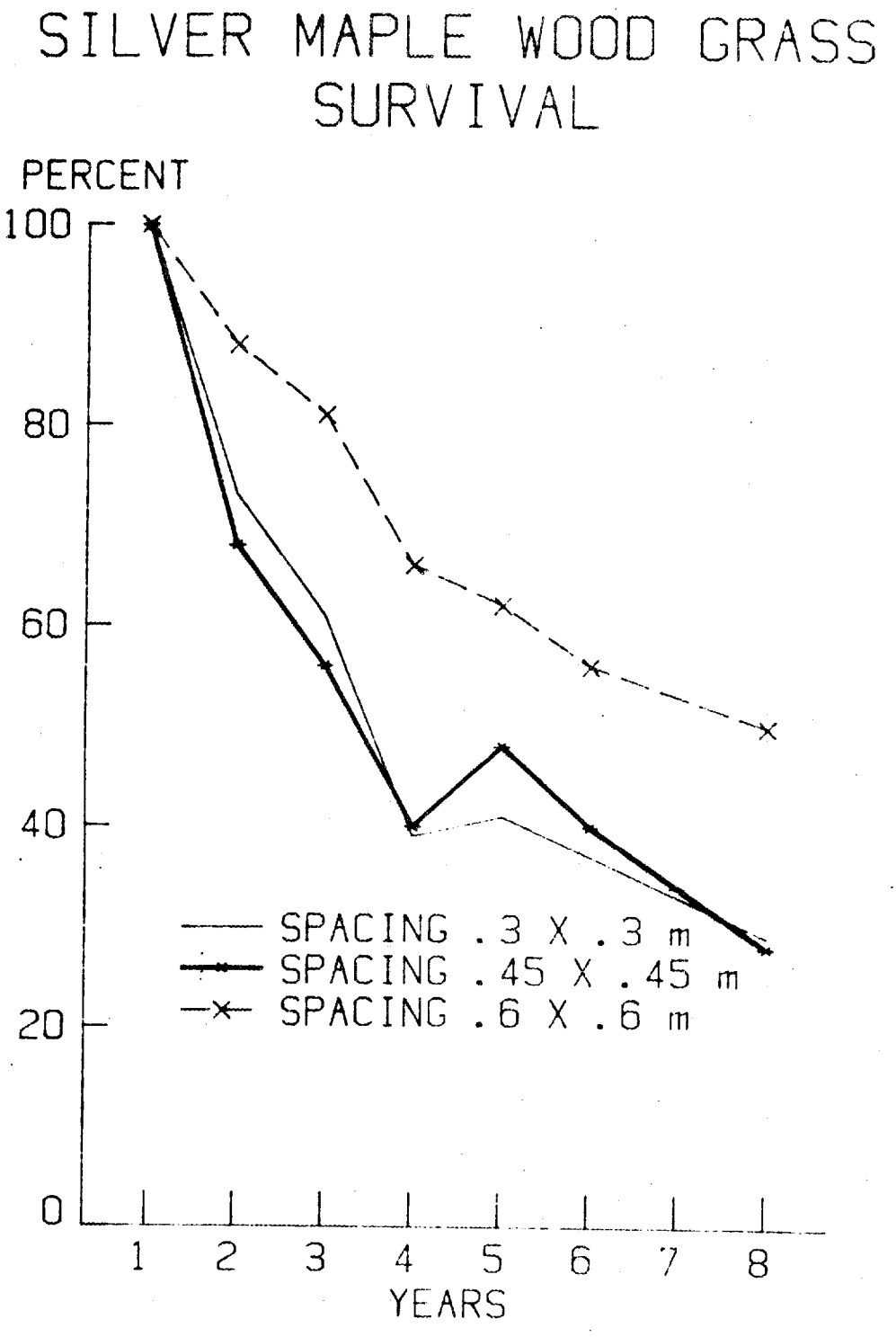
SILVER MAPLE WOOD GRASS SURVIVAL
PERCENT
100
80
60
40
20
0
SPACING .3 X .3 m
SPACING .45 X .45 m
SPACING .6 X .6 m
1
2
3
4
5
6
7
8
YEARS

FIGURE 1.

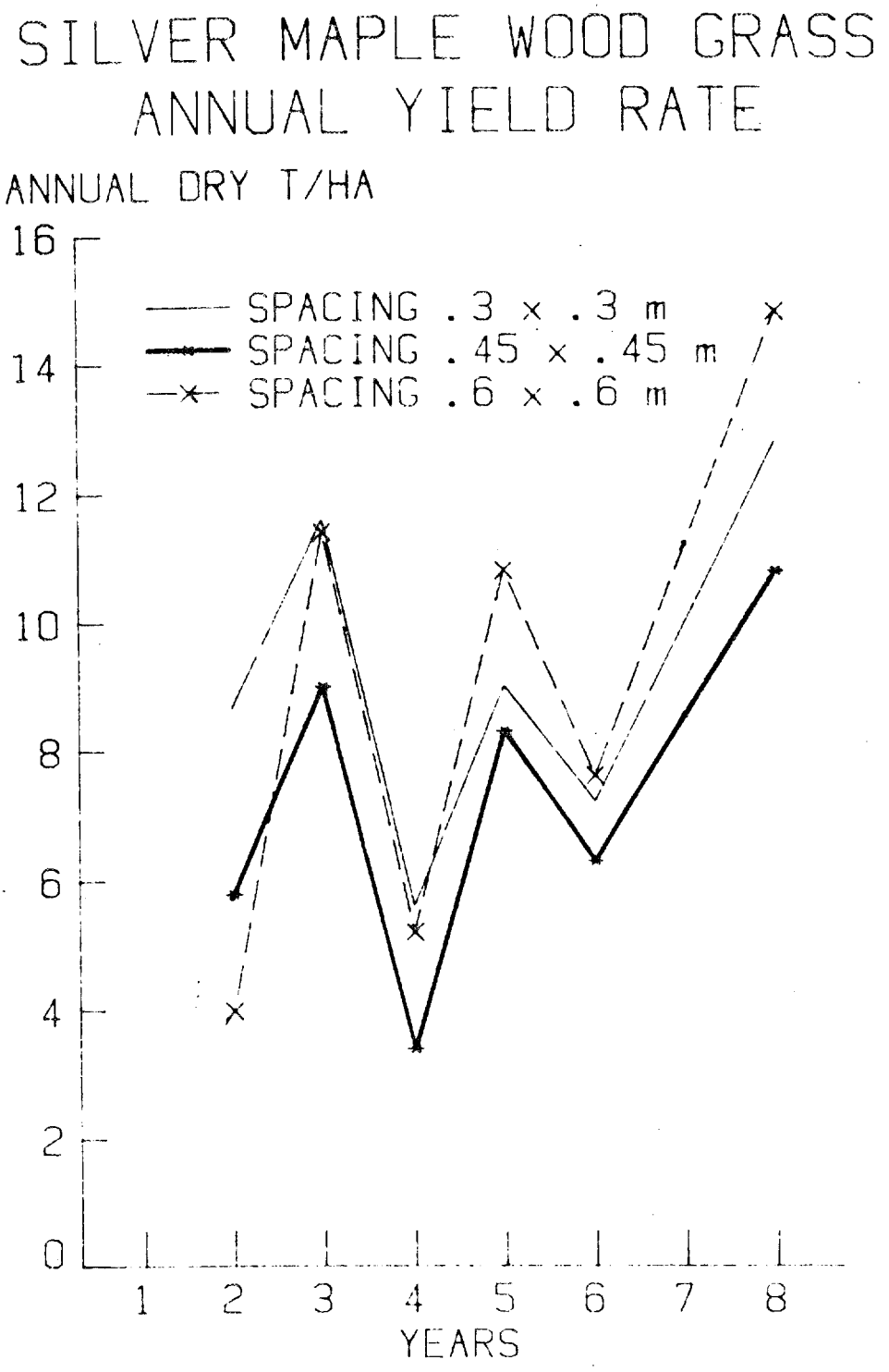
SILVER MAPLE WOOD GRASS
ANNUAL YIELD RATE
ANNUAL DRY T/HA
16
14
12
10
8
6
4
2
0
SPACING .3 x .3 m
SPACING .45 x .45 m
SPACING .6 x .6 m
1
2
3
4
5
6
7
8
YEARS

FIGURE 2.

Nelder-wheel plantings.

Present research is monitoring the effect of preemergent and/or postemergent herbicide applications on weeds and tree seedlings. Our goal is to determine which herbicide applications will adequately control weeds without affecting tree seedlings.

One study will detrmine the effect of individual or combination preemergent herbicide treatments on weed control and growth and development of five outplanted hardwood species. Individual and combination treatments of Devrinol, Casoron, and Enide were applied in the early stages of leafout over newlyplanted (1:0) honeylocust, black locust, silver maple, Siberian elm, and cottonwood on two sites--sandy and silty. These treatments were applied for two years, and this year were applied over seedlings which coppiced from original stumps. All herbicide treatments provided adequate weed control on each soil type. None of the individual or combination preemergent herbicide treatments appeared to inhibit tree growth.

A second study was initiated to determine the effect of tank-mix treatments of preemergent and postemergent herbicides on weed control and growth and development of five outplanted hardwood species. Poast, Goal, and Fusilade 4E, postemergent herbicides, were mixed individually with Surflan, a preemergent herbicide. These individual tankmixes were applied over newlyplanted (1:0) honeylocust, black locust, silver maple, Siberian elm, and green ash at three stages of leaf-out-prebudbreak, 1/4 leaf size, and full leaf. All herbicide treatments provided good weed control. No trees suffered any visual toxicity symptoms when oversprayed at prebudbreak. However, a variety of visual toxicity symptoms--leaf curling, necrosis, stunted leaves, vein chlorosis--were observed following postbudbreak applications. Siberian elm, silver maple and green ash appeared to be most sensitive. These symptoms occurred only on leaves which were present at the time of sprayings and all subsequent leaf and tissue growth and development appeared normal.

TASK: INFORMATION TRANSFER

1. Presentations/Meetings

   a. W. A. Geyer. June. Forestry practices in Italy. Eighth Annual So. For. Biomass Workshop in Gainsville, Florida. TALK.

   b. W. A. Geyer. June. Coppicing: a centuries-old practice crucial to SRIC forestry. Lawrence, Kansas. TALK.

   c. W. A. Geyer. August. Cultural processes to maximize productivity--tree density and rotation age at Hilo, Hawaii. TALK.

   d. G. G. Naughton. June. Production and harvesting costs of an 8-year-old energy plantation. 22nd An. Pop. Council at Lawrence, Kansas. TALK.

   e. W. A. Geyer. July. 9th World Forestry Congress, Mexico.

f. W. A. Geyer. August. Cultural practices to maximize productivity--spacing/cutting age. TALK. Annual DOE Contractors' Meeting. Hawaii.

2. Publications

a. Quarterly report for DOE.

b. W. A. Geyer, et al. 1985. Coppicing: a centuries-old practice crucial to SRIC forestry. In Proceedings: 22nd An. Pop. Council Meeting. Lawrence, Kansas.

c. G.G. Naughton. 1985. Production and harvesting costs of 8-year-old energy plantation. In Proceedings: 22nd An. Pop. Council Meeting, Lawrence, Kansas.

d. High Plains Journal. Newspaper. April 1985. Wood Biomass is both alternative fuel and crop.

3. Tours

a. June. On-site review with Lynn Wright, Oak Ridge staff.

b. June. Poplar Council Society. Annual meeting. Lawrence, Kansas.

c. July. A.I.D. graduate short-course for foreign foresters attending Univ. of Tenn.

d. August. Friends of Paraguay. Guest from South America. Manhattan and Lawrence, Kansas.

TREE SPECIES AND MANAGEMENT STRATEGIES FOR BIOMASS PRODUCTION IN THE LAKE STATES

Quarterly Report for the Period

June 1 to August 31, 1985

James W. Hanover

September 1, 1985

Report prepared by

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SHORT ROTATION WOODY CROPS PROGRAM
QUARTERLY REPORT

Name: James W. Hanover

Institution: Michigan State University

Project Title: Maximizing woody-biomass production through genetic selection, hybridization, and intensive culture.

Reporting Period: June 1, 1985 to August 31, 1985

Summary Work this quarter centered on the maintenance of plantations established in the past few years and on the planning and coordination of measurements in these and other SRWC species plantations. A meeting of the North Central Tree Improvement Association was held in East Lansing this quarter with about 40 people in attendance. A field trip similar to the one held during last year's SRWCP meeting was conducted. Cooperative arrangements were established for material exchange between MSU and other agencies at this meeting. Ray Miller represented our project at the annual contractor's meeting during this quarter.

The following is a summary of work completed for each task:

Goal I. Biomass tree improvement.

General: Major emphasis is being placed on black locust genetics and culture as a primary species for short rotation programs in the Lake States. The second emphasis is on aspen and its hybrids, especially Populus alba X P. grandidentata. Our project focus will be on these two species as we move towards larger biomass plantations.

1. Black locust. The four plantations which were established this spring were mowed and sprayed to control weeds as needed. Those at E. Lansing and Augusta are doing exceptionally well. Survival is high and the trees are growing well. Deer browsing is a serious problem at the Tawas site.

2. Aspen hybrids. Weed control was carried out in all aspen plantations this quarter. Each was mowed and sprayed if necessary. Plantations in East Lansing were pruned to prevent damage to trees during operations in the stands.

3. Hybrid pine. Dropped by ORNL.

4. Larches. Dropped by ORNL. Plantations were maintained and are in excellent condition. A summary of survival after 3 months was made to quantify the effect of planting shock and to serve as a baseline for future analysis of survival. This summary is attached.

5. Ailanthus. Plans for fall collections were developed.

6. Plans for measuring silver maple, white birch, and English oak were completed and measurements have begun.

Goal II. Biomass production strategies.

7. Spacing / Rotation length study. Dropped by ORNL.

8&9. Herbicide studies. Chemicals were applied in both studies and the effects are currently being evaluated.

10. Clearcut species screening. Dropped by ORNL.

Goal III. Commercial biomass plantations.

11. Delayed as explained in the previous quarterly report.

Presentations:

Progress in tree improvement of biomass species was reviewed before the North Central Tree Improvement Association Conference by Jim Hanover and Ray Miller. E. Lansing, MI. August 12-14, 1985.

Publications:

Miller, R.O. and J.W. Hanover, 1985. Kellogg hybrid pine (Pinus nigra X P. densiflora) breeding for improved growth rate and adaptability in the Lake States. IN: Proc. 4th North Central Tree Improvement Conference. E. Lansing, MI. August 12-14, 1985. IN PRESS.

O'Connor, J.M., G.T. Howe, and J.W. Hanover, 1985. Provenance variability in biomass production of Larix laricina in Michigan. (Same citation as above).

Reighard, G. and J.W. Hanover, 1985. Genetic analysis of physiological and morphological traits in Populus grandidentata, P. tremuloides, and their hybrids. (Same citation as above).

SPECIES SELECTION AND SILVICULTURAL SYSTEMS FOR PRODUCING FUELS FROM WOODY BIOMASS IN THE SOUTHEASTERN UNITED STATES

Quarterly Report for the Period

June 1 to August 31, 1985

Douglas J. Frederick, Project Leader
Robert C. Kellison, Co-Project Leader
Russ Lea, Co-Project Leader

September 1, 1985

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for

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Task 1: Evaluating different silvicultural systems for short-rotation woody crops production and determining seedling and coppice production under variable plantation conditions.

The major effort under this task during the summer is always plantation maintenance and protection. Now the trees are so large that mowing around borders and between blocks is the major requirement. Scott Torreano, a DOE-supported graduate student, has worked full-time during the summer summarizing the growth and yield data for plantations in North Carolina, Georgia and Alabama. This has been computerized and he has started analyses and comparisons for species, spacing, site and location. This work will go on through the fall of 1985 and winter of 1986. Scott has also assisted in developing biomass, nutrient and energy sampling schemes for coppice and seedlings for the four Scott Paper Company plantations in Alabama. Field sampling for these plantations is scheduled for November-December, 1985.

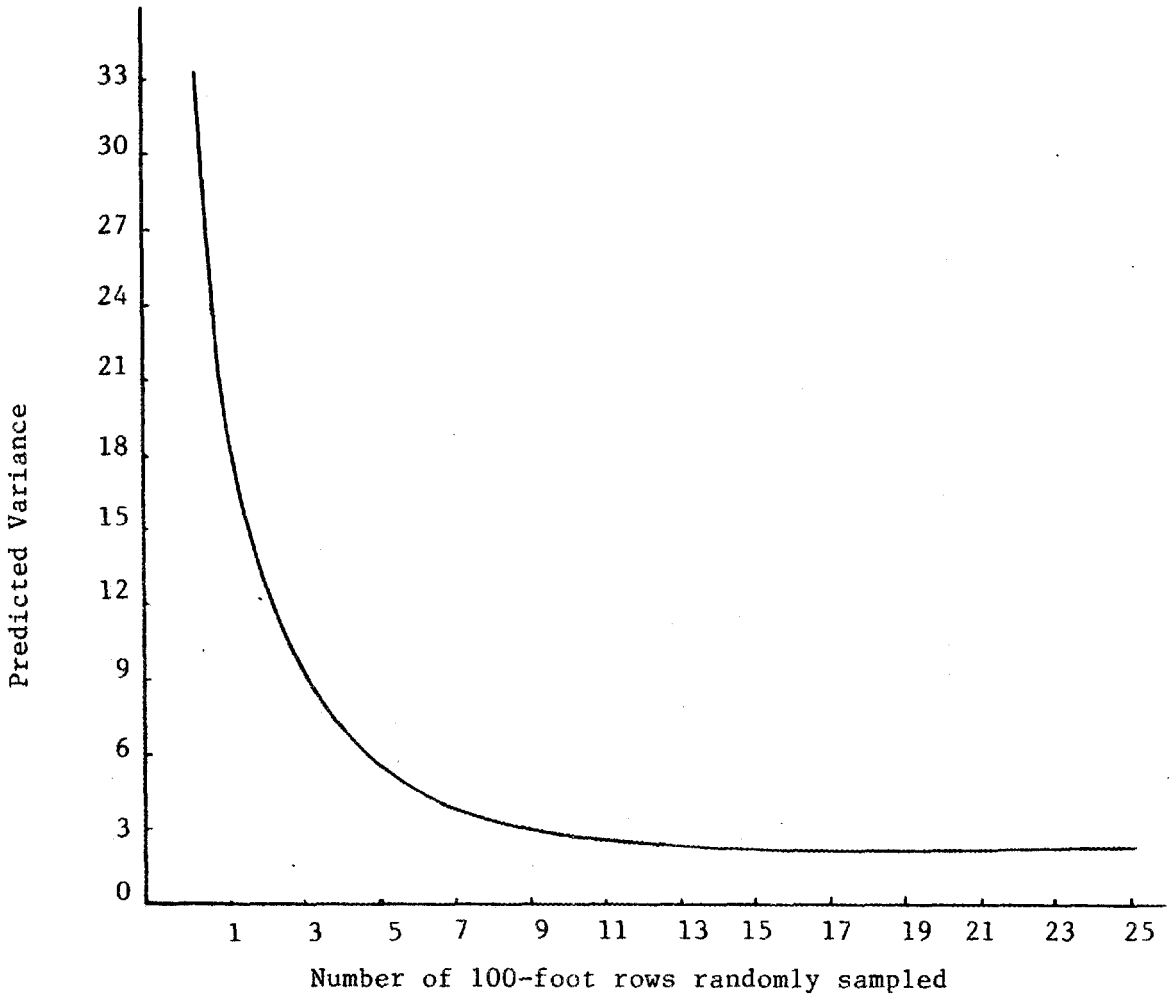
Task 2: Harvesting semioperational and operational energy plantations and determining yields, costs and efficiency.

Latest work under this task involves the analysis of data from the 2-ha 3-year-old sycamore operational plantations at Scott Paper Company in Alabama. This block was harvested in February, 1985, using the prototype Hyd-Mech Feller-Buncher. Regression equations predicting individual tree green weights, using various individual tree parameters, are being evaluated for seedling data. The predicted per-hectare yields using these equations have been compared to actual harvest yields from the cut block. The most accurate predictions within a 95% confidence interval use ground line diameter (GLD) and total height (TH) rather than DBH or half-height values. The best equation has the following form:

$$Y = a*GLD^2*TH$$

where Y = predicted green weight (Kg)
GLD^2 = ground line diameter squared (cm)
TH = total tree height (m)
a = parameter estimate

To increase efficiency and cut measurement costs, a Monte Carlo simulation using the "best" predictor equations was used. The initial runs simulated random sampling in units of 100-foot (30-m) rows within last season's measurement data. This closely duplicated the original sampling scheme (100 x 100-foot plots) except that different intensities could be used. Our results showed that the present level of accuracy can be achieved by sampling 9 - 11 100-foot rows rather than the 40 rows originally sampled. The relationship between sampling variance and number of rows is shown in the figure below.



Predicted variances from a Monte Carlo sampling simulation of an operational sycamore biomass plantation in Alabama

The actual weighed yield from this block, based on chip vans, was 41.8 tonnes while our estimate was 41.4 ± 1.1 tonnes. Furthermore, the variables needed to make such estimates are all easily measured in the field.

Plans for this year's harvesting the 4-year-old seedling block and 2-year-old coppice block are progressing. Negotiations are underway between Scott Paper Company and Hyd-Mech Engineering of Woodstock, Ontario for bringing the prototype machines down for the harvesting trials. Dennis Curtin from TVA is acting as a liaison for these negotiations. Hopefully plans will be firmed up by this fall.

Task 3: Planting an operational-size energy plantation, using optimal species, spacing and silvicultural systems.

We are still in the planning stages for this work. Several industries have been contacted to cooperate and provide planting sites and labor. We will be evaluating planting sites during the fall, 1985 and planting during the winter, 1986. We are also making arrangements for planting stock which, depending on site conditions, will likely be sweetgum. This species is in good supply and there should not be a problem obtaining adequate numbers of seedlings.

Task 4: Installing detailed coppicing studies in several biomass plantations to better understand the dynamics of this regeneration method and provide recommendations to maximize yields.

Coppicing physiology and dynamics are areas of urgent research need if the Short-Rotation Woody Crops Program continues to follow the coppicing scenario. Based on the results of the Annual Contractors' Meeting, several key research areas were identified and prioritized. We have begun work on several of these problem areas, including: (1) Evaluating the effects of fertilizers and herbicide weed control on coppice development, and (2) screening herbicides for use in coppice management. Study sites have been evaluated and installation will begin in fall, 1985 and winter, 1986. Union Camp Corporation is providing the sycamore plantations and some of the labor and equipment for this work. First data collection will be during 1986 and then annually thereafter.

PUBLICATIONS AND PRESENTATIONS

Clark, A., Phillips, D. R. and D. J. Frederick. 1985. Weight, volume and physical properties of major hardwood species in the Gulf and Atlantic Coastal Plains. SEFES Res. Pap. SE-250. 66 pp.

Gower, S. T., R. Lea and D. J. Frederick. 1985. Aboveground energy production and distribution of southeastern hardwood swamp forests. Biomass 7: 185-197.

Kellison, R. C. 1985. Forest resource technology and transfer in developing countries. Presented at International Forestry Working Session, SAF Annual Convention, Fort Collins, Colo. July 29-31. 5 pp.

Kellison, R. C. 1985. Seed procurement and nursery management of the southern pines in the People's Republic of China. Presented at the International Symp. on Nursery Management Practices for the Southern Pines. Auburn, Alabama. August 4-9. 5 pp.

Kellison, R. C. and R. G. Hitchings. 1985. Harvesting more young southern pines will require pulpmill changes. Pulp and Paper 59(7):53-56.

Lea, R. 1985. Aboveground biomass, nutrient, energy and growth and yield of bottomland hardwood forests. Presented at Characterization of Bottomland Hardwood Forests, St. Francisville, LA. 16 pp.

Mroz, G. D., D. J. Frederick and M. F. Jurgensen. 1985. Site and fertilizer effects on northern hardwood stump sprouting. Can. J. For. Res. 15: 535-543.

Mroz, G. D., M. F. Jurgensen and D. J. Frederick. 1985. Soil nutrient changes following whole-tree harvesting on three northern hardwood sites. (Accepted: Soil Sci. Soc. Amer. J.).

Roeder, K. R. and G. D. Hansen. 1985. Season of harvest influences on sycamore coppice productivity--5-year trends. 7th Ann. So. For. Biomass Workshop. Gainesville, FL. June 12-14. (In press)

NET ENERGY AND ECONOMIC ANALYSES FOR PRODUCING *POPULUS* HYBRID UNDER FOUR MANAGEMENT STRATEGIES

Quarterly Report for the Period

June 1 to August 31, 1985

Paul R. Blankenhorn
Todd W. Bowersox
Charles H. Strauss

September 1, 1985

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This project is designed to obtain critical biomass production data for use as an input to the economic model. The financial and energy analyses for this project consider the inputs for producing, harvesting, transporting, and processing forest biomass for multiple rotations. These inputs are balanced against the recoverable energy from forest biomass, taking into account the conversion efficiencies of the energy recovery system. The financial and energy analyses using liner programming will establish the sensitivity and relative significance of the various inputs for multiple rotations. 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 goals of this project are to establish and analyze: (1) biomass yields for two rotations as a function of management strategy, site and age, (2) financial and energy measures of key inputs for producing short-rotation hybrid poplar using four management strategies (control, irrigation, fertilization and combined fertilization/irrigation) for two rotations, (3) wood properties related to use as a source of fuel as a function of management strategy and site, (4) sensitivity analyses of the strategies to energy inputs for each selected management strategy for two rotations, (5) a comparison of the financial and energy analyses for selected management and conversion strategies for two rotations and (6) recommendations concerning a management strategy for two rotations with the most favorable financial and energy considerations based on biomass yields coupled with usable energy products obtained from the biomass.

Current Quarter Activity

The major effort this past quarter has been the completion of the first rotation final report and maintenance of the plantation. The coppice growth and five year old production data from the 1980 planted trees have been obtained and will be analyzed and reported in the future.

TASK 1 - PLANTATION BIOMASS PRODUCTION

The research in this task is designed to determine biomass yields, growth values and properties as a function of management strategy, age, site and rotation. In addition, the SRIC cultural financial and energy inputs needed to operate and maintain the plantations under the selected management strategies will be investigated.

Current Quarter Activity

All trees have completed their first four year rotation (seedling rotation) and are now in the second rotation (first coppice rotation). Trees planted in 1980 are completing their second year of coppice growth and the 1981 planted trees are completing their first year of coppice growth. Frequency of stump sprouting, stem diameter, total height and yield values for the coppice growth will be measured or estimated at the end of the growing season. Second rotation yield estimates for wood, bark plus branches and total tree will be based on first rotation age-treatment specific equations.

First rotation treatment of control, irrigation, fertilization and fertilization/irrigation were continued in the coppice rotations. As required, fertilization to maintain non-limiting nutrient conditions for N-P-K-Ca-Mg were applied last quarter. Irrigation to maintain non-limiting soil moisture conditions for the 1985 growing season was started in July and continued through August for the irrigation and fertilization/ irrigation treatment units. Irrigation was terminated August 30 and the system will be winterized next quarter.

TASK 2 - ANALYSIS OF BIOMASS FINANCIAL AND ENERGY DATA

This task is concerned with analyzing and comparing the financial and energy data for the selected management/conversion scenarios for a period extending through at least two rotations of the plantation. 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 yields, growth values and properties will be used to standardize the data. Linear programming is being used to analyze the various input requirements, associated constraints and outputs from the combinations of the various production/conversion scenarios. This will permit an evaluation of production/conversion scenarios that maximize net financial and net energy flows. In 1985-1986 the economic analysis will concentrate on the financial analysis. The net energy analysis will be postponed for the next year and continued in 1986-1987.

Current Quarter Activity

Three general economic evaluations of SRIC plantations were pursued during this past quarter;

(1) A synthesis of production, harvest and conversion costs for a complete evaluation of total supply systems and alternatives to these systems.

(2) An identification of the major inputs within the production and harvest phases of the supply system and the sensitivity of cost changes from any of these particular inputs upon the total costs of production and harvest.

(3) An evaluation of alternate interest rate changes upon the cost of all investment items used at specific points of time and as subsequently prorated costs over time.

Most aspects of the first two evaluations were included in our presentation at the Hilo, Hawaii Annual Contractor's Conference.

Total cost of production at the plantation site varied from $28.71/ODt for control to $96.40/ODt for irrigation on the better quality Basher site for the first 4 year rotation. Modest increases in production costs were evident on the moderate quality, Morrison site. Although the control strategy was least expensive during the first rotation, the fertilization

strategy has the better, long term potential for sustaining high yield outputs. First rotation production costs for the fertilization strategy on the Basher site was $35.60/ODt.

Harvest, chip and transit costs ranged form $19.08/ODt for a prototype feller-buncher system to $33.30/ODt for a commercially available chip-harvester system. The combination of a fertilizer strategy production system and the less expensive feller-buncher harvest system would provide delivered wood chips at the plant site for $59.57/ODt. The final conversion of this biomass to ethanol via hydrolysis developed a total output cost at $.48/ℓ ($1.83/gal). Within this particular conversion scenario, plantation production costs contributed 32.8% to total output cost, harvest-chip-transit another 15.6%, with the remaining 51.6% tied to the final manufacturing stage.

The input analysis of the control (Basher) strategy for plantation production found 10.4% in equipment and fuel, 16.5% in materials, 37.2% in labor and 35.9% in land. Thus, labor and land have the greatest impact on production costs. The fertilizer strategy had 9.3% in equipment and fuel, 41.1% in materials, 25.5% in labor and 24.1% in land. Irrigation was both capital and labor intensive, having 47.0% in equipment and fuel, 5.3% in materials, 36.1% in labor and 11.6% in land. Any proposed percentile change in cost for a given input, multiplied by the inputs previously noted percentage of total production cost, will define the percentile sensitivity of an input's cost change upon total production cost. Thus, a 10% change to labor in the control strategy would impose a 3.7% change to total production cost (.1 x .37).

The sensitivity analysis also showed variations in output having a more direct and greater impact on production costs. Since biomass output functions as the key denominator in any determination of cost-per ODt, a 10% increase in output would cause a 9.1% decrease in cost per ODt, whereas a 10% decrease in output would raise the ODt cost by 11.1%.

The third stage of analyses, having to do with the impact of interest rate change on production costs, is still under investigation. Its intent is to compare the investment expectations from the production phase of operations with those often presented in the harvest and conversion phases. This comparison will illustrate the effect of higher investment changes, often displayed in conversion feasibility studies, upon the costs of production and harvesting. Alternate rates of interest of 10%, 15% and 20% were utilized in evaluating each component of production in the 4 strategy/2 site options.

TISSUE CULTURE OF ELITE BIOTYPES OF *ATRIPLEX CANESCENT* AS A SHORT-ROTATION WOODY BIOMASS CROP

Quarterly Report for the Period

June 1 to August 31, 1985

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September 1, 1985

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Contract No. DE-AC05-840R21400

INTRODUCTION

This is the 1st quarter report for "Tissue culture of elite biotypes of Atriplex canescens as a short rotation woody biomass crop". The research project is on schedule and making good progress. We are optimistic about the long-term implications for improved utilization of Atriplex as a result of project findings.

The objectives of this project are to establish a tissue culture system for the elite gigas form of Atriplex canescens that will allow rapid, low-cost, high volume propagation of plants for biomass production. To provide a source of plant materials for future study, an observation nursery will be established at University Research Park, Salt Lake City. Research activities are organized under four tasks.

A) DESCRIPTION OF CURRENT RESEARCH ACTIVITIES IN ALL TASKS IDENTIFIED WITHIN THE CONTRACTUAL STATEMENT

Task 1. Collection of Plant Materials

Collections of influorences and fruit have been made on June 23, July 10, July 26 and August 12, 1985, from the Jericho Sand Dunes.

Task 2. Development and Utilization of Tissue Culture Techniques

2A. Adventitious regeneration

Embryos and influorence collected from Jericho Sand Dunes in June, July, and August have been disinfested, and cultured in

Plant material have been placed on a total of 32 media containing differing hormonal and nutrient supplements. Formation of callus and/or adventitious embryoids is being quantitated for each media regime.

2B. Selection of increased salt and drought tolerance

As new genotypes are being analyzed for salt tolerance. Analysis is at the whole plant, microshoot and callus levels.

Task 3. Saponin Extraction

Saponin contents are being analyzed after extraction by different methods. This will enable us to determine the efficiency of a variety of extraction procedures.

Task 4. Establishment of an Observation Nursery and Production of Research Materials

Plantlets of A. canescens from the Tissue Culture Laboratory and greenhouse have been established in the observation nursery. Twenty plantlets each from two high biomass gigas genotypes are available to other researchers.

B) SUMMARIZATION OR SYNTHESIS OF RESEARCH RESULTS FOR SELECTED TASKS

Plantlets from two genotypes of A. canescens Gigas, obtained via axillary enhancement tissue culture systems, have been established at our NPI observation nursery. These plants can be evaluated at a later date.

Large scale experiments have been initiated using influorences and various stages of embryos as the tissue sources, to develop an adventitious regeneration system.

C) TECHNICAL DISSEMINATION ACTIVITIES

A presentation was made at SRWCP Annual Contractors Meeting in Hilo, Hawaii.

D) NEW PUBLICATIONS

Two papers are presently in review for submission to journal editors.

PRODUCTION OF WOOD BIOFUELS FROM MESQUITE (*Prosopis* spp.)

Quarterly Report for the Period

June 1 to August 31, 1985

Peter Felker

September 1, 1985

Report prepared by

Peter Felker, Sonia de Souza, Tom Tabone, Edward Glumac,
Scott Wrightman, and Charles Wiesman

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under

Subcontract 19X-09066C

for

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
operated by
Martin Marietta Energy Systems, Inc.
for the
U.S. Department of Energy
Contract No. DE-AC05-840R21400

Task 1 Fertility aspects of site characterization

Foliage samples have been taken for both the Kingsville and Zachry Ranch Sites for three collection dates. Foliage from the first two collection dates have been analyzed once for P, K, Ca, Fe, Zn, Mg, Mn, Cu, and Na. Two additional samples of the ground composited foliage will be analyzed so that there will be three determinations per plot (replicate).

Leaf P values for the second evaluation were approximately 2/3 of the initial spring flush value. The leaf P values for the Zachry plots were lower than the Kingsville plots on both evaluation dates. However, based upon greenhouse P values obtained under stress from high pH, neither of these values appear to be in the range that would indicate P deficiencies.

The soils for the Kingsville plots have been analyzed for particle-size, pH and sodium bicarbonate extractable phosphorus. The soil P values were less than 2 mg/kg and would be considered very low for agricultural crops.

We are experiencing mechanical difficulties with both the spectrophotometer and atomic absorption unit used for these determinations and are working on getting them repaired.

Task 2 Clonal comparisons of mesquite biomass production under 27 inch average annual rainfall conditions(Kingsville Prosopis alba B_2V_{50} clonal plots.

The coppiced plots have been disked once again since the last report. The weed control is fair under the non-coppiced plots but it is not possible to get our equipment in these plots. These trees are multistemmed and approximately twice head height. We anticipate a large growth increment in biomass for this December measurement.

Task 3 Clonal comparisons of mesquite biomass production under 18 inch annual rainfall conditions (Zachry Ranch plots).

The coppiced portions of these plots have been redisked twice since the last quarterly report. The non-coppiced plots have been rope-wicked with roundup by hand to control the weeds since cultivation is not possible in these plots. However the weed control is much better in the coppiced plots than in the non-coppiced plots. Much of the coppice re-growth is over head height and is in full leaf. In contrast the non-coppice regrowth has suffered considerable leaf drop due to water competition from either greater water consumption due to greater canopy area or to inadequate weed control.

The coppiced regrowth in the Zachry plots is much greater than the initial seedling growth at the same age. Since the major problem is providing adequate weed control prior to canopy closure, we anticipate it will be easier to provide good weed control in established coppiced plots than in the initial seedling establishment.

Task 4 Compare seeding depths and herbicides for effectiveness in direct seeding of leucaena

The seedlings in this trial failed to germinate in spite of very favorable soil moisture conditions. A germination test on the hot-water scarified seed for the field trial indicated survival's less than 10 % despite 77 % survival for the smaller scale trial run. No further work has been conducted on this task.

Task 5 Native mesquite comparison trial

These plots have been redisked. The trees have not yet been pruned and the trees are exhibiting a very bushy habit.

Task 6 Seed orchard maintenance and germplasm documentation

The seed orchard has been redisked twice since the last quarterly report. Treflan has been applied for grass and broad leaf control and solicam has been applied near the base of the trees to control difficult weed species such as johnsongrass, bindweed, and bermudagrass.

Task 7 Rooting of cutting research

A manuscript was prepared the last quarter on the influence of fertilization on the carbohydrate and nutrient supply of cuttings and subsequent influences on rooting. Two additional light benches are nearly completed and are being equipped with the either a traditional mist system or with an air driven fog device. This should be completed by the end of August.

Since stem nitrogen of the stock plants was more highly correlated with rooting percentages than P, Ca, K, Mg, Fe, Zn or carbohydrate an experiment has been initiated to vary the nitrogen concentration of the basal fertilizer solution. Four nitrogen concentrations are being used with a basic hoaglands solution.

Task 8 Tissue culture research

The previous quarterly report noted that for shoot proliferation, glutamine was a superior nitrogen source than either ammonium or nitrate. This was interesting since glutamine is the first product of nitrogen fixation in legumes, and since it is the form in which nitrogen is transported from the nodules to shoots in many legumes.

The amide nitrogen in the side chain of glutamine and asparagine is "donated" to organic acids in the Krebs cycle to make amino acids and then proteins. In contrast the alpha amino nitrogen common to all amino acids cannot perform this function. Thus it was of interest to know if the beneficial attributes of glutamine were attributable to the standard alpha nitrogen or to the amide nitrogen in the side chain.

Thus glutamine and asparagine, which contain both kinds of nitrogen were compared (at half the concentration to compensate for an additional N/mole) to glutamic acid and aspartic acid, which are identical in all

respects except for the amide nitrogen. At the 60 day evaluation aspartic acid and glutamic produced 0.9 and 0.8 shoots per explant respectively. In contrast asparagine and glutamine produced 2.5 and 1.8 shoots per explant respectively. This clearly identifies the amide nitrogen as the crucial nitrogen for shoot development.

Additionally, we have two sources of iron, iron EDTA and iron sequestrene 138 which has better stability at high pH. Four concentrations of iron were evaluated using each source. The standard iron EDTA was clearly superior to the iron sequestrene 138.

The second evaluation of the influence of photoperiod on shoot production of tissue cultured explants has been finished. The results have not yet been statistically analyzed.

We are continuing to get increasing number of shoots per explant and longer shoots prior to senescence. Nearly every explant can be induced to produce shoots on the best medium identified thus far. We appear very close to the point where rapid and routine shoot multiplication will occur.

ESTABLISHMENT OF POPLAR ENERGY PLANTATIONS*

Quarterly Progress Report for the Period

June 1 to August 31, 1985

Edward A. Hansen

and

Hans Nienstaedt

September 1, 1985

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U. S. Department of Energy
Biomass Energy Technology Division
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*Registered Trademark, Intertechnology-Solar Corporation

RESEARCH ACTIVITIES

Genetics:

1. Populus balsamifera clones have been established in stool beds at Harshaw Farm using rooted softwood cuttings. Approximately 95% of the 200 newly collected clones were propagated in sufficient numbers for planting in the stool beds. Original stock plants have been retained and will be established in the nursery for continued production of cuttings.

2. Hardwood cuttings from 75 clones of Populus deltoides selected in replicated tests in Wisconsin and Minnesota have been rooted in containers and will be field planted at Rhinelander in September.

3. Damage to Populus trichocarpa clones at Rhinelander has been evaluated. Among clones from Oregon, Washington, and British Columbia (IUFRO provenance collection) there was a significant positive correlation between survival and latitude of origin. From this we conclude that poor survival in the stool bed planting was due to lack of adaptation to severe winter cold. Seven provenances from British Columbia and eastern Washington have been tentatively identified as cold hardy and will be further field tested along with new collections from Idaho and interior BC. Growth of Populus trichocarpa clones planted in the nursery at East Lansing, Michigan is excellent. Many plants exceed 4 m in height after 2 years. This planting will produce sufficient cuttings from selected clones for field planting at Rhinelander in May 1986.

4. Site preparation consisting of herbicide spraying, mowing, disking, and plowing was completed on 9 acres in preparation for planting the new genetic material listed above.

Mid-rotation Management:

1. Four acres were sprayed with Roundup and plowed for plant moisture stress and nutrition studies to be installed in 1986.

2. A 3-acre area was site prepared by spraying, removing stumps, and plowing in preparation for a new demonstration planting.

3. Removal of old study plots is proceeding with the goal of clearing about 6 acres of completed studies by fall.

4. A "wide-spacing weed control study" was sprayed and disked down because of excessive deer damage. The study will be replanted in spring 1986 and surrounded by an electric fence.

5. Clone NC-5272 was removed from the stool bed being maintained for production of large quantities of clonal material. The area was sprayed and disked with a "woods disk" pulled by a cat to destroy the stumps.

6. Irrigation and fertilizer were applied to several studies according to prescription.

7. Weed control was continued in other, more recently established, plantations.

Physiology:

1. Completed rough draft of manuscript for IUFRO Symposium on "Whole Plant Physiology" Knoxville, Tennessee, October 6-10, 1985. The paper outlines workable ecophysiological model for SRIC poplars.

2. Collected data at University of Washington (UW), Seattle, for independent validation of ecophysiological model. J. G. Isebrands visited UW during week of August 26 for research coordination.

3. J. G. Isebrands attended DOE contractors' meeting in Hilo, Hawaii during week of August 19 and participated as panel member of a discussion group on integration of physiology, genetics, and biotechnology.

PUBLICATIONS

McLaughlin, Richard A.; Phillip E. Pope, and Edward A. Hansen. Nitrogen fertilization and ground cover in a hybrid poplar plantation: effects on nitrate leaching. Journal of Environmental Quality, 14(2): 241-245. 1985.

Michael, D. A.; D. E. Dickmann; K. W. Gottschalk; N. D. Nelson; and J. G. Isebrands. Determining photosynthesis of tree leaves in the field using a portable $^{14}CO_2$ apparatus: procedures and problems. Photosynthetica 19(1): 98-108. 1985.

Nelson, N. D. Woody plants are not inherently low in photosynthetic capacity. Photosynthetica 18(4): 600-605. 1985.

Nelson, Neil D.; John A. Sturos; Paul R. Fritschel; Larry D. Satter. Ruminant feedstuff from the commercial foliage of hybrid poplars grown under intensive culture. Forest Products Journal 34(4): 37-44. 1984.

INCREASING THE BIOMASS PRODUCTION OF ALDER PLANTATIONS IN THE PACIFIC NORTHWEST

Quarterly Progress Report
for the Period

June 1 to August 31, 1985

Dean S. DeBell, Donald D. Hook, M. A. Radwan,
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September 1, 1985

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QUARTERLY REPORT

General

Work is on schedule in all aspects of our program. The comprehensive, cooperative studies on productivity of alder and poplar, however, will be replanted next year for reasons outlined later in this report. Progress during the quarter is summarized below.

Integrated Practices

Our poplar and alder research plantations at the DNR Tree Improvement Center (Yelm) did not develop as well as expected. In the last quarterly report, we mentioned the unusual frosts and damage to red alder but were uncertain as to its severity. Since that time we appraised the extent of damage and decided to replant the alder next year. In addition, we were concerned about the unusually slow shoot development of poplar clones other than Dula's D-01. This early concern was well-founded and despite much interplanting, height growth of the other clones (especially the UW-WSU Hybrid #11) is extremely variable. Although the stands would be acceptable for operational purposes, we had reservations about their suitability for long-term, fundamental research on productivity. Based on discussions with DNR people, our staff, and Oak Ridge (Jack Ranney), we decided to use the present poplar plots as a cutting orchard and replant the poplar next year. By so doing, we will be able to use more rigorous standards in selecting cuttings for planting. Except for Dula's D-01, available stock was very limited in spring 1985 for clones of interest and we were grateful to Crown Zellerbach for sharing their limited stock with us. Next year it appears that cuttings will be abundant at several sources.

During this quarter, we did some additional work on the frost damage problem and on cutting performance. Our findings are summarized below:

(1) Frost damage to red alder families

The spring of '85 differed substantially from those of the past 20 years in that: (1) there was a period of unusually mild weather with no frosts from March 29 to April 19, and (2) this mild weather was followed by repeated frosts, including one of 28° F on May 12.

As a result, more than 60% of all seedlings were killed back to the ground. Such damage, however, varied significantly among the 18 open-pollinated alder families, ranging from 86% to 45%. Susceptibility to damage did not appear related to location of parent stand.

A short research note has been drafted on this topic by Kevin C. Peeler (student intern) and Dean S. DeBell.

(2) Differential development of poplar clones

Initial sprouting and growth varied substantially among the four clones planted at Yelm. Dula's D-01 hybrid and native black cottonwood clone Orting #5 were much more successful in establishment than UW-WSU hybrid #11 and native clone Nisqually #1. A survey of bud, shoot, and root patterns was conducted, and although results have not been analyzed statistically, some trends are apparent. Success was correlated with presence of healthy buds on the cutting at time of planting; "spent" buds (i.e., where sylleptic branching occurred) were a major cause of failure, especially with hybrid #11. Our cuttings from the latter clone had been taken mostly from portions of stems where axillary buds had sprouted into branches during the same year that primary growth occurred; these branches were cut off and discarded. As a result, no buds remained on the cuttings and success was dependent upon formation of adventitious buds. Such buds formed slowly or not at all this spring, presumably because of the unusual frosts and drought conditions. Thus, the tendency towards profuse sylleptic branching in some clones and hybrids of black cottonwood may create some additional considerations and problems in cutting production not encountered with P. deltoides.

Spacing

The spacing trial on the WIDCO strip-mine reclamation site has nearly completed its fourth growing season. Many trees are now more than 4 meters tall, but growth appears to have been less than expected in this unusually dry year. The soil was exceptionally dry, except for a few areas where water-saturated soil has been observed in the past. Exceptionally dry soil and exceptionally wet soil both contributed to poor vigor and growth of trees in localized areas. Some new mortality was observed, and many trees suffered moderate to severe leaf loss associated with drought. On each of two plots, a third of the trees suffered at least moderate leaf loss (more than half). On several plots, some trees lost all their leaves.

During late-July and early-August, trees were tagged on about two-thirds of the 52 plots. On the other plots, a majority of trees are still to small to be tagged; tagging on these plots will be postponed another year. In September and October, we will measure all inner-plot trees for dbh and will record their condition. Twenty-five, or more, trees per plot will be remeasured for height.

Nutrition and Fertilization

Work continues on statistical analyses and/or writing for three manuscripts based on the portion of the Lady Island study dealing with pure and mixed culture of alder and cottonwood. Subjects of these papers are: (1) nutrient relations of the two species, (2) stand dynamics, and (3) effects of 10 years of repeated harvesting on soil properties. They are being written by M. A. Radwan and D. S. DeBell.

We visited the new Crop Rotation Experimental at Lady Island in mid-July. Weeds were under control and crown closure had occurred.

Genetics

A manuscript entitled, "Variation in growth of red alder families in relation to shallow water table levels", by D. D. Hook, M. D. Murray, D. S. DeBell, and B. C. Wilson was edited and submitted to Forest Science.

Alan Agar and Susanne Brown are continuing to work on their theses on natural genetic variation and reproductive biology, respectively, at the University of Washington under the guidance of Reinhard F. Stettler.

A first draft of a manuscript on the red alder provenance trial (Cascade Head) was completed this quarter in collaboration with Donald T. Lester.

We have been successful in rooting cuttings taken from epicormic branches of old trees, young trees, and stump sprouts. We have used IBA as a dip and in nutrient solution. Although results are not complete, we believe that cuttings taken from red alder of various ages can be successfully rooted; and, also, that red alder clones can be propagated readily from cuttings.

Productivity Prediction

The two manuscripts mentioned in the last report are moving along through the Pacific Northest Station's publication process. They have been edited and will soon enter the typesetting phase. These papers are: (1) Development and use of the red alder soil-site model by C. A. Harrington and (2) New height growth and site index curves for young red alder by C. A. Harrington and R. O. Curtis.

Other Items

Hook and DeBell spent 2 days at Crown Zellerbach's Irrigated Poplar Installation near Boardman, Oregon at the invitation of R. F. Strand.

DeBell participated in the Annual Contractor's Workshop for the Short Rotation Woody Crops Program in Hilo, Hawaii.

A PROGRAM OF RESEARCH FOR THE PRODUCTION OF WOODY BIOMASS FOR FUELS AND CHEMICALS IN SOUTH CENTRAL VIRGINIA

Quarterly Report for the Period

May 1 to August 31, 1985

Donald L. Price

September 1, 1985

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for the
U.S. Department of Energy

REPORT ABSTRACT

This report summarizes the activities of Virginia State University as a participant in the Short Rotation Woody Crops Program, under a subcontract (19X-43389C) managed by Oak Ridge National Laboratory for the U. S. Department of Energy. Project activities have included an overview of stand conditions found on non-industrial private forest land ownership in the study area, the identification of forest management practices found in the ares, and the administration of a survey instrument to 1,500 selected landowners.

PROJECT TASKS STATUS - 1 June 1985 - 31 August 1985

Task One: Stand Condition Identification

Information on stand condition in the study area includes stand-size class, land site class, stand density, stocking percentage and stand type. Poletimber is the dominant stand-size class. On the average 85% of the forest land in the study area falls in site classes 4 and 5. On average one-half (50.5%) of the forestland is in medium-stocked stands, and one-third (33.9%) of the forestland is in fully stocked stands. By forest type pine stands are mainly medium stocked to fully stocked; mixed hardwoods are mainly understocked to medium stocked; pine-hardwood stands are mainly understocked to fully stocked. Some form of intensified forest management is needed to get increased production off the poorer quality forestland.

Task Two: Identification of Management Regimes

Management opportunities in the study area are as follows:

(i) Regeneration with no site preparation - seed tree regeneration or planting pine seedling understory.

(ii) Regeneration with site preparation - removal of competing or undesirable vegetation followed by planting pine seedlings. Removal is accomplished by dozing, drum chopping, burning or a combination of these operations. Site preparation is light, medium or heavy.

(iii) Stand conversion - involves conversion of hardwood stands by clearcut harvesting, site preparation and planting pine seedlings; removal of hardwoods from a pine-hardwood stand and allowing pine to grow through seed tree propagation or from planting an understory of pine seedlings.

(iv) No treatment.

(v) Clearcut-total removal of all trees on a timber stand - followed by pine regeneration

Based on a subsample of 150 returned mail surveys it appears that the most common treatment is no treatment. One possible explanation can be seen in the responses to the question below:

How important are each of the following reasons for owning your woodland?

	Very Important	Somewhat Important	Hardly Important	Not Important
Investment	48	46	26	7
Hunting	31	43	14	32
Other recreation	22	31	14	34
Protect against soil erosion	78	23	7	10
Watershed	45	36	10	12
Pasture for livestock	19	30	13	25
Commercial timber production	37	37	13	22
Source of wood products for own use	64	36	12	18
Esthetic enjoyment	53	39	9	11

One sees at a glance that environmental concerns (watershed maintenance and soil erosion control) and esthetics are more important than production of a commercial timber crop. The sample is composed of small farmers and rural landowners who own less than 100 acres of forest land. Forestland ownerships in the 10-100 acre range describe most of the small farm population in the study area. There was little appreciation for cost sharing programs. Landowners, when they do opt for timber management, opt for regeneration with no site preparation or only light site preparation. Discussions with county foresters reveals that NIPFL frequently decide against clearcutting a stand, favoring instead to thin and plant an understory of pine seedlings or leave seed trees. Heavy site preparation, involving release of undergrowth through herbicide application, site fertilization and irrigation is not used among the subgroup of NIPFL in our sample.

The NIPFL ownerships in the 400-2,500; 2,500-5,000; 5,000-25,000; and 25,000-50,000 acre range were not sampled. Intensive timber production and improved management is more common on these ownerships because wood is commercially grown.

The non-response of small farmer NIPFL to public assistance programs is part of the problem of low productivity on non-industrial forestland caused by inadequate management:

> Would you consider obtaining financial assistance from any of the following sources to begin a program intensive woodland management?

	YES	NO	POSSIBLY
Bank Loan	13	113	11
Cost sharing program			
FIP	32	95	17
ACP	38	85	17
RT	28	81	20
Land lease management program with:			
Insurance Company	4	78	8
Forest Industry	19	89	16
Federal or State Government	22	94	17
Tax credit	40	75	27
Forestry Cooperative			

The respondents in the subsample are clearly risk aversive with regard to investments in improved management. This is an indication that the reason they prefer not to do any, or at most a minimum of, cultural treatments is because of the low priority given to management of forestland for commercial production. The minimal prior participation in ACP, FIP or RT programs, and minimal interest in using extension or consulting forester services regarding forestland management mitigate against the use of improved management regimes among this category of NIPFL.

Primary data from analysis of costs and revenues associated with timber management will help determine the ability and inclination of woodland owners to adopt improved management. From this information will emerge a framework for determining whether these NIPFL sub-categories will contribute to increased output of pine. Response to investments will be an indicator of economic feasibility. Short Rotation Intensive Culture (SRIC) can be ruled out as a management option for woodland owners in the 10-100 acre range. It is likely not feasible for NIPFL in any acreage range in Virginia because of lack of sufficient high site index land; high per-acre cost of heavy site preparation for stand conversion on marginal land; high cost of harvesting wood biomass on small tracts; lack of market for hardwood pulpwood and low prices for hardwood sawtimber; availability of cheap coal;

and, lack of large-scale industrial use of biomass fuels for energy production, most of which would be hardwoods.

Task Three: Growth and Yield

Halifax and Pittsylvania are located in the Southern Piedmont. Growth and yield data on pine, pine-hardwood and mixed hardwood stands is a function of stand age, stocking density, and stand type (natural or planted). Given medium site index (growth rate of 50-85 cubic feet per acre per year) and natural stands with no heavy site preparation and fully stocked stand the average growth and yield is as follows:

TABLE I. GROWTH AND YIELD

STAND	STAND	TREES 1.0 + INCHES DBH				GROWING STOCK TREES		
		BIOMASS	BIOMASS	PINE	BASAL	TOTAL	SAWLOG	MAI
	AGE	VOLUME	VOLUME	VOLUME	AREA	VOLUME	VOLUME	VOLUME
TYPE	YEARS	CU.FT.	TONS	%	SQ.FT.	CU.FT.	CU.FT.	CU.FT.
PINE	10	724	26.0	85	18	223	-	22
	20	1955	71.3	90	76	1076	271	54
	30	2598	91.7	92	101	1765	775	559
	40	3001	110.7	86	110	2260	1410	57
	50	3271	120.8	87	114	2520	1810	50
OAK-PINE	10	433	16.6	34	10	129	-	13
	20	1683	63.8	42	48	729	140	36
	30	2336	88.4	38	78	1362	422	45
	40	2679	102.9	39	95	1787	691	45
	50	2825	109.4	34	103	1925	937	39
OAK-HICKORY	10	354	14.4	15	7	91	-	9
	20	1621	63.3	12	42	729	174	36
	30	2305	91.0	11	75	1317	434	44
	40	2750	109.5	7	93	1811	679	45
	50	3064	122.2	7	103	2089	920	42

Source: Vasievich, J. M. and P. D. Schroeder. 1985. Southern Timber Study: Economic Opportunities for Intensive Forest Management (Reference Data Book - Virginia). Southeastern Center for Forest Economics Research.

Task Four: Costs and Revenue

Using the QUICK-SILVER Forestry Investment Analysis Program on selected case studies chosen from the subsample, we will compute costs and revenue associated with timber management and marketing. Data are not yet analyzed for these cases. Cash flows will be generated from the transacts and will be used to compute financial reports on each case. These data will be used to make inferences about NIPFL (small farmers and rural landowners who have 10-100 acres of forestland) response to investment opportunities.

Task Five: Landowner Attitude Toward Improved Timberland Management

The average landowner in the subsample is a Caucasian male aged 60 years or older. He has a high school education and is a part time farmer who resides in the state, has some off-farm income and a 1984 pre-tax income below $25,000. A significant portion of the subsample is composed of Caucasian males in white collar or blue collar employment, aged 30-59, whose 1984 pre-tax income was $40,000 or more, who reside in another state and have some college or trade school education. Seventy percent of the landowners have done no management of the forestland in the past ten years.

Although many in the subsample have the resources to finance investments in intensive forest management, 63% replied that they would not consider investing money in cost sharing arrangements such as ACP, FIP and RT. More people participated in ACP than FIP and RT combined, indicating greater involvement in farming as a primary occupation among those who responded. Only 25% of the respondents have requested the services of consulting foresters or extension foresters in the Virginia Division of Forestry.

In combination, economic and sociopsychological factors such as markets, tax policies (capital gains and investment tax credit), assistance programs and cultural influences play an important role in forest landowner investment behavior. In the study area sociopsychological factors are more important than economic factors in explaining management decisions. As mentioned previously, esthetic enjoyment and conservation are more important reasons for owning forestland than pecuniary satisfaction of raising a timber crop for market.

NIPFL, lest it be forgotten, do respond to market forces. There is no market for hardwoods so no income would derive from stand conversion to planted pine. Even when willingness to be a better manager leads NIPFL to seek assistance from cost-sharing programs, they are sometimes frustrated because the money allocated at county level is not sufficient to help everyone seeking assistance. Tax policy on capital gains treatment of timber income may fall victim to the "tax simplification" schemes of Bradley-Gephart and Kemp-Kasten. When they read that the tax advantages of investing in forestry may be eliminated NIPFL do the logical thing - they minimize risk associated with a long term venture by not investing. The 1985 Farm Bill and the new Federal budget may render USDA-Forest Service projections of future softwood supply null and void, of they erode economic incentives to invest in increased production of timber on non-industrial forestland ownerships. Virginia's economy has a great deal to lose in that eventuality.

EVALUATION AND GENETIC IMPROVEMENT OF BLACK COTTONWOOD FOR SHORT-ROTATION COPPICE CULTURE

Quarterly Report for the Period

June 1 to August 31, 1985

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September 1, 1985

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Martin Marietta Energy Systems, Inc.
for the
U.S. Department of Energy
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The weather in western Washington this summer has been much warmer and drier than usual causing reduced growth of trees on drier, unirrigated sites. However on irrigated sites, tree growth is exceptional with individuals already over 3.5 m tall in the first year. First year coppice growth has exceeded 4.5 m with some hybrid clones.

All irrigation was guided with the use of tensiometers. These instruments were also installed at the two driest non-irrigated sites. Here, soils at 30 cm depth became drier than one atmosphere by July 3. At one of these sites the soil became drier than one atmosphere at 80 cm depth by July 26 whereas at the other, moisture at that depth remained above one atmosphere (0.7 atm.) through September 2.

Foliage samples for diagnosis of nutritional status of plants were collected from 73 hybrid clones at Alger, Pack Forest, Westport (Oregon), the new Skagit County Nursery site and at the clone bank at Farm 5. These samples have been dried and ground for chemical analysis.

Soil samples were collected from all experimental sites during August. These samples were analyzed for water content and are being processed for nutrient analysis.

Performance of the clones in the new nursery planting at Allen, Washington has been good despite some weed control problems and difficulties with the irrigation system. Nevertheless, cutting production for most clones will meet expectations. Efforts to locate sites for demonstration trials in western Washington have begun with identification of four possible cooperators. Two of these are in Whatcom County north of the Alger site, one in southern Thurston County and one in Grays Harbor County. At least two of these will be selected for the initial effort in establishing demonstration trials in cooperation with the Washington State Extension Service.

Task I - Field Trials 1a and 1b

These trials, now six years old, contain clonal materials collected from 50 black cottonwood trees (5 trees each of 10 source stands) representing the range of the species west of the Cascade Mountains from central Oregon to southern British Columbia. Three of the five replications in each of the two trials were harvested after four years and were then allowed to resprout. The second harvest will be made when the sprouts reach four years of age.

Work over the summer consisted of full irrigation of the coppiced area and only maintenance irrigation of the unharvested portion. Foliage samples were not collected from this trial.

Task II - Field Trials 2, 2a, and 2b

These trials are mainly the repository for the seedlings produced in the breeding part of the project. Contrary to the annual harvesting in these trials in previous years, these trials were not harvested in 1984 but were allowed to grow for a second year. Work during the quarter was mainly in conjunction with maintenance of the irrigation system.

The only field work done in these trials over the summer was irrigation.

Task III - Field Trial 2c

Field Trial 2c is a test planting of some of the selected clones along with other clones we have obtained. It, too, was left to grow this year. As above, irrigation was the only work that was done in this trial during the quarter.

Task IV - Expanded Crossing Program

The seedlings produced this spring were raised in the greenhouse and transferred outside in the flats on July 30. Nine families of P. trichocarpa X P. deltoides crosses yielded a total of 258 new hybrids; nine families of interpopulation crosses resulted in 1150 plants. All seedlings will be hardened off during fall and then transplanted to the field in December.

Task V - Field Trial 2d

Materials in this trial are the seedlings produced in the first phase of the expanded crossing program started in 1984. The 474 new hybrids produced in the spring of 1984, now growing in the field, show much variation in growth and vigor. They were all scored for Melampsora rust susceptibility on September 4. Out of 20 families there were three in which all progenies without exception showed high rust incidence. All three involved the same male parent (P. deltoides Mn 169-5, from Minnesota); this male did not occur in any other crosses. No further use will be made of this parent nor of any hybrids from these families. An additional 27 hybrids from six different families showed various degrees of rust infection. However, in each of these families the majority of plants were free from rust. Finally, 11 families with a total of 394 hybrids showed no signs of rust. These results clearly document the importance and effectiveness of selection in F_1 progenies at the family and individual levels.

Irrigation was the only requirement for this planting over the summer.

Task VI - Field Trials 3a and 3b

These trials, located away from our Puyallup site, contain best material from each of the crosses we have made in our breeding program. Together with Trial 3c, they represent Phase 1 plantations to determine clonal ranking on several different soils/sites.

Reaction of P. trichocarpa clones in Field Trial 3a to drought conditions was evaluated. All trees were inspected for bud set on laterals and terminals and for leaf shedding in response to drought. These data were recorded over the period of August 12-27. It has not yet been statistically analyzed. Foliage samples were collected from selected hybrid clones at both Pack Forest and Westport.

Task VII - Field Trial 3c (Alger, Washington)

This plantation contains not only a set of our most promising production clones but, separately from them, a common-garden trial of ten geographical sources of black cottonwood and their progenies. This latter material offers a first opportunity to verify at a different location and at a greater genetic resolution the geographic trends identified in our Field Trial 1a.

The Alger Trichocarpa plantation consists of approximately 1500 trees representing ten populations or sources along a latitudinal gradient stretching from southern British Columbia to Oregon. It is an ideal collection in which to study differences in native material occurring at the clone, family and population levels. During the second growing season, emphasis has been placed on describing the phenology of the trees. Susceptibility to frost damage was noted early in June. Survival was reassessed in order to determine the success of the 62 trees replanted last fall. Survival in the plantation is now over 99%.

An intense effort was made in June to describe the trees during the early growth period prior to any significant moisture stress (Alger is a relatively dry site). For each tree, the number of leaves was counted on the current terminal and/or the fifth and sixth branches of last year's growth. Leaf samples were collected and measured for area, length and width. These data will allow comparisons of total leaf area among the trees.

During August bud setting began on most of the trees due to an unusually dry season. In order to take advantage of the expression of differences which this stress produced the trees were scored in mid-August according to their stage of bud development.

Data collection this fall will focus on the description of maximum leaf area, abscission patterns, branch characteristics and height and diameter growth of the trees.

Foliage samples for diagnosis of nutritional status of selected hybrids were collected.

Task VIII - Field Trial WC-2 (Herbicide Tolerance Trials)

This task is largely completed and will be written up in a Master's thesis by the end of the year (the graduate student involved is currently on a leave of absence in Australia).

Task IX - Physiological Studies

This task concerns the comparative study of leaf anatomy of P. trichocarpa, P. deltoides and hybrids. Its aim is to correlate differences in leaf anatomy with differences in physiological properties, notably those associated with water relations.

The analysis of leaf cross sections was continued, and many of the data have been compiled. The graduate student responsible for this task has begun writing parts of his Master's thesis.

Task X - Clone Bank/Stool Collection

This clone bank contains the most promising individuals from all crosses made to date under the program. Considerable work was done during the quarter on this trial. Individuals found to be unsatisfactory were rogued from the trial and replaced with other individuals from the respective families. Additionally, the clone bank was expanded to include additional hybrids and P. deltoides and trichocarpa parental materials. After the needed cutting material was obtained from this planting, the entire area was uniformly cut back to provide for uniform sprouting in 1985.

Work over the summer has consisted of irrigation and collection of foliage samples from selected clones.

Tasks XI and XII - Ecophysiology Plantation

The climatic conditions of the summer 1985, characterized by high temperatures and clear days with high solar irradiance, together with an optimal soil moisture content, maintained by frequent irrigation, have caused a considerable growth of all the clones represented in the plantation. The best performers were again the hybrids and, among these, mainly 44-136, Hy 11 and 47-160, with plants reacting heights of 3-4 m by the end of August.

Growth and form characteristics of plants have been recorded on a bi-weekly basis with measurements of height, diameter, length of branches and leaves and branch orientation. Furthermore, every month 5 trees per clone have been harvested for above- and below-ground biomass determination. The good growth performance shown by the plantation is reflected in the high values of leaf area reached in the month of August; again, Hy 11 ranks first and it also shows a high percentage of light intercepted by the crown. On the overall leaf area production an important role is played by the sylleptic branches that are produced in high numbers by the clones Hybrid 11 and Chilliwack 2 (P. trichocarpa); but, surprisingly enough, later in the season also other clones like 44-136 and Illinois 5 (P. deltoides) started developing sylleptic branches.

As for physiological measurements, every two weeks net photosynthesis has been recorded at different times during the day. At the end of each month C 14 treatments have been conducted in the field to assess the relative contribution of different kinds of leaves, the ones on the main stem and on the branches, to the allocation of assimilates in the different parts of the plants. Early results indicate definite differences among the clones in their allocation patterns.

Task XIII - Mechanisms of Drought Resistance

Our work on this task has ended with the successful defense of Paul J. Schulte's Ph.D. dissertation entitled "Stomatal Responses to Leaf Water Potential in Populus." The major conclusions from this dissertation are as follows:

A) For all clones of P. trichocarpa examined, the desiccation and subsequent wilting of leaves excised from a shoot leads to little or no change in leaf conductance. The stomata on foliage from clones of P. trichocarpa X deltoides hybrids close when excised leaves desiccate and the response of P. deltoides appears to be intermediate.

B) A period of water stress to P. deltoides, P. trichocarpa, and hybrid clones growing in a greenhouse leads to closure of the stomata on foliage from P. deltoides and hybrid clones, and partial closure of P. trichocarpa stomata with the greatest reductions in conductance occurring in young, expanding foliage.

C) When plants of P. trichocarpa are grown under well-watered conditions, the stomata remain open in spite of plasmolysis of the guard cells. While lacking direct evidence, Schulte's results suggest that this phenomenon is due to an abnormal physical characteristic of the guard cell walls that is normalized to some degree by a period of water stress, especially if applied while leaves are still expanding.

E) The inability of P. trichocarpa stomata to close when the guard cells are plasmolyzed is not due to an inability of this species to produce an increase in foliar ABA level in response to water stress as is the case for wilty mutants of tomato and potato.

F) Application of ABA to developing leaves of well-watered P. trichocarpa plants induces a normal functioning state in stomata. It is not clear if this condition persists beyond two weeks following the original ABA application.

G) These results lead to the following hypotheses:

1) The non-functioning nature of P. trichocarpa stomata when plants are maintained in a well-watered condition results from a low "resting" level of ABA in the foliage.

2) ABA has a role in the development of stomatal function and some critical level is necessary to influence guard cell wall characteristics in a manner that will result in the production of functioning stomata -- that is, stomata that respond to low leaf water potential with closure.

Presentations

1. Schulte, P. J. and T. M. Hinckley. Stomatal aperture and guard cell water potential relationships in Populus. Annual Meeting of the American Society of Plant Physiologists, Brown University, June 23-28, 1985.

2. Van Volkenburgh, E., C. Ridge and T. M. Hinckley. Limits to popular leaf growth. Annual Meeting of the American Society of Plant Physiologists, Brown University, June 23-28, 1985.

3. Hinckley, T. M. Short rotation intensive culture of Populus: The role of physiology. Sponsored by Interdisciplinary Plant Group, University of Missouri, Columbia, August 23, 1985.

4. R. F. Stettler. The cottonwood breeding and selection program and its biotechnology effort. Contractors Workshop, Hilo, Hawaii (August 19).

Abstracts Published

1. Schulte, P. J. and T. M. Hinckley. 1985. Stomatal aperture and guard cell water relationships in Populus. Plant Physiol. (Suppl.) 77:142.

2. Van Volkenburgh, E., C. Ridge and T. M. Hinckley. 1985. Limits to poplar leaf growth. Plant Physiol. (Suppl.) 77:136.

Papers

Schulte, P. J. and T. M. Hinckley. 1985. A comparison of pressure-volume curve data analysis techniques. J. of Exptl. Bot. (in press).

Heilman, P. E. 1985. Sampling and genetic variation in foliar nitrogen in black cottonwood and its hybrids in short rotation. Accepted for publication Canadian Journal of Forest Research. August 1, 1985.

Heilman, P. E. and R. F. Stettler. 1985. Nutrient cycling in short rotation: A comparison of black cottonwood and hybrid clones. In review.

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