Oct. 26-27 1988
Forest Genetics - PAC



# TOWARD A PRODUCTIVE HARDWOOD PROJECT

CHARTER FROM JANUARY MEETING:

CORRECT CURRENT UNDER-UTILIZATION OF AVAILABLE HARDWOODS

WHAT KIND OF FIBER IS NEEDED?

WHERE AND HOW CAN IT BE OBTAINED?

MODIFY MILL PROCESSES?

GROW OR MODIFY THE RAW MATERIAL?

DEVELOP FROST TOLERANT EUCALYPTUS

IDENTIFY NATIVE SPECIES HAVING GROWTH AND FIBER CHARACTERISTICS OF EUCALYPTUS

DEVISE MEANS TO BREED, CLONE, AND MANAGE PREFERRED NATIVE SPECIES

STARTED DOWN THIS PATH, BUT TALKS WITH CONCERNED MEMBERS SOON REVEALED:

SOME - PREFER A PARTICULAR NATIVE SPECIES

PRODUCT/MARKET DRIVEN
EG., ASPEN FOR OSB & LIGHT WEIGHT COATED PAPERS

DEPENDENT ON ONE OR A FEW SPECIES
EG., PNW

LIKE GROWTH RATES & FIBER PROPERTIES

HAVE BREEDING & MANAGEMENT PROGRAMS

DESIRE GREATER GAIN & UNIFORMITY

SOME - LACK SUFFICIENT & RELIABLE SUPPLIES

LOCAL SUPPLIES OF ALL SPECIES INADEQUATE FOR RECENT OR PROJECTED MILL EXPANSION/RECONFIGURATION

SOUTH = 80S/20H TO 20S/80H
WEST = WANT MORE HARDWOOD
LAKE STATES = COATED WHITE PAPER EXPANSION & MORE OSB MILLS

SCATTERED STANDS AND VOLUMES = HARD TO GATHER ECONOMICALLY

CONCENTRATED IN WET OR MOUNTAINOUS AREAS = DIFFICULT TO HARVEST

GENERALLY INCREASING HAUL DISTANCES

HIGHLY VARIABLE SPECIES MIX & QUALITY

SPECIES VARY ALMOST DAY-TO-DAY
ALL AGES, SIZES, & SHAPES

ELEVATED PROCESSING COSTS
VARIABLE PRODUCT QUALITY
HIGH HARVEST, HANDLING, & HAULING COSTS

OTHERS - SOME COMBINATION OF ABOVE

SOME EARLY CONCLUSIONS:

THOUGH HARDWOOD FIBER IS GENERALLY ABUNDANT,

(OFTEN A DRUG ON THE MARKET IN SOME AREAS)

SUPPLIES ARE TIGHT OR TIGHTENING NEAR A SIGNIFICANT NUMBER OF MILLS, REGARDLESS OF SPECIES

SOME MEMBERS, BY VIRTUE OF LOCATION OR DESIGN, DEPEND ON ONE OR A FEW SPECIES

DELIVERED WOOD COSTS ARE RISING

EXTREME VARIABILITY & POOR QUALITY RAISE ALL OPERATING COSTS

THUS, BACKED AWAY FROM EXAMINING

MILL MODIFICATION OR SPECIES SUBSTITUTION

AS WAYS TO IMPROVE UTILIZATION

OR CORRECT SHORTFALLS

CONCENTRATED EFFORTS ON

IDENTYING USEFUL SPECIES,

APPLICABLE TECHNOLOGIES,

AND HOW RESEARCH CAN HELP

ANOTHER VIEW: HARDWOOD SUPPLY TRENDS

SOUTH - REGIONAL INVENTORIES ARE AND WILL REMAIN HIGH

GROWTH HAS SLOWED; REMOVALS HAVE INCREASED RAPIDLY (ESPECIALLY IN COASTAL PLAIN)

SUCH TRENDS ARE EXPECTED TO CONTINUE:

GROWTH WILL EXCEED REMOVALS UNTIL LATE 1990'S

REMOVALS WILL THEN EXCEED GROWTH BY FAIR MARGINS

INVENTORIES WILL FALL AFTER 2000, BUT GENERALLY REMAIN LARGE

TIGHT AND TIGHTENING SUPPLIES WILL CONTINUE IN CERTAIN LOCALES

LAKE STATES - LARGE SURPLUSES FOR MOST SPECIES & AREAS

STATUS OF ASPEN, THE PREFERRED SPECIES

ACCOUNTS FOR 50% OF TOTAL HARVEST, & 70% OF HARDWOOD HARVEST

REMOVALS EXCEED GROWTH IN MN & WI, CLOSE IN MI

TIGHTENING SUPPLIES NEAR SOME MILLS

PULP & OSB MILL EXPANSIONS

LOSING ACREAGE THROUGH SUCCESSION TO LESS DESIRABLE SPECIES

AGE CLASS IMBALANCES WILL WORSEN THE SITUATION (1998)

PNW - LIMITED # OF SPECIES

REASONABLE ALDER INVENTORIES THROUGH 2010

AVAILABILITY FLUCUATES WITH EXPORT MARKET

VOLATILE PRICING

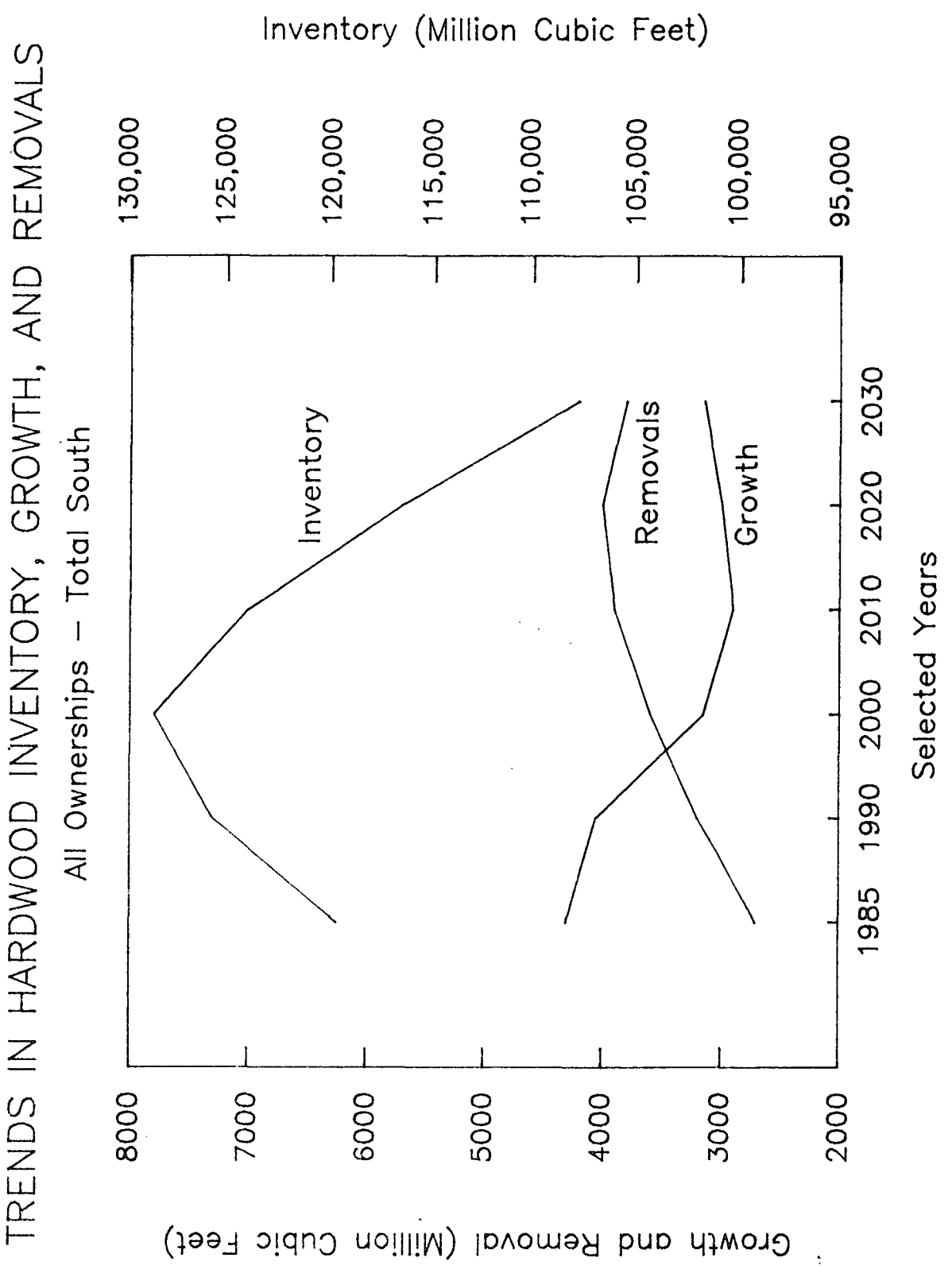
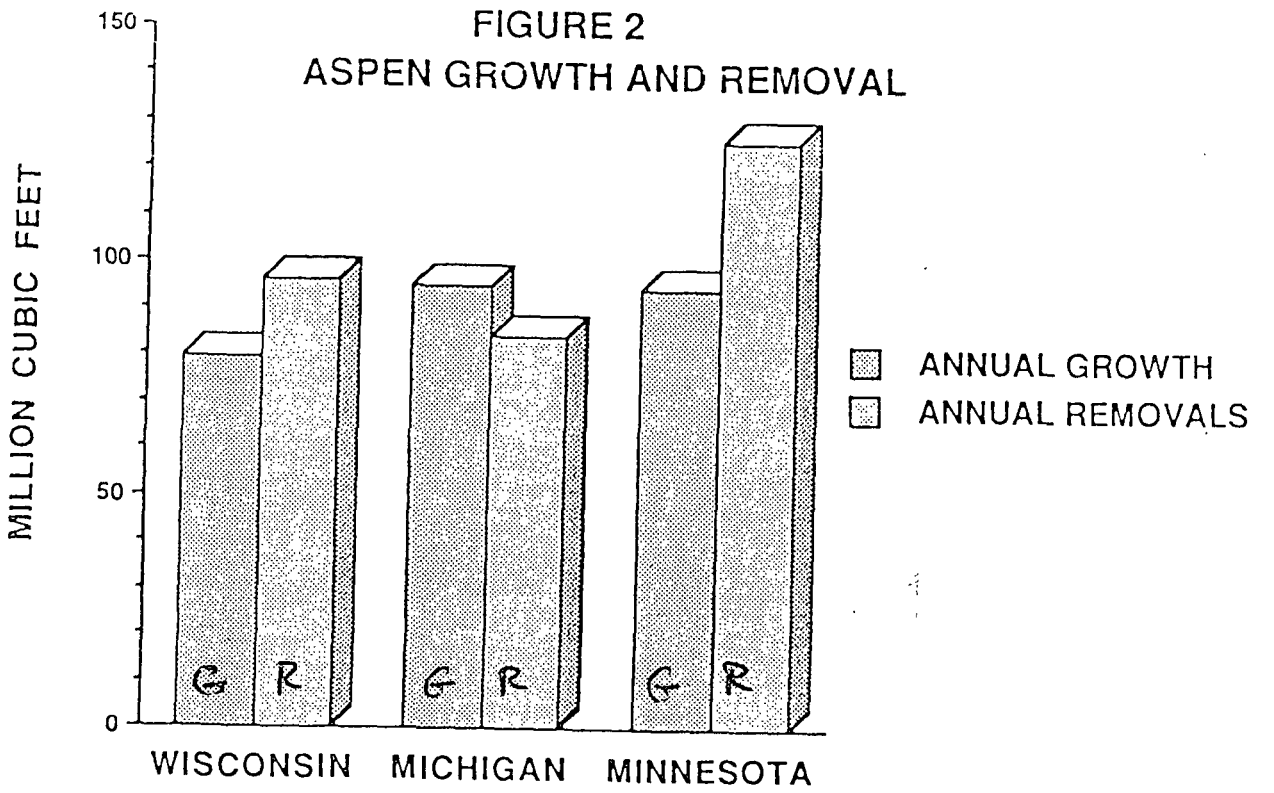

TRENDS IN HARDWOOD INVENTORY, GROWTH, AND REMOVALS
All Ownerships – Total South
Inventory (Million Cubic Feet)
130,000
125,000
120,000
115,000
110,000
105,000
100,000
95,000
Inventory
Removals
Growth
8000
7000
6000
5000
4000
3000
2000
Growth and Removal (Million Cubic Feet)
1985 1990 2000 2010 2020 2030
Selected Years

FIGURE 2
ASPEN GROWTH AND REMOVAL



FIBER CHARACTERISTICS OF PRIME HARDWOOD KRAFT PULPS

| SPECIES | EUROPEAN BIRCH | NORTHERN HARDWOODS | EUCALYPTUS SPP. |
|---|---|---|---|
| FIBER LENGTH (mm) | 1.1 | 1.0 - 1.1 | 1.0 |
| FIBER WIDTH (μm) | 22 | 19 | 16 |
| WALL THICKNESS (μm) | 3 | 2.5 - 3.0 | 3 |
| MILLINER OF FIBER PER GRAM PULP | 8 | 10 | 13 |

NOTE: SOUTHERN HARDWOODS = SLIGHTLY LONGER AND WIDER THAN NORTHERN, WITH HALF THE #/g.

SOME CONSEQUENCES OF EUCALYPTUS FIBER PROPERTIES

| FIBER PROPERTY | PULP, PAPER & MANUFACTURING | |
|---|---|---|
| DESIRABLE LENGTH | | OPACITY |
| | BONDED AREA | |
| SLENDER WIDTH | | FORMATION |
| | ENTANGLEMENT | BULK |
| HIGH WALL THICKNESS | | SOFTNESS |
| TO FIBER WIDTH RATIO | | WET WEB STRENGTH |
| | HIGH #/UNIT WT | |
| LOW VARIABILITY | | LOW REFINING ENERGY |
| | | RUNNABILITY (FAST) |

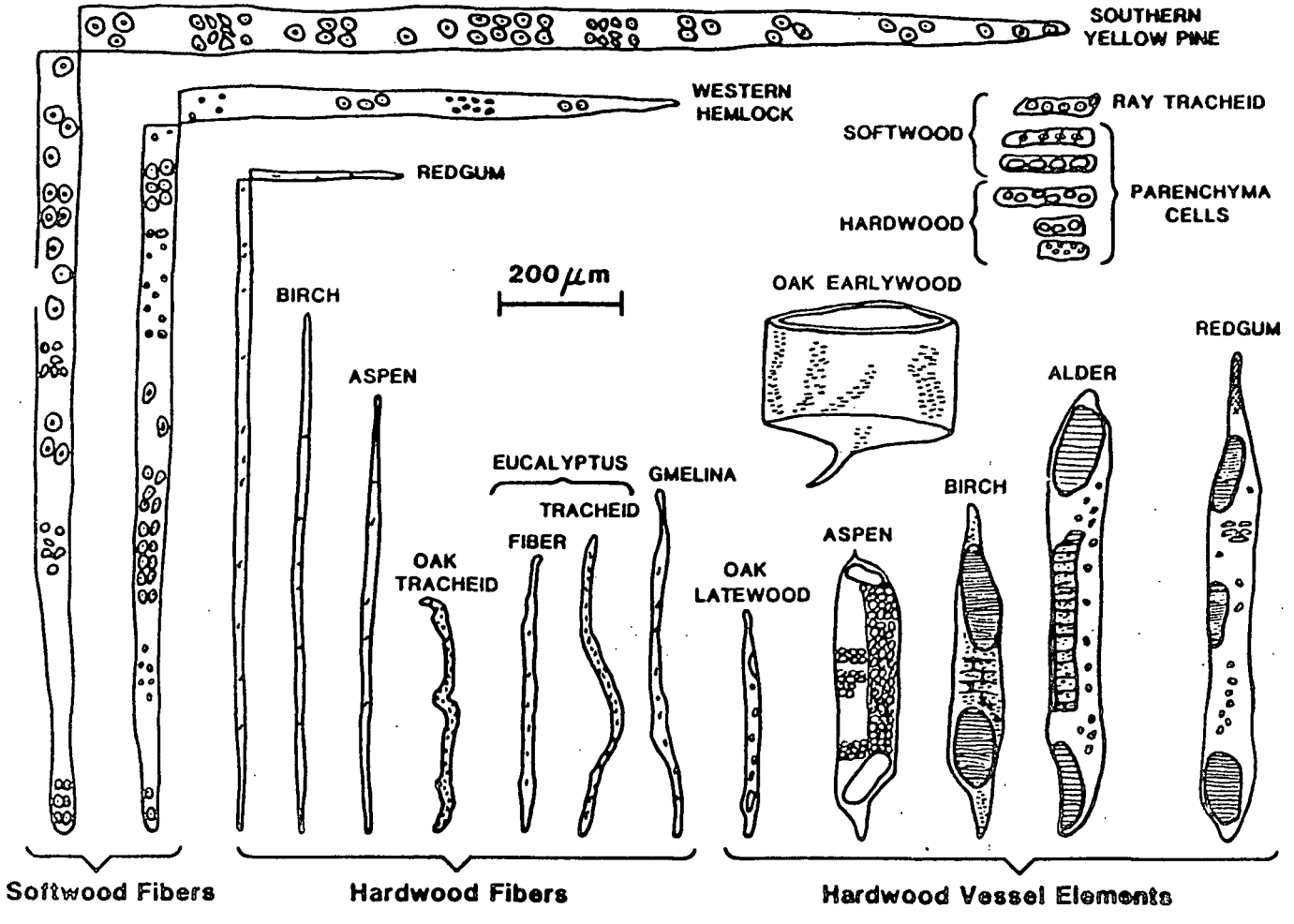



**Fig. 40. Diagrammed major cell types in softwoods and hardwoods, as listed in Tables 5 and 6. All diagrams are at the same magnification to show the relative sizes of these elements.**

WOOD & FIBER PROPERTIES: VALUED & PROMISING SPECIES

| SPECIES | SP. GR. | FIBER LENGTH (mm) | FIBER WIDTH ($\mu$) | WALL THICKNESS ($\mu$) |
|---|---|---|---|---|
| Eucalyptus | 0.40 - 0.50 | 1.00 | 16 | Thin |
| Hard Maple | 0.56 | 0.90 | 16-30 | Thin-Med. |
| Soft Maple | 0.49 | 0.80 | 16-30 | Thin-Med. Thick |
| Birch | 0.48 | 1.40 | (20) | Thin |
| Cottonwood | 0.37 | 1.00 | 25-40 | Thin-Thick |
| Aspen | 0.35 | 0.95 | 10-25 | Thin |
| Alder | 0.37 | 1.20 | 16-40 | Thin-Med. Thick |
| Sweetgum | 0.44 | 1.70 | 20-40 | Thick |
| Green Ash | 0.56 | 1.30 | 12-22 | Med-Med. Thick |
| Sycamore | 0.45 | 1.50 | 20-36 | Thick |
| Yellow Poplar | 0.40 | 1.80 | 24-40 | Thin-Med. |
| Red Oak | 0.60 | 1.40 | 14-22 | Med. |

CHEMICAL PROPERTIES: VALUED & PROMISING SPECIES

| SPECIES | LIGNIN | CELLULOSE | ALCOHOL-BENZENE EXTRACTIVES |
|---|---|---|---|
| | % | % | % |
| Eucalyptus | 21 | 49 | Low |
| Hard Maple | 22 | 44 | 5.0 |
| Soft Maple | 23 | 45 | 2.5 |
| Birch | 19 | 45 | 2.8-6.4 |
| Cottonwood | 23 | 48 | 1.5 |
| Aspen | 18 | 50 | 2.8 |
| Alder | 24 | -- | -- |
| Sweetgum | 23 | 46 | 3.0 |
| Green Ash | 25 | -- | -- |
| Sycamore | 24 | -- | 5.7 |
| Yellow Poplar | 25 | -- | 3.5 |
| Red Oak | 22 | 44 | -- |

VESSEL CHARACTERISTICS

| SPECIES | ABUNDANCE (#) | LENGTH (mm) | DIA, LARGEST (μm) |
|---|---|---|---|
| Eucalyptus | N | -- | -- |
| Hard Maple | F-N | 0.41 | 70-90 |
| Soft Maple | F-N | 0.42 | 60-80 |
| Birch | F-N | 1.00 | -- |
| Cottonwood | F-VN | -- | 100-150 |
| Aspen | N-VN | 0.67 | 95-100 |
| Alder | N | 0.7-1.0 | 70-100 |
| Sweetgum | VN | 1.32 | 60-95 |
| Green Ash | VF | 0.26 | -- |
| Sycamore | VN | 0.43-0.85 | 60-100 |
| Yellow Poplar | N | 0.89 | 80-130 |
| Red Oak | N(SW) | 0.42 | 200-430 |

Legend: VF = Very Few

F = Few

N = Numerous

VN = Very Numerous

SOME PROPERTIES OF YOUNG SOUTHERN HARDWOODS[1]

| Property | Green Ash (9 yr) | Sycamore (11 yr) | Sweetgum (13 yr) | Sweetgum Mature |
|---|---|---|---|---|
| Sp Gr | 0.60 | 0.42 | 0.47 | 0.48 |
| % Glucans[2] | 44 | 45 | 41 | 43 |
| % Lignin | 25 | 21 | 20 | 21 |
| % Extractives (A/B) | 1.4 | 0.8 | 1.5 | 2.0 |
| Bleached Yield, % | 47 | 48 | 48 | 48 |
| Bulk, $cm^3/g^3$ | 2.1 | 1.9 | 1.8 | 1.8 |
| Breaking Length, km | 2.3 | 3.9 | 4.7 | 4.0 |
| Stretch, % | 2.8 | 3.1 | 4.8 | 2.6 |
| TEA, $ft\text{-}lb/ft^2$ | 4.8 | 5.2 | 16.2 | 3.8 |
| Tear Factor | 50 | 101 | 128 | 95 |
| Burst Factor | 32 | 58 | 83 | 53 |
| Scattering Coeff., cm/g | 423 | 397 | 297 | 312 |

1 Adapted from Barker, 1974
2 % Glucan = Indicator of Cellulose Content
3 All paper properties evaluated after 10 min refining

Bleaching: No major differences in chemical consumption, bleaching response, brightness, or reversion.

LIKELY SPECIES: RANGE & SITE/ADAPTABILITY

EUCALYPTUS SPP.

RANGE - FROST FREE PARTS OF FL & CA
SITES - GENERALLY LIGHT TEXTURED & BETTER DRAINED SOILS, BUT SPECIES ARE NUMBEROUS & SUITED TO A VARIETY OF SITES
GROWTH - EXTREMELY RAPID IN TROPICAL AREAS
COMMENTS - A PAPERMAKER'S DREAM, BUT NOT LIKELY TO BE USABLE IN NEAR-TERM

SOFT MAPLES

RANGE - EASTERN U.S.
SITES - QUITE VARIABLE, FROM SWAMPS TO MODERATELY MOIST UPLANDS
GROWTH - RAPID, SHORT-LIVED
COMMENTS - MOST ABUNDANT TREE IN EASTERN U.S. SELECTED FOR USE IN DOE TRIALS

BIRCH

RANGE - N STATES, LIMITED TO NORTHERNMOST PORTIONS
SITES - COOL, MOST SITES; BUT GROWS WELL ON VARIOUS ASPECTS & ELEVATIONS: TOLERATES EXTREMES OF MOISTURE
GROWTH - FAST GROWING, SHORT-LIVED
COMMENTS - PREFERRED FIBER & PLANTED WIDELY IN SCANDINAVIA

COTTONWOOD, EASTERN

RANGE - EASTERN U.S., BUT CONFINED TO RIVER BOTTOMS
SITES - MOIST, WELL-DRAINED SOILS, RATHER SPECIFIC
GROWTH - VERY RAPID GROWING, SHORT-LIVED
COMMENTS - VALUABLE PULP SPECIES PROPAGATED BY CUTTINGS

COTTONWOOD, WESTERN

SIMILAR, BUT NATIVE TO PNW, SOMEWHAT MORE ADAPTABLE, LONGER-LIVED, AND LARGER. W x E HYBRIDS = ESPECIALLY FAST-GROWING IN PNW.

ASPEN

RANGE - N STATES & W MOUNTAINS
SITES - VARIABLE, QUITE ADAPTABLE
GROWTH - FAST GROWING, SHORT-LIVED
COMMENTS - MOST WIDELY DISTRIBUTED U.S. SPECIES PREFERRED PULP SPECIES IN LAKE STATES

RED ALDER

RANGE - PNW, COASTAL
SITES - DEEPER, BETTER-DRAINED SOILS
GROWTH - RAPID GROWING, SHORT-LIVED
COMMENTS - MOST IMPORTANT HARDWOOD IN PNW
FIXES NITROGEN

SWEETGUM

RANGE - SOUTHERN & LOWER MIDWEST STATES
SITES - MOIST, ALLUVIAL SOILS ARE BEST, BUT GROWS WELL ON A WIDE VARIETY OF SITES
GROWTH - RELATIVELY FAST-GROWING ON BETTER SITES
COMMENTS - AN IMPORTANT COMMERCIAL SPECIES WIDESPREAD IN SOUTHERN FORESTS

GREEN ASH

RANGE - EASTERN U.S.
SITES - BEST ON MOIST BOTTOMLANDS, BUT GROWS WELL ON UPLANDS AND TOLERATES CLIMATIC EXTREMES
GROWTH - MODERATE TO FAST
COMMENTS - MAKES BEST GROWTH IN FLOOD PLAINS

SYCAMORE

RANGE - EASTERN U.S., EXCEPT LAKE STATES
SITES - RATHER SPECIFIC, GENERALLY CONFINED TO RIVERBANKS & BOTTOMLANDS
GROWTH - MODERATE, LONGER-LIVED
COMMENTS - ONE OF LARGEST EASTERN HARDWOODS

YELLOW POPLAR

RANGE - OHIO RIVER VALLEY E TO COAST AND S TO FLORIDA
SITES - MODERATELY MOIST & LOOSE TEXTURED SOILS, BUT MORE SENSITIVE & DEMANDING THAN MOST
GROWTH - FAIR GROWTH RATES, LONGER-LIVED
COMMENTS - EXCELLENT FORM & HEIGHT & VALUABLE WOOD

SUITABILITY FOR MANAGEMENT:

| Spp. | Tree Improvement | Nursery Practices | Planting I | Planting DOE | Competition Control | Thinning | Pests I, D, A | Estimated Rotation (yrs) | Coppice |
|---|---|---|---|---|---|---|---|---|---|
| Eucalyptus | + | ++* | + | + | M | - | L, M, L | 7 - 10 | +++ |
| Soft Maples | + | + | + | + | L | ++ | H, M, H | 30 | ++ |
| Birch | + | + | - | - | M | - | M, M, H | 40 | - |
| Cottonwood | +++ | +++* | ++ | ++ | H | ++ | M, H, H | 10 | ++ |
| Aspen | +++ | +++ | ++ | - | M | + | M, H, M | 25 | +++ |
| Alder | - | + | - | - | L | ++ | L, L, M | 25 | + |
| Sweetgum | ++ | +++ | ++ | ++ | M | ++ | L, L, M | 25 | + |
| Green Ash | ++ | ++ | + | - | L | - | H, M, H | 20 | + |
| Sycamore | ++ | ++ | ++ | ++ | M | + | H, M, L | 20 | + |
| Yellow Poplar | ++ | ++ | ++ | - | M | - | L, L, M | 30 | - |

LEGEND:

TREE IMPROVEMENT = DEGREE OF ACTIVITY; NONE (-) TO HIGH (+++)

NURSERY PRACTICES - DEGREE OF DEVELOPMENT; SAME
* PROPAGATED BY CUTTINGS

PLANTING - EXPERIENCE BY INDUSTRY & DOE; LITTLE (-) TO MUCH (++)

NEED FOR COMPETITION CONTROL - LOW, MEDIUM, OR HIGH

NEED FOR & UTILITY OF THINNING - NOT NECESSARY (-) TO NEEDED
AND/OR BENEFICIAL (++)

PESTS - POTENTIAL FOR INSECT, DISEASE, AND ANIMAL DAMAGE; LOW, MEDIUM OR HIGH

ESTIMATED ROTATION - YRS TO 10" DBH

ABILITY TO COPPICE - NONE (-) TO HIGH (+++)

ADDITIONAL COMMENTS:

TREE IMPROVEMENT: PROGRAMS ON HOLD, BUT PROVENANCE/PROGENY TESTS, CLONE BANKS, & SOME SEED ORCHARDS ARE AVAILABLE

GENETIC GAINS = THOSE FOR CONIFERS
COTTONWOOD = GREATER, 40+%

CELLULOSE CONTENT: LOW HERITABILITY, BUT CAN BE CAPTURED BY CLONING.

MANAGEMENT PROBLEMS: HIGH ESTABLISHMENT COSTS ASSOCIATED WITH NEED FOR COMPETION CONTROL; MOST START SLOWLY UNLESS COMPETING VEGETATION IS CONTROLLED. SENSITIVE TO HERBICIDES.

IDENTIFYING PROPER SITE = MORE ART THAN SCIENCE. HAVING CLONAL MATERIAL COULD HELP DEFINE SITE REQUIREMENTS & CLARIFY GENOTYPE X ENVIRONMENT INTERACTIONS

CLONING AND RELATED TECHNOLOGIES: STATE-OF-THE-ART

| Species | -Cloning Method- Macro | Micro | SE | Somaclonal Variation | Protoplast Culture | Another Culture | Gene Transfer |
|---|---|---|---|---|---|---|---|
| Eucalyptus | A | D/A | R | -- | -- | -- | -- |
| Betula | X | A | R | -- | R | -- | R |
| Populus | A | D/A | R | R/D | R | R | R |
| Aspen | D/A | D/A | -- | -- | R | -- | -- |
| Alnus | D/A | D/A | -- | -- | R | -- | -- |
| Sweet Gum | X | D/A | R | -- | -- | -- | -- |
| Yellow Poplar | X | D/A | R | -- | R | -- | -- |

LEGEND: R = REQUIRING RESEARCH
D = NEEDING DEVELOPMENT
A = BEING APPLIED OR NEARING APPLICATION
X = NOT EFFICIENT

GENUS = WORK NOT ALWAYS DONE ON SUBJECT SPECIES; EG., MUCH RESEARCH ON BIRCH HAS BEEN DONE IN FINLAND

MAPLES, GREEN ASH, & SYCAMORE = UNCERTAIN

LIST NOT MEANT TO BE ALL INCLUSIVE

SOME EXAMPLES OF ADVANCES:

MACRO-PROPAGATION - COTTONWOOD HAS BEEN PLANTED VIA CUTTINGS FOR MANY YEARS: CLONAL VARIATION IN FIELD ROOTING CAN BE A PROBLEM, AND AN ALTERNATIVE PROPAGATION SYSTEM MIGHT IMPROVE EFFICIENCY.

MICRO-PROPAGATION - SEEMS AN EFFICIENT METHOD FOR ASPEN AND SWEETGUM. COULD HELP ALLEVIATE ASPEN SEED SHORTAGE IF COST EFFECTIVE.

SOMATIC EMBRYOGENESIS - OBSERVED IN SEVERAL SPECIES; COULD BECOME AN EFFICIENT SYSTEM FOR PROPAGATION OF ELITE GENOTYPES AND SET STAGE FOR GENE TRANSFER.

SOMACLONAL VARIATION - VARIANTS HAVE BEEN PRODUCED IN POPULUS; DISEASE RESISTANCE & HERBICIDE TOLERANCE.

PROTOPLAST CULTURE - PLANTS HAVE BEEN RECOVERED VIA SHOOT INDUCTION IN POPULUS & ASPEN, AND VIA SOMATIC EMBRYOGENESIS IN YELLOW POPLAR.

ANOTHER CULTURE - PRODUCED RECENTLY IN COTTONWOOD; POTENTIAL FOR CREATING "DIHAPLOIDS."

GENE TRANSFER - GENE FOR HERBICIDE TOLERANCE MOVED INTO POPULUS, & EXPRESSION NOTED.

## RESEARCH NEEDS/DIRECTIONS

| SPECIES, TRAIT, OR PROBLEM (WHY?) | RESEARCH AREA OR APPROACH (HOW?) | GOAL/OBJECTIVE TECHNY/PRODUCT (WHAT?) |
|---|---|---|
| **AREAS/TOPICS FOR DEVELOPMENT/APPLICATION:** | | |
| SG, CW, & ASPEN EXPLOIT ELITE GENOTYPES | MICRO OR SE | INCREASED GAIN & UNIFORMITY BENEFITS/COSTS |
| ASPEN SEED SHORTAGE | MACRO, MICRO, OR SE | MEET DEMAND, GET CLONAL TESTS IN FIELD |
| CLONAL FORESTRY, WILL IT HAPPEN? | MASS PROPAGATION (MICRO, SE) | GET CLONES INTO FIELD FASTER |
| CW, VARIABLE ROOTING | " " | ASSURED STOCKING CHEAPER & FASTER |
| SITE SELECTION, ART VS. SCIENCE | LARGE SCALE PROPAGATION | CLONAL MATERIAL FOR GENOTYPE x SITE TRIALS |
| SLOW PROGRESS WITH CONIFERS | TEST METHODS ON HARDWOODS; EG., ENCAPSULATION | HAVE AVAILABLE FOR CONIFERS; LEAP AHEAD |
| PLANTATION IDENTITY | ISOZYME ANALYSIS | CONFIRMATION OF IDENTIFY, & PREVENTION OF THEFT |
| **AREAS/TOPICS FOR RESEARCH/DEVELOPMENT:** | | |
| HIGH COST OF PLANTATION ESTABLISHMENT | SOMACLONAL VARIATION | HERBICIDE TOL. PLANTS (PATENT?) |
| CW & ASPEN DISEASE PROBLEMS | SCREENING IN CULTURE OR SOMACLONAL VARIATION | DISEASE RESISTANCE (PATENT?) |
| CW & ASPEN INSECT PROBLEMS | SOMATIC EMBRYOGENESIS | SET STAGE FOR EVENTUAL GENE TRANSFER |

| | | |
|---|---|---|
| 3N ASPEN, NARROW GENETIC BASE | PROTOPLAST FUSION<br>ANTHER CULTURE<br>MASS PROPAGATION | MORE & BETTER 3N HYBRIDS (PATENT?) |
| GENETICS RESEARCH | ANTHER CULTURE | HAPLOID PLANTS |
| CW: VARIABILITY OF HYBRIDS | ANTHER CULTURE & CHROMOSOME DOUBLING | "DIHAPLOIDS" TRUE BREEDING HYBRIDS |
| HIGH CAPITAL COSTS FOR LAND | WIDE CROSSES & EMBRYO RESCUE;<br>PROTOPLAST FUSION | HYBRIDS FOR MARGINAL (CHEAP) SITES |

EXPLORATORY RESEARCH:

| | | |
|---|---|---|
| DROUGHT & COLD TOLERANCE | SCREEN IN CULTURE OR SOMACLONAL VARIATION | CLONAL MATERIAL DIFFICULT SITES |
| NOVEL HYBRIDS & VARIANTS | PROTOPLASTS + NUCLEAR OR ORGANELLE TRANSFER | REGULAR/SOMATIC HYBRIDS (PATENT?) |
| INCREASED PULP YIELDS, LOWER PROCESSING COSTS, & BY-PRODUCTS | SOMACLONAL VARIATION & MASS PROPAGATION | ALTERED CHEMICAL COMPOSITION; EG., CELLULOSE & EXTRACTIVES |
| QUALITY: FORM & BRANCHING HABIT | SOMACLONAL VARIATION & MASS PROPAGATION | IMPROVED HARVEST INDEX |
| CONTROL OF FIBER FORMATION | MANIPULATION & GROWTH IN CULTURE | IMPROVED FIBER PROPERTIES |

PERHAPS THE GREATEST BENEFIT: RAPIDLY MOVE CLONAL MATERIAL INTO HANDS OF MEMBERS FOR EVALUATION AND DEMONSTRATION. GIVEN THE AVAILABILITY OF USABLE TECHNIQUES, THIS COULD BE DONE, BY ONE MEANS OR ANOTHER, IN THE NEXT FEW YEARS, THEREBY BUILDING CREDIBILITY AND SUPPORT FOR THE SOFTWOOD PROJECT AS WELL AS FOR THE HARDWOOD EFFORT.

Ronald J. Dinus
10/7/88