Wood Transportation &

WTRANS

Resource Analysis System

The Wood Transportation and Resource Analysis System (WTRANS):
Description and Documentation
and
User's Guide for WTRANS

by
Burton English,
Kim Jensen,
William Park,
Jamey Menard,
and
Brad Wilson

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Department of Agricultural Economics
The University of Tennessee

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Wood Residues in Tennessee

Tennessee is a major hardwood lumber and wood products producing state in the U.S. According to 1997 County Business Patterns for Tennessee, there were 1,087 lumber and wood products establishments, 322 furniture and fixtures establishments, and 171 paper and allied products establishments. These establishments employed over 65,000 people. Wood residues generated by sawmills and other primary wood users have been estimated at over 140 million cubic feet, with the majority being derived from hardwood residues (Stratton and Wright). These estimates do not include residues generated by secondary wood products manufacturers, such as furniture manufacturers.

According to a 1997 survey of primary wood-using plants, about 56% of residues was used for industrial fuel, 20% was used for fiber products, 15% was used for miscellaneous purposes, and 9% was not used (Stratton and Wright). The amount not used is somewhat higher than the national average of 2% (McKeever). The largest proportion of residues is coarse (43%), followed by bark (32%), and sawdust (25%). Less than 1% of primary mill residues are shavings. About 45% of the coarse mill residues was used for manufacturing fiber products. However, most of the bark and sawdust was used for industrial fuel. In total, about 78 million cubic feet of residues were used for fuel.

While a large amount of wood residues are generated in the state, profitable disposal of wood residues can be problematic, because transportation costs are high relative to the value of the product. The Wood Transportation and Resource Analysis System (WTRANS) is a computer program designed to help

potential users in sourcing residues, estimating the costs of transporting the residues, and estimating and comparing the costs of using residues for greenhouse heating with the users current fuel source.

What is WTRANS?

The Wood Transportation and Resource Analysis System (WTRANS) is a Web-based spreadsheet that allows users to examine:

a) locations of green mill hardwood and softwood residues in Tennessee on a county-by-county basis,

b) estimated transportation costs from county-to-county points in Tennessee,

c) overall estimated delivered costs based on residue prices and transportation costs,

d) potential residue needs for energy use, and

f) estimated fuel cost comparisons using residues for greenhouse heating.

Suggested values for transportation costs and other factors are provided in WTRANS based on secondary data sources and information derived from a 2000 survey of wood residue producing firms in Tennessee. However, WTRANS users can adjust many of these costs and factors based on their firm's situation within the spreadsheet program. A description of the program including documentation and data sources is provided in the paper, along with a User's Manual contained in the Appendix. WTRANS was adopted from TREADSS (The Tire Resource Evaluation and Decision Support System) model developed by the UT Management Science Program for locating used tires.

Transportation Analysis:

The transportation analysis portion of WTRANS provides estimated costs to transport wood residues on a county-by-county basis and on a statewide basis. The transportation costs include loading/unloading (LOADC) and hauling costs (HAULC). The loading/unloading costs are labor costs from loading at the time of residue pick up and unloading at the time of residue delivery.

(1) LOADC = Labor Hours to Load * Hourly Wage + Labor Hours to Unload * Hourly Wage.

The labor wage rate default value for loading/unloading is $8.75 per hour (Bureau of Labor Statistics, 1998). Default times are 1 hour for loading and 45 minutes for unloading. WTRANS users can adjust the labor hour and wage rate defaults.

Hauling costs include fuel cost, driver's wage, overhead, and maintenance on the truck. Equations 2 through 8 are used to calculate hauling costs.

(2) HAULC = FUELC + DRIVEC + OVHDC + MAINTC

(3) FUELC = [Round Trip Mileage/(Miles/Gallon)] * Fuel Price per Gallon

(4) DRIVEC = [Round Trip Mileage/(Speed in Miles per Hour)] * Driver Wages per Hour

(5) OVHDC = [(Truck Depreciation per Year + Truck Interest per Year + Truck Insurance per Year + Truck Fees per Year)/Operating Hours per Year] * [Roundtrip Miles/Speed in Miles per Hour]

(6) MAINTC = Round Trip Mileage * [Repair Costs per Year + Lube Costs per Year + Tire Costs per Year]/(Operating Hours per Year * Average Speed on Trips During Year)

(7) Truck Depreciation per Year = (Truck Purchase Cost - Truck Salvage Value)/Truck Life in Years

(8) Truck Interest per Year = Interest Rate * ((Truck Purchase Cost - Salvage Value) * (Truck Life in Years+1)/2 * Truck Life in Years) + Truck Salvage Value)

The default driver wage is for heavy or tractor-trailor truck drivers. The 1998 Tennessee estimate is $14.36 an hour for truck drivers (Bureau of Labor Statistics). The default fuel price is set to the Midwest regional price for diesel as of September 25, 2000 (Department of Energy). Tennessee falls into the Midwest region for Department of Energy diesel price calculations. The average regional price was $1.629 per gallon. Default values for interest rates are assumed at the current prime-lending rate of 9.5 percent (Federal Reserve). The Internet provided price estimates for truck purchase costs. The price for a new 25,000-pound haul dump truck is about $74,000 (based on phone conversations with truck dealers). The life of the truck is assumed on a 10-year schedule, with the salvage value being $30,000 (based on prices of vehicles about ten years old found on the Internet). Mileage per gallon is about 9 miles per gallon (phone conversations with truck dealers). Insurance costs are assumed at $2,000 per year (based on rates quoted on the Internet). Truck fees include licenses and registration. The default value is set at $5,500. This value is based on information obtained from the licensing agencies (Knox County Clerk's Office).

Operating hours (travel hours, excludes load and unload times) were assumed at 5 hours per day with 200 work days or 1,000 hours per year. Maintenance costs are assumed at $3,500 per year ($1,800 for tires, $500 for lube, and $1,200 for repairs and other maintenance) or about 8 cents per mile. Maintenance is assumed at every 10,000 miles.

The hauling costs (HAULC) are for a truckload of residues. To calculate the hauling costs on a per ton basis, the weight load of residues hauled must also be included. The weight per truckload can be calculated from truck capacity and density of the wood residues, where:

(9) TWTC = Truck weight capacity in tons

(10) TVOLC = Truck volume capacity in cubic feet.

The capacity of the truck will either be reached through the volume maximum or the weight maximum. If the density of the wood residue (tons/cubic yard) (DENS) is greater than TWTC/TVOLC, then the capacity will be based on the weight. If the density of the wood residue is less than TWTC/TVOLC then the capacity is based on the maximum volume the truck will hold. Densities of the residues are set to default values for common hardwood and softwood species in Tennessee (.03 for hardwood or softwood bark, .06 for coarse hardwood, .036 for hardwood sawdust, .035 for coarse softwood, and .03 for softwood sawdust). These estimates are used as the suggested or default values in WTRANS. An information box specifying densities for other species is also provided.

The TREADSS model assumes a maximum truck capacity of 25 tons or 3,800 cubic feet in volume for trucks hauling tires. This estimate is similar to

estimates for average truckloads of residues (44,000 pounds) by Badger. The values of 25 tons or 3,800 cubic feet are used as the default values for the truck capacity.

Once the weight in tons/truckload (RTONSTL) is calculated, the transportation costs/ton (TCOST) can be calculated as:

(11) TCOST = (HAULC + LOADC)/RTONSTL,

and the cost per ton-mile to transport the residues is,

(12) TCOSTM = TCOST/Round trip mileage.

The delivered price of residues per ton is then

(13) DPRESID = PRESID + TCOST.

The values of PRESID are based on information from a 2000 survey of Tennessee wood products processors. Undelivered price estimates from the survey results were $16.37 per ton for coarse green hardwood residues, $7.36 per ton for green hardwood sawdust residues, and $7.97 per ton for green hardwood bark residues. The undelivered prices for green softwood residues are $14.80 per ton for coarse green softwood residues, $8.21 per ton for green softwood sawdust residues, and $9.67 per ton for green softwood bark residues.

Wood Residue Resources:

Primary wood users, such as sawmills, generate green mill residues. The Tennessee County estimates for green mill residues (tons) are adopted from the 1995 and 1997 surveys of primary wood using mills (Stratton and Wright). The 1995 data are provided by county, while the 1997 data are generated at the state level. The county data are adjusted according to growth in the state values

between 1995 and 1997. The residue types for which county data are provided include hardwood and softwood bark, coarse residues (for example chips), and sawdust. These residue values in WTRANS are identified as tons of:

HGB = Green Hardwood Bark SGB = Green Softwood Bark

HGC = Green Hardwood Coarse SGC = Green Softwood Coarse

HGSW = Green Hardwood Sawdust SGSW = Green Softwood Sawdust

Requirements for Energy Use:

Users of WTRANS can determine wood residue availability and estimated potential costs of these residues for use in energy production. One option calculates the wood residue required to generate electricity. Users can edit the kWh per year of energy required (or BTU's required per year). The tons of residues required are calculated from the required kWh as:

(14) RBTU = (RKWH/.00029)

(15) RTON = (RBTU/BTULB)/2000

where:

RKWH is the required kWh of energy,

RBTU is the required BTU's of energy,

RTON is the required tons of residue, and

BTULB is the BTU's generated per pound of residue.

A second option calculates the wood residues required for greenhouse heating. According to conversations with greenhouse growers in Tennessee, liquid propane, natural gas, and/or fuel oil are fuel sources normally used for heating greenhouses. Users can input the quantity of fuel source (either liquid

propane, natural gas, or fuel oil) used in an average year. The following conversion factors are used to convert liquid propane, natural gas, or fuel oil to required BTU's of energy (RBTU):

(16) RBTU = LPG * 67,500

(17) RBTU = NGT * 75,000

(18) RBTU = FOG * 112,000

where:

LPG is liquid propane in gallons,

NGT is natural gas in therms, and

FOG is fuel oil in gallons

Inherent in the conversion factors are system efficiencies for existing greenhouse burners. For both liquid propane and natural gas, a 75% burner system efficiency was used. For fuel oil, 80% was used. Once the RBTU is determined, equation 15 is used to determine the tons of residues required. In order to compare the economics of a greenhouse grower's current fuel source with wood residues as a potential heat source, local natural gas, liquid propane, and fuel oil suppliers were contacted to obtain fuel costs. Currently, liquid propane sells for $1.32/gallon, fuel oil for $1.29 per gallon, and natural gas for 68¢/therm. These are the default values used in the model.

The BTU's per pound vary according to the type of wood, whether hardwood or softwood, the efficiency of the residue burner system, and the moisture content of the wood. The wood residues required can be altered on the basis of the residue burner system's efficiency. For example, if a system is 70%

efficient, more residues will be required than an 80% efficient system. According to Panshin and Zeeuw, the BTU's generated by wood vary with moisture content as:

(19) BTULB = [H * (100-MC/7)/(100+MC)] * EFFIC

where:

H is the BTU's per pound produced by bone dry wood, about 8500 for hardwood and 9000 for softwood,

MC is the moisture content percentage, and

EFFIC is the burner system's efficiency (expressed as a percent).

References

Badger, P. "Marketing Wood Waste for Fuel," BioCycle, January 1995, pp. 71-74.

Bartok, J. "Make the Right Choice," Greenhouse Grower, December 1995, pp. 24-25.

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Department of Energy. "EIA" Retail On-Highway Diesel Prices," Department of Energy WWW site at http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/weekly_on_highway_diesel_prices/current/html/diesel.html.

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McKeever, D. "How Wood Residuals are Recycled in the United States," BioCycle, December 1999, 33-44.

Stratton, D. and R. Wright. "Tennessee's Timber Industry--An Assessment of Timber Product Output and Use, 1997. Resource Bulletin SRS-42, USDA Southern Research Station, August 1999.

Tennessee Wood Residue Data for 1995 by County, UT Center for Industrial Services WWW site at http://www.cis.utk.edu/woodwa.htm. Data provided by R. Wright, TDA/TDF and D. Stratton USDA/FS/SRS.

Tire Resource Evaluation and Decision Support System (TREADSS) User's Guide and Technical Documentation, UT Management Science Program.

APPENDIX: A User's Guide for WTRANS

Before you Begin

The WTRANS (Wood Transportation and Resource Analysis System) user's guide contains detailed information for using WTRANS for Windows. Information regarding all spreadsheet data files and the required input data sets is also presented. It is advisable to make a back up copy of the WTRANS files once you have downloaded them.

What you need to use WTRANS

System Requirements for WTRANS for Windows

- Any IBM-compatible machine with a Pentium processor or higher.
- A hard disk with at least 25 MB of free space.
- At least 16 MB of RAM.
- Windows 9x, NT, or 2000.
- A screen resolution of 800x600 with 256 colors or higher (1024x768 with 65,000 colors preferred).
- A Microsoft Mouse or compatible pointing device.

Installing WTRANS

1) Download the WT_Setupxxxx.exe file and save it to a temporary directory on your hard disk.
2) Double click the file to begin the setup process.
3) Follow the setup wizard's instructions.

4) Locate the WTRANS icon on your start menu.

The Basics-Starting and Quitting WTRANS

Starting WTRANS

1. In Windows Explorer, double click on the file WTRANS.exe to open WTRANS.
2. The main menu for WTRANS is now displayed (Figure 1). You may begin working in WTRANS.

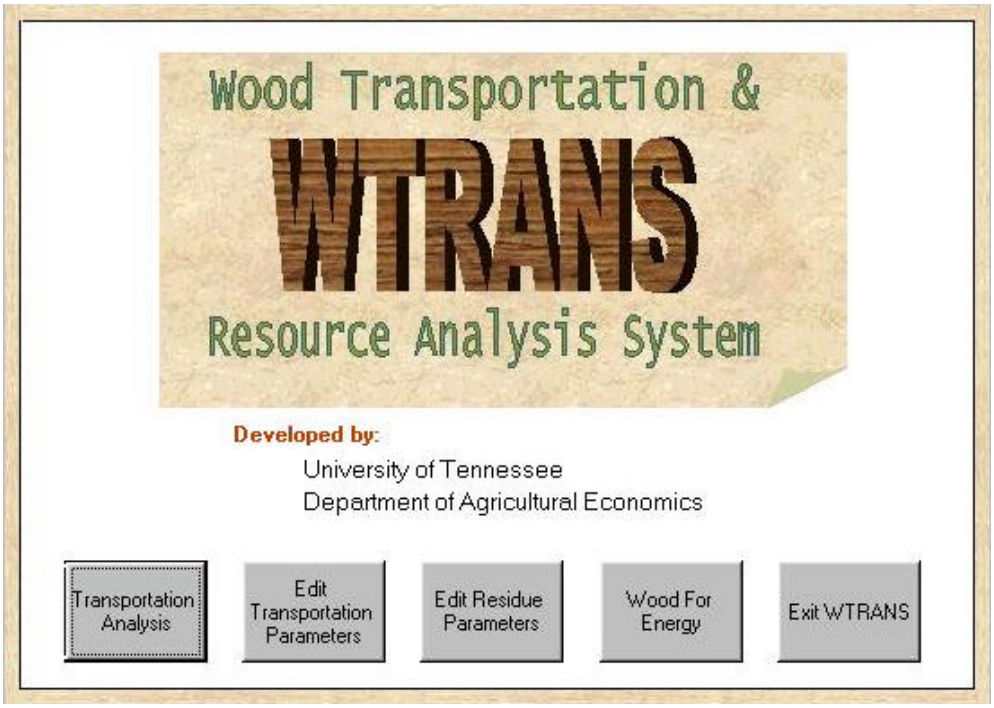

Figure 1. WTRANS Main Menu Screen

Quitting WTRANS

You will notice the button “Exit WTRANS” on the main menu screen. Click on this button to exit WTRANS. Please note: unless you have saved values to files elsewhere in the program where this option is available, no changes will be saved when you exit WTRANS.

Inside WTRANS

WTRANS contains several options. These are Transportation Analysis, Edit Transportation Parameters, Edit Residue Parameters, and Wood for Energy. A brief description of each of these options is provided below:

1. ***Transportation Analysis***: This performs two types of analyses:
    a. a county-to-county type analysis and presents the results in a message box, and
    b. a statewide type analysis of transportation of residues to a particular destination county and presents the results on a Tennessee map.
2. ***Edit Transportation Parameters***: This option enables the transportation parameters used in WTRANS to be adjusted. The transportation parameters that can be adjusted include truck weight and volume limits, vehicle speed, and operation costs (fuel, labor, and maintenance/overhead costs).
3. ***Edit Residue Parameters:*** This allows you to view and change permanently the residue parameters ($/ton before delivery and residue density by species) for the whole state or by county. This option has a dialog box interface and the residue resources can be changed by user input through edit boxes.

4. ***Wood for Energy***: This option enables potential users of wood residues for energy to estimate their residue needs to obtain a given level of BTU's or kilowatt-hours. Once the amount of residues needed is determined, the user then can enter the Transportation Analysis section to examine where residues may be located and the costs of transport to their county.

The Edit options of ***Residue***, ***Transportation***, and ***Energy*** parameters have default input parameters. The user may adjust the default parameters and then use WTRANS for further analysis. The option to restore the defaults is available if the user wishes to return the ***Residue***, ***Transportation***, and ***Energy*** parameters to their original values.

Transportation Analysis

1. Click the ***Transportation Analysis*** button on the main menu screen for WTRANS.
2. At this point you may select "County to County" or "Statewide" analysis or you may return to the main menu (Figure 2).

County-to-County Analysis:

1) Click on the "County-to-County" button. You will now see window entitled "Transportation Analysis-County to County " and a menu of options allowing you to choose the counties of residue origin and destination and the type of residue (Hardwood or Softwood, and Bark, Coarse, or Sawdust) (Figure 3).

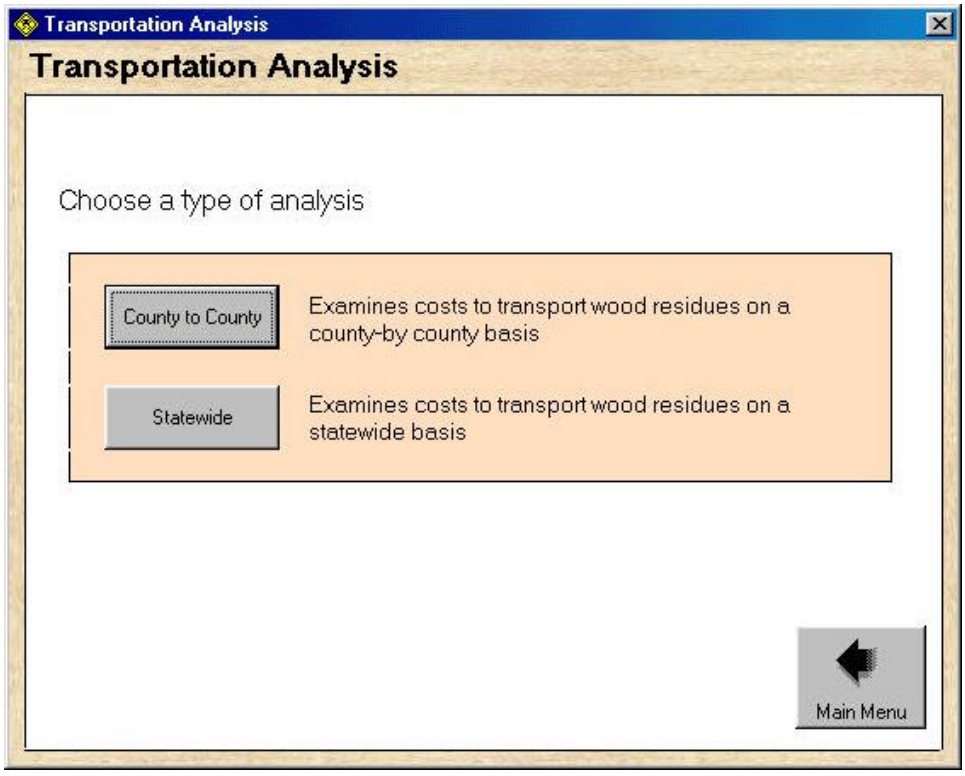

Figure 2. Transportation Analysis: County-to-County or Statewide

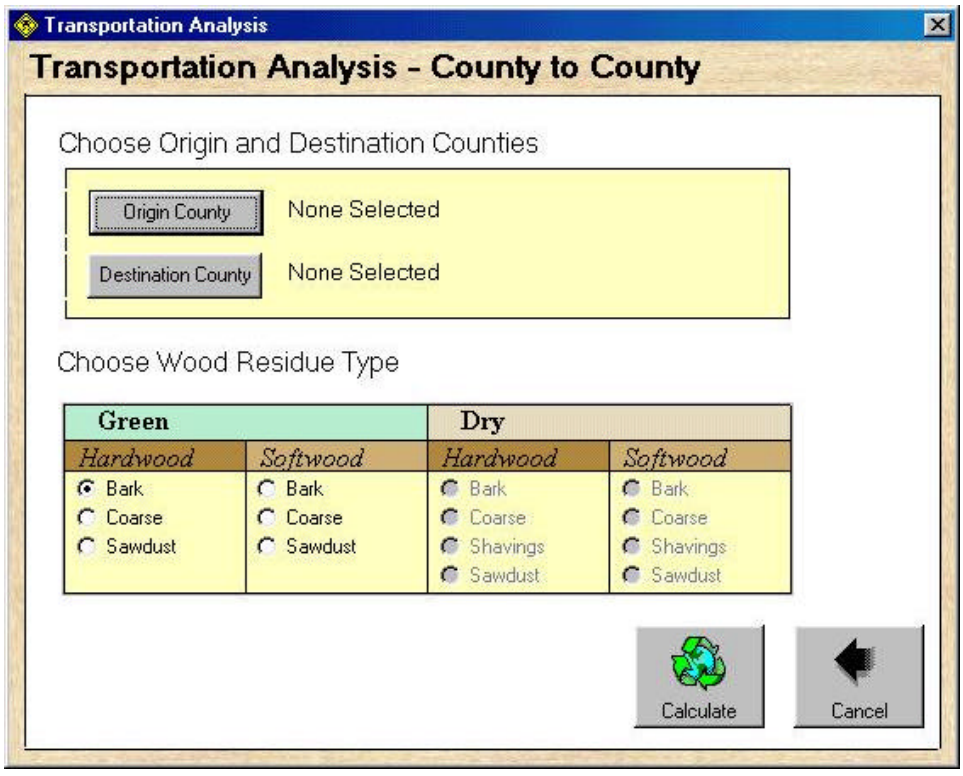

Figure 3. Transportation Analysis: County-to-County

2) Select the button, “Origin County”. From the Tennessee map that appears, select the county from which the residues will be obtained. This will input the county from which the residues will be transported.

3) Now select the button, “Destination County". From the Tennessee map that appears, select the county to which the residues will be transported.

4) The names of the origin and destination counties will now appear in the “Transportation Analysis-County to County” window.

5) From the “Choose Residue Type” menu, select whether you wish to perform the analysis for Hardwood or Softwood Bark, Coarse, or Sawdust residues (Figure 4).

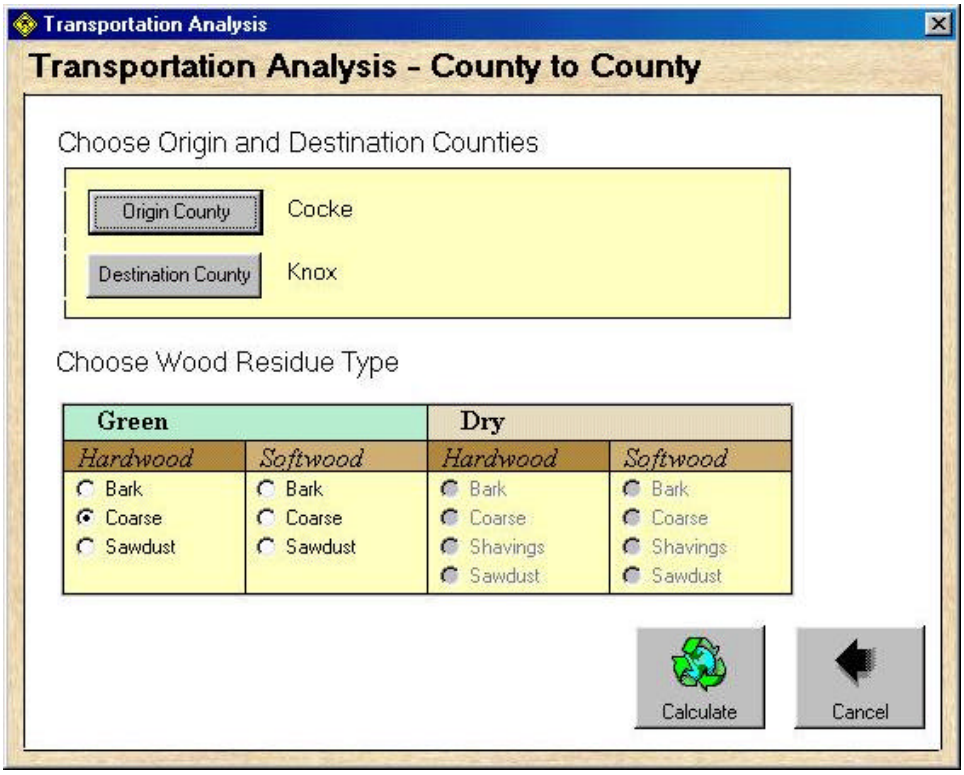

Figure 4. Counties and Residue Type Selected

6) Now click on the “Calculate” button.

7) After the analysis is performed, a window will appear, “Results for County to County Analysis” (Figure 5).

8) Information will be provided for the following:

Residue Type

Origin County

Destination County

One Way Distance (miles)

Round Trip Distance (miles)

Load Time (hours and minutes)

Unload Time (hours and minutes)

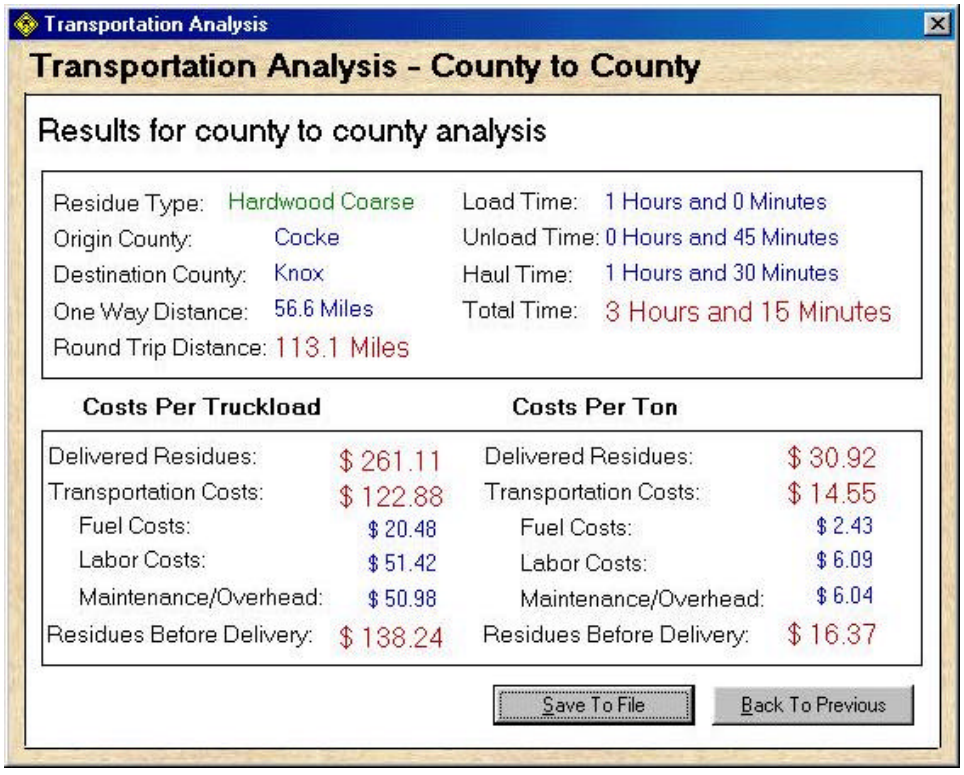

Figure 5. Transportation Analysis: County-to-County Results

Haul Time (driving time)

Total Time (driving, load/unload time)

On a per truckload basis:

Cost of Residues Before Delivery ($/truckload)

Fuel Costs ($/truckload)

Labor Costs ($/truckload)

Maintenance/Overhead Costs ($/truckload)

Transportation Costs (Fuel +Labor + Overhead Maintenance) ($/truckload)

Cost of Delivered Residues ($/truckload)

On a per ton basis:

Cost of Residues Before Delivery ($/ton)

Fuel Costs ($/ton)

Labor Costs ($/ton)

Maintenance/Overhead Costs ($/ton)

Transportation Costs (Fuel + Labor + Overhead Maintenance) ($/ton)

Cost of Delivered Residues ($/ton)

9) You may save the results by clicking on the “Save to File” button or you may return to the “Main Menu”. The file will be saved as a comma separated text file.

Statewide Analysis:

1) Click on the “Statewide button”. You will now see a window entitled “Transportation Analysis-Statewide “ and a menu of options allowing you to choose the county of destination for the residues and the type of residue (Hardwood or Softwood, and Bark, Coarse, or Sawdust) (Figure 6).

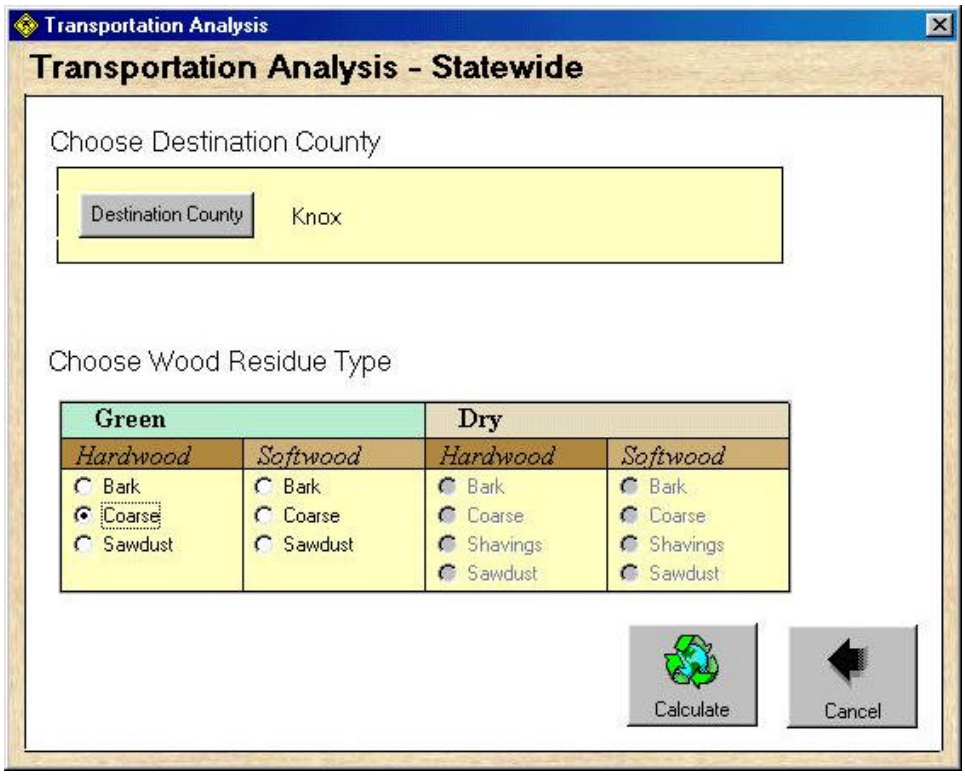

Figure 6. Transportation Analysis: Statewide

2) Click on the button "Destination County". From the Tennessee map, which appears in the window, select the county where you wish the residues to be transported.

3) Now select a residue type to be transported.

4) Click on the "Calculate" button.

5) A results map for the state will appear (Figure 7). In each county are the tons of unused residues estimated to be in that county and the costs of residues delivered from that county to your destination county. At the top of the window you may select the drop down windows to choose additional cost information on a per truck or ton basis for display in each county. Pressing the "View Chart" button at the top of the window box displays the six least costly county sources of residues. Pressing the "Export the

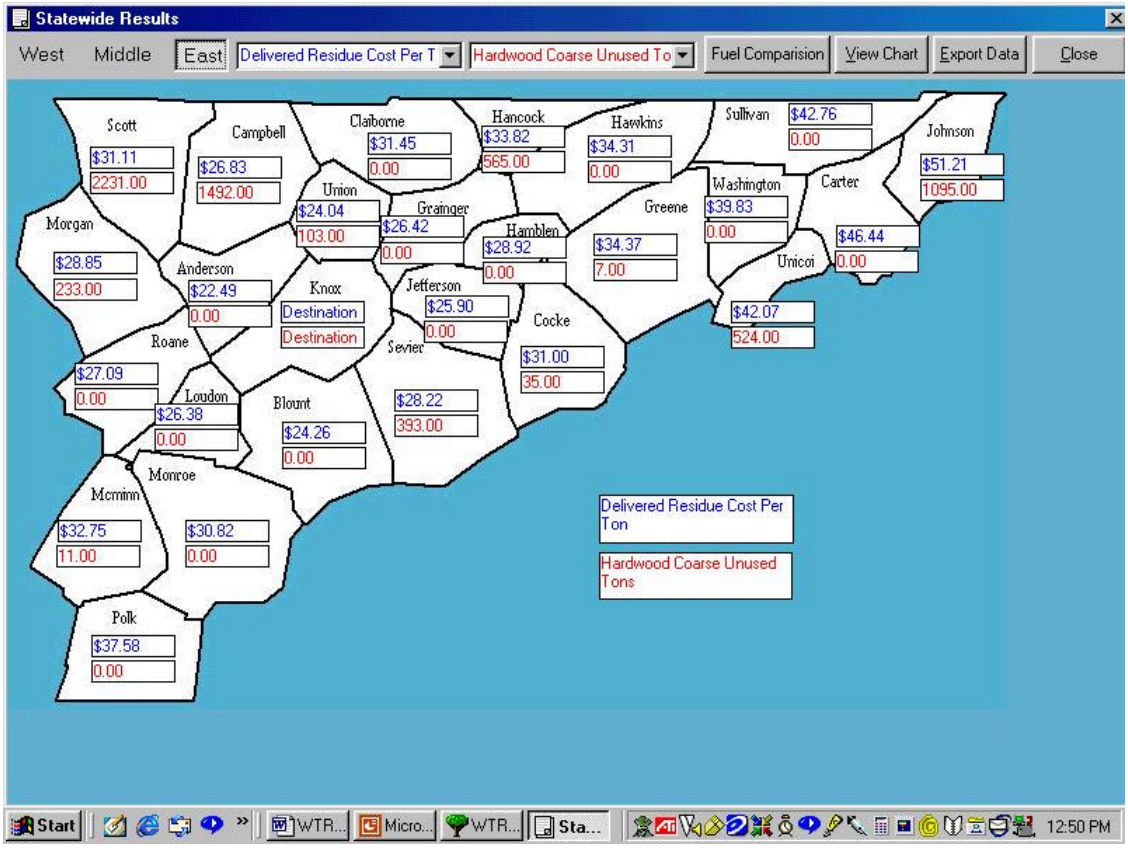

Figure 7. Transportation Analysis: Statewide Results

Data" button will allow the user to export data into a comma-separated file. This will give you the county-by-county information on residues, the costs of the delivered residues, and the six best choices.

6) Click on the "Fuel Comparison" button.

7) The screen "Greenhouse Heating" appears (Figure 8). The user can enter the quantity of fuel source currently used (liquid propane, natural gas, or fuel oil) for greenhouse heating. The values displayed for residue burner system efficiency and moisture content of the wood are defaults and may be changed. Once the values are entered click on the calculate button.

8) WTRANS calculates the required BTU's for fuel sources entered by the user and the tons of residues required for both hardwood and softwood.

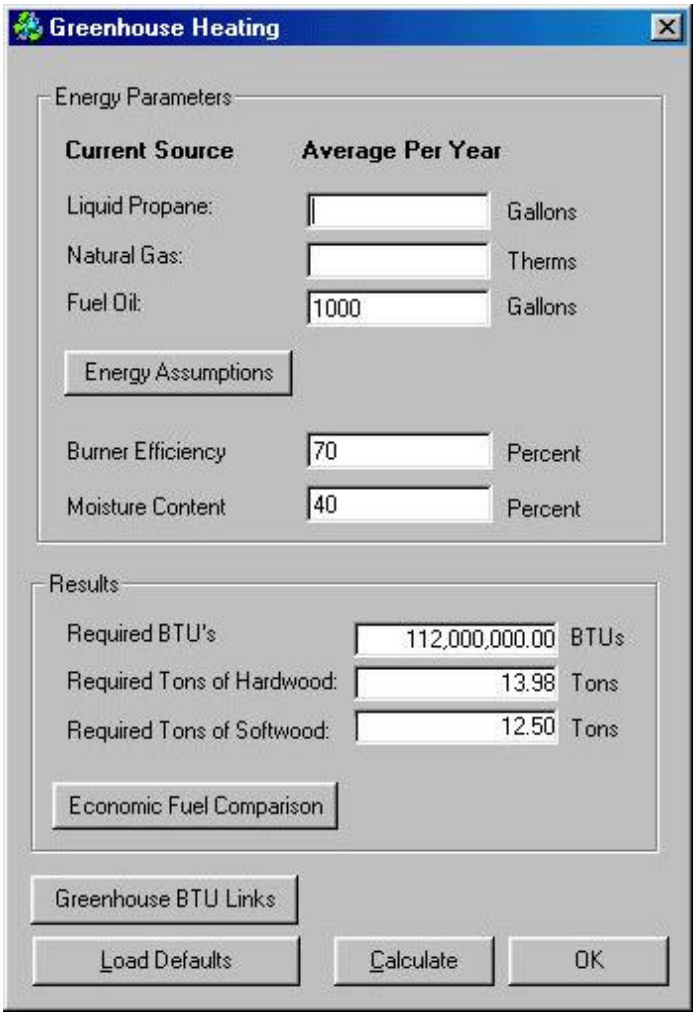

Figure 8. Greenhouse Heating

9) Click on the “Energy Assumptions” button. Burner system efficiency assumptions are displayed for calculating BTU’s for fuel heating systems in current use.

10) Click on the “Economic Fuel Comparison” button.

11) The screen “Economic Fuel Comparison” appears (Figure 9). Press the “Calculate” button. The annual fuel bill for a users current fuel source is compared to the annual fuel bill for the wood residue chosen in the statewide analysis and the quantity of residues needed for the BTU’s

required in the previous screen ("Greenhouse Heating"). The residue price per ton is based on the four least county sources of residues. The savings or costs for using wood residue as a fuel source for heating is displayed at the bottom of the screen. The values for the fuel prices are the default and may be changed by the user. Click "OK" to return to the previous screen.

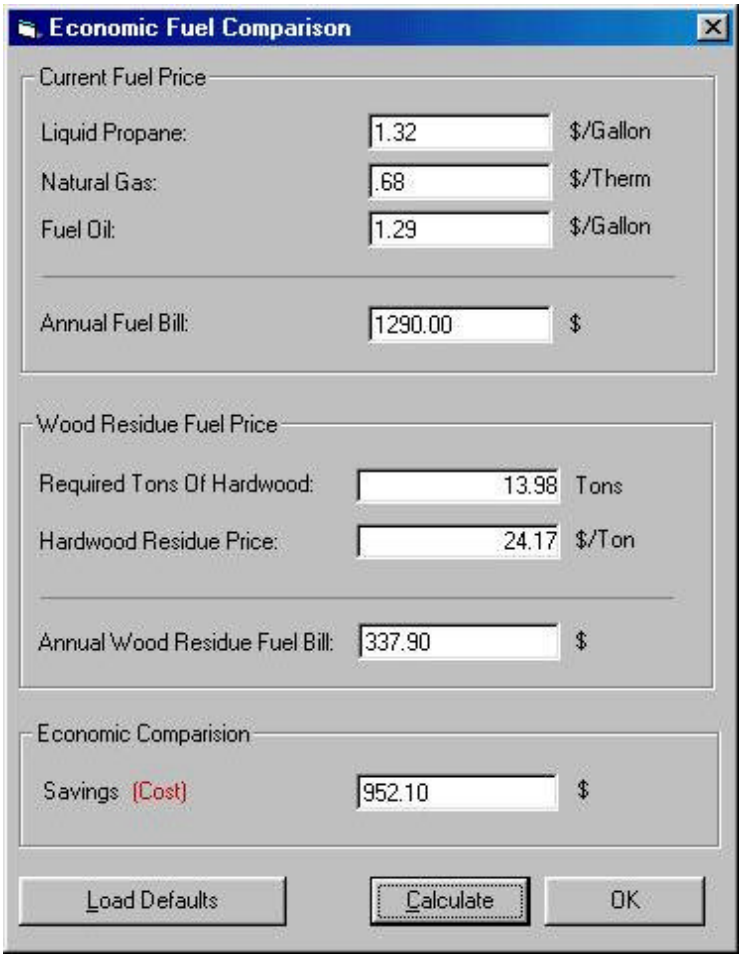

Figure 9. Economic Fuel Comparison

12) Clicking on the "Greenhouse BTU Links" button displays two web site addresses that will assist users interested in determining BTU requirements for heating greenhouses depending on type and size. An

additional web site address is listed for users interested in the amount of BTU's generated for a particular hardwood/softwood species. Click "OK " button to close and return to the statewide results screen.

13) Once you are done with viewing the statewide results, please click on the "Close" button.

Edit Transportation Parameters

1. Click on the ***Edit Transportation Parameters*** button on the main menu screen.
2. The screen "Transportation Parameters" appears with the "Trip Parameters" button selected (Figure 10).

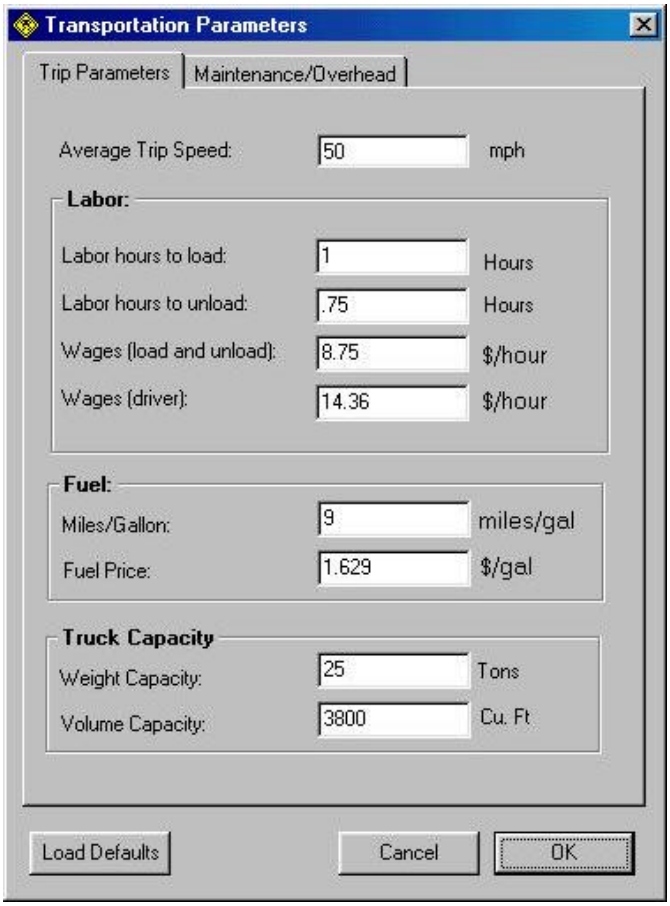

Figure 10. Trip Parameters

3. Parameters that may be edited include:

   Average Trip Speed (mph)

   Labor

      Labor Hours (both loading and unloading)

      Wages (for loading and unloading)

      Driver's Wages

   Fuel

      Miles per Gallon

      Fuel Price

   Truck Capacity

      Weight

      Volume

4. Select the "Maintenance/Overhead" button (Figure 11).

5. Parameters that may be edited include:

      Interest Rate

      Truck Insurance per Year

      Truck Fees per Year

      Truck Purchase Price

      Truck Life

      Truck Operating Hours per Year

      Repair Costs per Year

      Lube Costs per Year

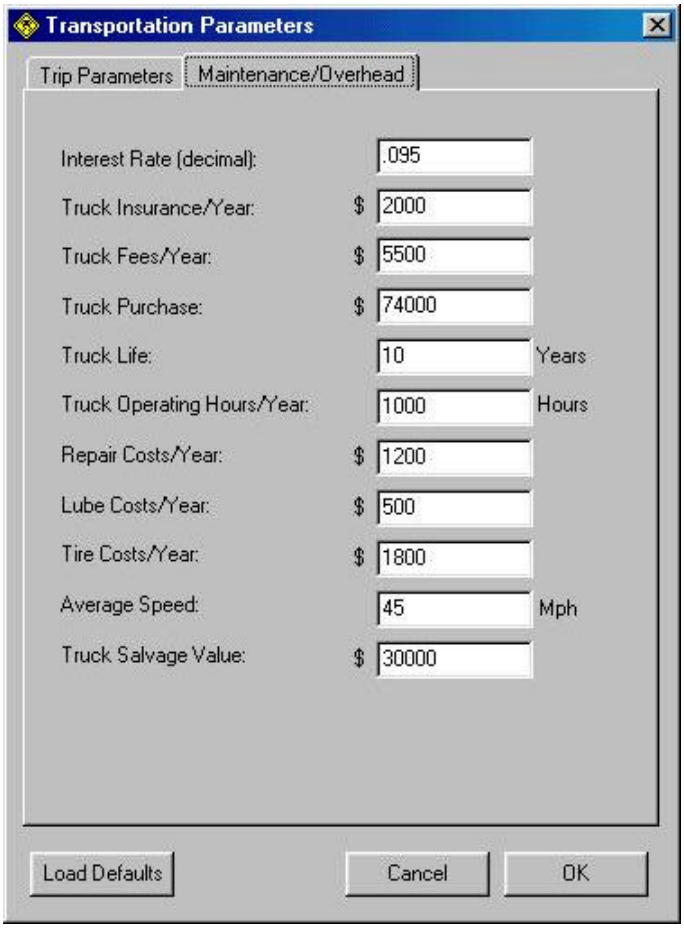

Figure 11. Maintenance/Overhead Parameters

Tire Costs per Year

Average Speed per Trip

Truck Salvage Value

6. Once you are done editing transportation parameters, click on the "OK" button to close.

Edit Residue Parameters

1) Click on the ***Edit Residue Parameters*** button on the main menu screen.
2) The screen "Residue Parameters" appears with the "Prices" button selected (Figure 12). The default values ($/ton before delivery) displayed for both hardwood and softwood residues are estimates from a 2000

survey of Tennessee wood processors. The user has the option of editing the cost per ton of residues for both hardwood and softwood.

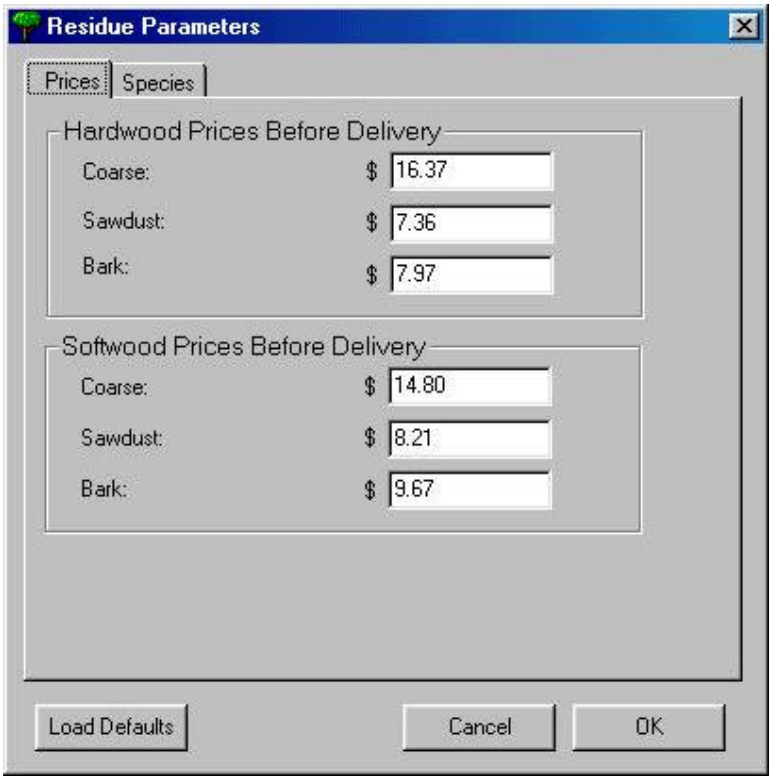

Figure 12. Hardwood and Softwood Residue Prices

3) Select the "Species" button. A list of various hardwood and softwood species is shown (Figure 13). The user can choose the hardwood or softwood density value by species for the residue of interest. The density default value for hardwood is Red Oak; for softwood, it is White Pine.
4) Once you are done editing residue parameters, click on the "OK" button to close.

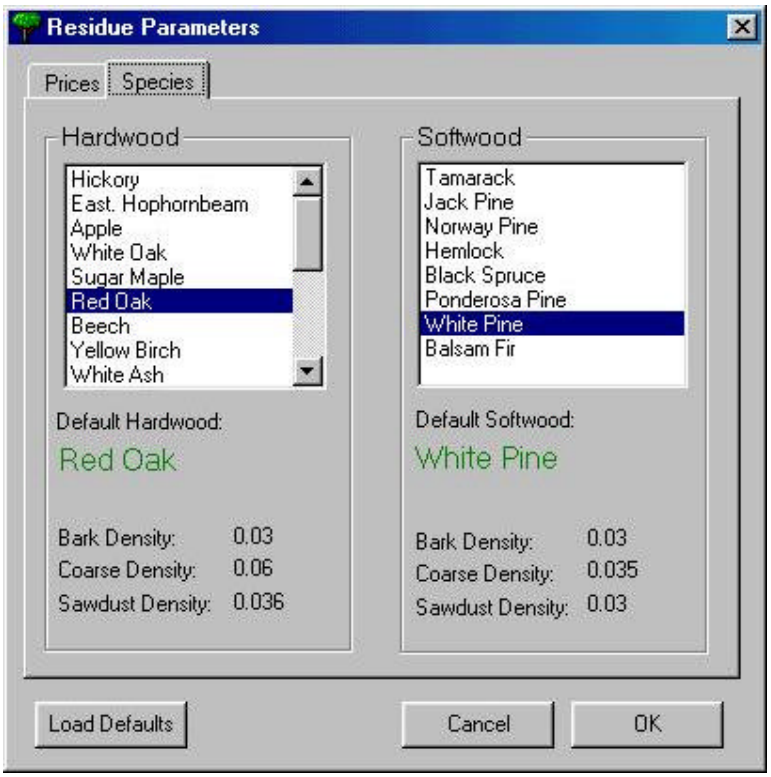

Figure 13. Hardwood and Softwood Densities by Species

Wood For Energy

1) Click on the ***Wood For Energy*** button on the main menu screen.

2) At this point you may select "Electricity Production" or "Greenhouse Heating" or you may return to the main menu (Figure 14).

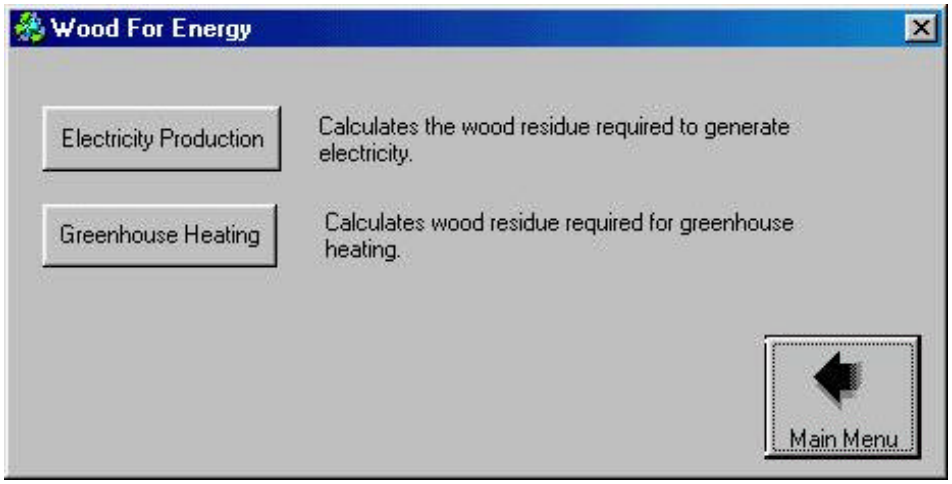

Figure 14. Wood for Energy: Electricity Production or Greenhouse Heating

Electricity Production:

1) Click on the “Electricity Production” button. The screen named “Electricity Production” appears (Figure 15). The user can enter the required kilowatt-hours, residue burner system efficiency, and the moisture content of the wood to estimate BTU requirements and residue needs. The values displayed are the defaults. Once the values are entered, click on the calculate button.
2) WTRANS calculates the required BTU’s for the kilowatt-hours entered by the user and the tons of residues required for both hardwood and softwood.
3) Click the “OK” button to close.

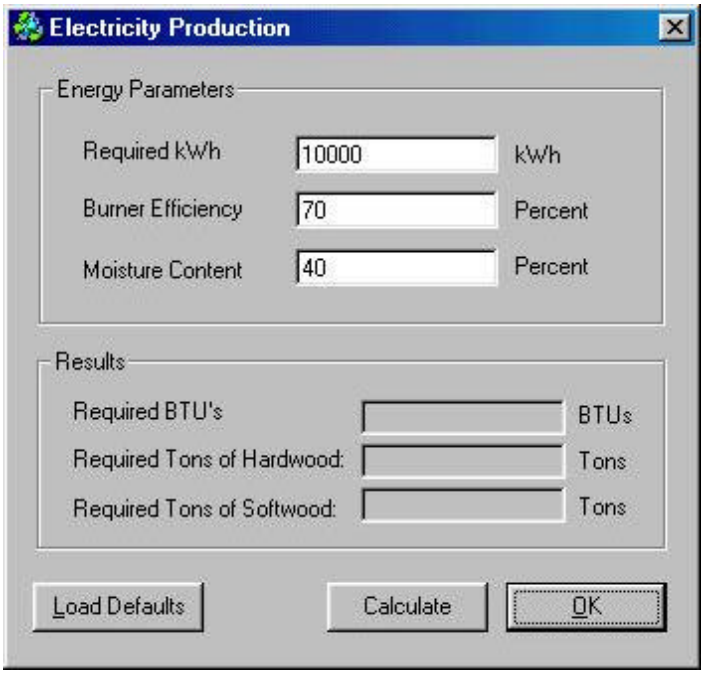

Figure 15. Electricity Production

Greenhouse Heating:

1) Click on “Greenhouse Heating” button. The screen named “Greenhouse Heating” appears (Figure 16). The user can enter the quantity of fuel source currently used (liquid propane, natural gas, or fuel oil) for greenhouse heating, the residue burner system efficiency, and the moisture content of the wood. The values displayed are the default. Once the values are entered click on the calculate button.

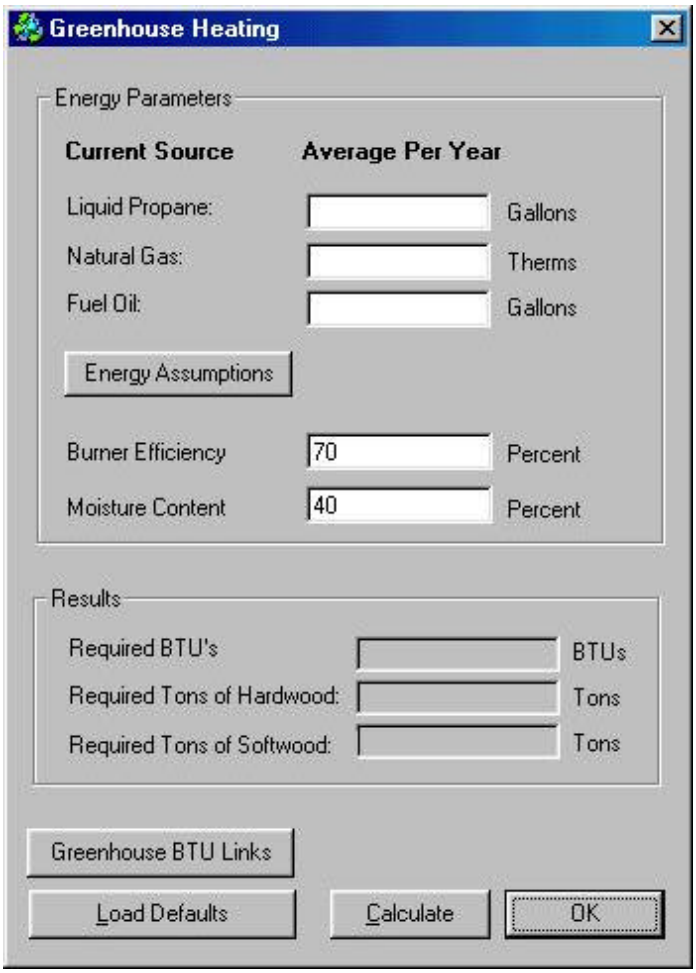

Figure 16. Greenhouse Heating

2) WTRANS calculates the required BTU's for the fuel source entered by the user and the tons of residues required for both hardwood and softwood.
3) Click on the "Energy Assumptions" button. Burner system efficiency assumptions are displayed for calculating BTU's for fuel heating systems in current use.
4) Clicking on the "Greenhouse BTU Links" button displays two web site addresses that will assist users interested in determining BTU requirements for heating greenhouses depending on type and size. An additional web site address is listed for users interested in the amount of BTU's generated for particular hardwood/softwood species.
5) Click on the "OK" button to close.