BANR: A PROGRAM TO PREDICT BIOMASS YIELD AND NUTRIENT WITHDRAWAL BY HARVEST OF SOUTHERN HARDWOOD STANDS

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ABSTRACT
Intensive harvest of southern hardwoods can yield biomass in a greatly varied mix. This causes variation in the withdrawal rates of nutrients. A need exists for a computer program to perform biomass and nutrient content calculations on diverse stands. such a program BANR-(Biomass And Nutrient Removal)- is described in this paper. It was written for the Hewlett-Packard 9830 and later adapted for Apple IIe and IBM-PC/XT microcomputers. Diameters (DBH) and heights of all trees on a plot of known size is required. Biomass models from published sources for 11 species (including loblolly pine) plus a general equation for small hardwood trees are used to calculate green and dry weights of leaves, branches, bole wood, and bole bark. Harvests can be specified with any combination of tree species, upper and lower DBH limits, and tree portions to be utilized. If available, the user should enter his own tissue nutrient concentrations on the querry of the program. Otherwise, the program defaults to data obtained by the author from Mississippi and Arkansas. Biomass and nutrient withdrawal data are presented in easy-to-read tables. Program listings or magnetic copies and a paper describing the program's use are available on request from the author.

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An official of a leading meatpacking firm once said that packers used every bit of the pig except the squeal. Modern wood-using industries are often as thorogh. In whole-tree harvest, even the leaves are processed along with the branches and bark for fuel. What was formerly wasted, now yields a return, but it adds a cost of harvesting and shipping it to the mill. Under traditional harvesting methods, part of the tree is hauled to the mill and the part left behind (slash) must be disposed of. This harvested material, a mixture of wood, bark, branches, and leaves, is also a mixture of species. A means of predicting the green and dry weights of biomass components of natural tree mixtures from timber inventory data is highly desireable. Both values and costs can be predicted from green and dry weights of the material.

Although Southern hardwoods are generally found growing on fertile soil, considerable variation does exist. The withdrawal of essential nutrients in harvested forest products is a subtle form of site degradation. The first noticeable effect, reduced growth, may not be seen for several rotations. Lost nutrients can be replenished through fertilization, but it will be an expensive process. The impact of withdrawing nutrients may be predicted if the sites' nutrients reserves are known and if the quantiies removed in harvest can be determined.

This paper describes a computer program designed to predic, from diameters and heights, biomass component weights of the important Southern hardwoods removed by several types of harvest. The program also calculates weights of nutrient removed from the site.

THE PROGRAM

General

The central "core' of the program is more than 60 regression equations used to predict biomass components: total green weight, total dry weight, dry weight of leaves, branches, stem wood and stem bark from tree diameters and heights. These were all adopted from published sources (Appendix A). Twelve species or species categories are represented:

1. willow oak — Quercus phellos
2. sweetgum — Liquidambar styraciflua
3. sugarberry — Celtis laevigata
4. Overcup oak — Q. lyrata
5. Nuttall oak — Q. nuttallii
6. Green ash — Fraxinus pennsylvanica
7. Box-elder — Acer negundo

8. Bald cypress Taxodium distichum
9. Small hardwoods general category.
10. Loblolly pine Pinus taeda
11. Hickory Carya sp.
12. Yellow poplar Liriodendron tulipifera

Other species such as Eastern cottonwood and American sycamore would have been included had appropriate biomass models been available. If such a species is encountered, it must be entered in another species category and the bias accepted.

After weight components for each species are calculated, each is multiplied by a tissue concentration value for N, P, K, Ca, and Mg. Ideally, these concentration values should be obtained by sampling the appropriate species in the areas under study. The values stored in the program for each species-tissue-nutrient, obtained by sampling in Mississippi and Arkansas, may be substituted when samples are unavailable. Species and site variation may cause these values to differ somewhat from the average ,tissue nutrient concentrations in other areas.

The program, originally written for the Hewlett-Packard 9830 microcomputer with 64K memory and ROM's for string variables and matrix manipulation, has been translated to the Microsoft dialect of BASIC for the Apple IIe microcomputer using a CP/M-80 operating system. A version is also available for the IBM-PC/XT using a MsDOS 2.0 operating system. The Hewlett-Packard 9830 is equipped with cassette tape drive and the Apple IIe and the IBM-PC/XT are equipped with floppy diskdrives. Only a single drive for loading the program is needed in each case.

Application

A minimum of information is required to use BANR: diameters, heights, and species identification of the trees. The program accommodates one plot at a time. All dimensions entered or printed as output will be in English units of measure. An example of program output may be seen in Appendix B.

The program meets several needs. Users of the various forms of biomass will be interested in total tree weights (green and dry) and perhaps the proportions of leaves, branches, stem bark and stem wood. Such information is needed in research and natural resource management planning also. Any complete study of nutrient cycling or nutrient depletion over time must take into account nutrients withdrawn from sites by harvest. In addition, the average deameter and basal area per acre in the trees projected for

cutting are given. The program is flexible; any combination of species or tree sizes can be projected for harvest. Projections can be repeated for any combination of species and sizes without reentering the original plot data.

The program is interactive. As requested by the program, the user supplies a site or plot name, the decimal acre of the plot, and the number of trees to be entered. The plot data is then entered in the sequence called for: species code, tree diameter (DBH), and tree height. Species codes are listed in Table 1. A listing of data entered is printed along with green and dry weights of each tree. The program then offers the options of cutting any or all of the species and of setting upper and lower diameter limits for cutting, if desired. A table of the plot sum of dry weights by species and tissue is then printed. Note that component tissues do not usually sum exactly to the total dry weight. To reduce error, total dry weights are usually calculated by a seperate model. Before calculating nutrient weights removed, the praogram askes for "position of nutrient change". The user then enters a code or "address" to identify the nutrient value on the data matrix to be changed (see table 1). For example, the matrix address "13,2" refers to overcup oak leaves and the nutrient phosphorus. The new nutrient level is then entered. The process continues until the user halts it by entering the address "0,0". The computer then calculates the per-acre weights of each nutrient in each tissue and species. If the user wishes to make another run based on the same plot data but different harvest specifications, the user may do so by pressing "P" on the prompting of the program.

Program listings or magnetic copies of this program are available to any interested party. For the Hewlett-Packard version, send a blank digital quality cassette tape. The Apple and IBM versions require a blank 5 1/4 inch floppy disk. Please direct requests to:

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Table 1. Address code information used to change soil nutrient default values input to BANR.

Species Name and Code	Biomass Component Name	Species Address Number	Nutrient Name and Address Number				
			N	P	K	Ca	Mg
Willow Oak (1)	Leaves	1	1	2	3	4	5
	Branches	2	1	2	3	4	5
	Stem Wood	3	1	2	3	4	5
	Stem Bark	4	1	2	3	4	5
Sweetgum (2)	Leaves	5	1	2	3	4	5
	Branches	6	.	.	.	.	.
	Stem Wood	7	.	.	.	.	.
	Stem Bark	8	.	.	.	.	.
Sugarberry (3)	Leaves	9	.	.	.	.	.
	Branches	10	.	.	.	.	.
	Stem Wood	11	.	.	.	.	.
	Stem Bark	12	.	.	.	.	.
Overcup Oak (4)	Leaves	13	.	.	.	.	.
	Branches	14	.	.	.	.	.
	Stem Wood	15	.	.	.	.	.
	Stem Bark	16	.	.	.	.	.
Nuttall Oak (5)	Leaves	17	.	.	.	.	.
	Branches	18	.	.	.	.	.
	Stem Wood	19	.	.	.	.	.
	Stem Bark	20	.	.	.	.	.
Green Ash (6)	Leaves	21	.	.	.	.	.
	Branches	22	.	.	.	.	.
	Stem Wood	23	.	.	.	.	.
	Stem Bark	24	.	.	.	.	.
Boxelder (7)	Leaves	25	.	.	.	.	.
	Branches	26	.	.	.	.	.
	Stem Wood	27	.	.	.	.	.
	Stem Bark	28	.	.	.	.	.
Bald Cypress (8)	Leaves	29	1	2	3	4	5
	Branches	30	1	2	3	4	5
	Stem Wood	31	1	2	3	4	5
	Stem Bark	32	1	2	3	4	5

Table 1. .(Continued) Address code information used to change soil nutrient default values input to BANR.

Species Name and Code	Biomass Component Name	Species Address Number	Nutrient Name and Address Number				
			N	P	K	Ca	Mg
Small Hardwoods (9)	Leaves	33	1	2	3	4	5
	Branches	34	1	2	3	4	5
	Stem Wood	35	1	2	3	4	5
	Stem Bark	36	1	2	3	4	5
Loblolly Pine (10)	Leaves	37	.	.	.	.	.
	Branches	38	.	.	.	.	.
	Stem Wood	39	.	.	.	.	.
	Stem Bark	40	.	.	.	.	.
Hickories (11)	Leaves	41	.	.	.	.	.
	Branches	42	.	.	.	.	.
	Stem Wood	43	.	.	.	.	.
	Stem Bark	44	.	.	.	.	.
Yellow Poplar (12)	Leaves	45	1	2	3	4	5
	Branches	46	1	2	3	4	5
	Stem Wood	47	1	2	3	4	5
	Stem Bark	48	1	2	3	4	5

APPENDIX A

LITERATURE SOURCES OF REGRESSION EQUATIONS FOR TREE COMPONENT WEIGHTS

Species Code

1 Schlaegel, Bryce E. 1981. Willow oak volume and weight tables for the Mississippi Delta. U.S. Dep. Agric. For. Serv. Res. Pap. SO-173, 14 p. South. For. Exp. Stn., New Orleans, LA.

2 Schlaegel, Bryce E. 1984. Sweetgum volume and weight tables. U.S. Dep. Agric. For. Serv. Res. Pap. SO-204, 14 p. South. For. Exp. Stn., New Orleans, LA.

3 Schlaegel, Bryce E. 1984. Sugarberry volume and weight tables. U.S. Dep. Agric. For. Serv. Res. Pap. SO-205, 13 p. South. For. Exp. Stn., New Orleans, LA.

4 Schlaegel, Bryce E. 1984. Overcup oak volume and weight tables. U.S. Dep. Agric. For. Serv. Res. Pap. SO-207, 14 p. South. For. Exp. Stn., New Orleans, LA.

5 Schlaegel, Bryce E., and Regan B. Willson. 1983. Nuttall oak volume and weight tables. U.S. Dep. Agric. For. Serv. Res. Pap. SO-186, 14 p. South. For. Exp. Stn., New Orleans, LA.

6 Schlaegel, Bryce E. 1984. Green ash volume and weight tables. U.S. Dep. Agric. For. Serv. Res. Pap. SO-206, 14 p. South. For. Exp. Stn., New Orleans, LA.

7 Schlaegel, Bryce E. 1982. Boxelder (Acer negundo L.) biomass component regression analysis for the Mississippi Delta. For. Sci. 28(2):355-358.

8 Mitsch, W.J., and K.C. Ewel. 1979. Comparative biomass and growth of cypress in Florida wetlands. Am. Midland Nat. 101:417-426.

9 Wartluft, Jeffrey L. 1977. Weights of small Appalachian hardwood trees and components. U.S. Dep. Agric. For. Serv. Res. Pap. NE-366, 4 p. Northeast. For. Exp. Stn., Upper Darby, PA.

10 Taras, M.A., and A. Clerk, III. 1975. Above ground biomass of loblolly pine in a natural, uneven-aged sawtimber stand in central Alabama. Tappi 58:103-105.

Species Code

11 Sirgis, Donald L. 1983. Biomass of four hardwoods from lower Piedmont pine-hardwood stands in Alabama. U.S. Dep. Agric. For, Serv. Gen. Tech. Rep. SO-46, 18 p. South. For. Exp. Stn., New Orleans, LA.

12 Clark, A. III, and W. H. McNab. 1982. Total tree weight tables for mockernut hickory and white ash in North Georgia. Georgia For. Res. Pap. No. 33, 11 p. Res. Div., Georgia For. Comm.

13 Clark, A. III, and J. G. Schroeder. 1977. Biomass of yellow-poplar in natural stands in Western North Carolina. U.S. Dep. Agric. For. Serv. Res. Pap. SE-165, 41 p. Southeast. For. Exp. Stn., Asheville, N.C.

APPENDIX B

AN EXAMPLE OF PROGRAM OUT-PUT

SITE:DEMONSTRATION

DECIMAL ACRE= .1
LOWER DBH LIMIT= 4 UPPER DBH LIMIT= 100

SPECIES NO.:	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES CUT:	WO	SG	SB	OO	NO	GA	BE	BC	MISC	LP	HIC	YP
	X	X	X	X	X	X	X		X		X	

NO.	SP.	DIAMETER	HEIGHT	GREEN WT	DRY WT
1	1	26.40	110	13643.60	7630.79
2	2	17.10	88	4039.99	1887.83
3	2	15.90	86	3423.10	1595.96
4	2	11.50	72	1519.99	700.86
5	2	11.20	75	1502.09	692.50
6	3	10.70	65	1122.70	633.10
7	4	6.50	44	323.43	172.40
8	6	21.80	102	4807.63	3169.35
9	9	4.30	33	154.61	89.58
10	11	5.00	37	185.57	116.53

AVERAGE DBH CUT= 13.04 BASAL AREA/ACRE CUT= 118.643

PER ACRE DRY WEIGHTS (LBS.)

SPECIES	LEAVES	BRANCHES	S.WOOD	S.BARK	TOTAL
W.O.	944.50	20019.50	48921.50	7366.87	76307.90
S.G.	1047.67	8461.67	35841.70	4468.12	48771.50
S.B.	167.61	1633.28	4210.81	486.88	6330.96
O.O.	49.01	372.56	1180.16	171.23	1723.95
N.O.	0.00	0.00	0.00	0.00	0.00
G.A.	537.56	5040.90	22977.40	3675.22	31693.50
B.E.	0.00	0.00	0.00	0.00	0.00
B.C.	0.00	0.00	0.00	0.00	0.00
S.HW.	89.58	204.69	473.61	127.92	895.80
L.P.	0.00	0.00	0.00	0.00	0.00
HIC.	33.04	286.66	793.28	76.87	1165.33
Y.P.	0.00	0.00	0.00	0.00	0.00
TOTAL	2868.97	36019.30	114399.00	16373.10	166889.00

SOURCE	POUNDS OF NUTRIENT PER ACRE IN VARIOUS TISSUES N	P	K	CA	MG
W.O.					
LEAVES	14.26	0.94	6.52	5.29	1.98
BRANCHES	58.06	10.01	38.04	104.10	12.01
S.WOOD	44.03	0.98	14.68	29.35	4.89
S.BARK	24.31	1.47	6.63	184.17	3.68
S.G.					
LEAVES	16.34	1.15	6.29	9.85	3.04
BRANCHES	25.39	2.54	16.08	73.62	6.77
S.WOOD	28.67	3.58	17.92	43.01	10.75
S.BARK	14.74	1.34	5.81	110.36	5.36
S.B.					
LEAVES	2.40	0.22	1.24	1.16	0.22
BRANCHES	6.86	0.49	3.76	15.52	1.63
S.WOOD	8.00	1.26	8.42	5.05	1.26
S.BARK	3.02	0.19	1.36	7.35	0.58
O.O.					
LEAVES	0.83	0.06	0.37	0.28	0.11
BRANCHES	1.34	0.11	0.75	4.06	0.30
S.WOOD	1.53	0.24	0.83	1.53	0.12
S.BARK	0.92	0.05	0.26	6.37	0.14
N.O.					
LEAVES	0.00	0.00	0.00	0.00	0.00
BRANCHES	0.00	0.00	0.00	0.00	0.00
S.WOOD	0.00	0.00	0.00	0.00	0.00
S.BARK	0.00	0.00	0.00	0.00	0.00
G.A.					
LEAVES	10.00	0.81	3.06	5.59	1.51
BRANCHES	19.66	2.52	10.59	36.29	4.54
S.WOOD	25.28	2.30	18.38	20.68	6.89
S.BARK	16.91	1.10	5.15	67.26	4.04
B.E.					
LEAVES	0.00	0.00	0.00	0.00	0.00
BRANCHES	0.00	0.00	0.00	0.00	0.00
S.WOOD	0.00	0.00	0.00	0.00	0.00
S.BARK	0.00	0.00	0.00	0.00	0.00
B.C.					
LEAVES	0.00	0.00	0.00	0.00	0.00
BRANCHES	0.00	0.00	0.00	0.00	0.00
S.WOOD	0.00	0.00	0.00	0.00	0.00
S.BARK	0.00	0.00	0.00	0.00	0.00
SMALL H.W.					
LEAVES	1.91	0.13	0.99	0.99	0.28
BRANCHES	0.98	0.10	0.41	1.21	0.14
S.WOOD	0.62	0.09	0.47	0.71	0.19
S.BARK	0.67	0.05	0.24	2.98	0.13
L.P.					
LEAVES	0.00	0.00	0.00	0.00	0.00
BRANCHES	0.00	0.00	0.00	0.00	0.00
S.WOOD	0.00	0.00	0.00	0.00	0.00
S.BARK	0.00	0.00	0.00	0.00	0.00

HIC.					
LEAVES	0.69	0.04	0.27	0.51	0.14
BRANCHES	1.15	0.11	0.57	3.96	0.34
S.WOOD	0.95	0.08	1.11	1.43	0.71
S.BARK	0.37	0.02	0.14	2.67	0.12
Y.P.					
LEAVES	0.00	0.00	0.00	0.00	0.00
BRANCHES	0.00	0.00	0.00	0.00	0.00
S.WOOD	0.00	0.00	0.00	0.00	0.00
S.BARK	0.00	0.00	0.00	0.00	0.00
TOTAL (LBS/ACRE)	329.88	32.02	170.32	745.35	71.90
WHOLE TREE HARVEST WITH LEAVES=TOTAL ABOVE					
W.T.H. W/O LEAVES	283.45	28.66	151.58	721.69	64.62
BOLE HARVEST	106.99	6.37	44.20	193.78	18.88
BOLE WOOD	60.94	4.24	19.59	381.17	14.06

PROGRAM TITLE

BANR: Program to Predict Biomass Yield and Nutrient Withdrawal by Harvest of Southern Hardwood Stands

PROGRAMMER

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HARDWARE/SOFTWARE REQUIREMENTS

Computer make and model...(1) Hewlett-Packard 9830, (2) Apple IIe, (3) IBM-PC/XT.
Operating system...(1) standard, (2) CP/M-80, (3) MsDOS 2.0
Programs required...(1) ROMs for matrix manipulation and string variables
Minimum memory...32k
Floppy disk drives required...1, (1) uses cassette tape drive
Printer required... yes
Additional peripherals required... none
PROGRAM AVAILABLE FROM

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PROGRAM AVAILABLE ON

Handcopy, cassette tape (1), diskette (2 & 3)

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