North Central Forest Experiment Station 5.10

CENTRAL HARDWOOD NOTES

Growth And Yield Models For Central Hardwoods

Over the last 20 years computers have become an efficient tool to estimate growth and yield. Computerized yield estimates vary from simple approximation or interpolation of traditional normal yield tables to highly sophisticated programs that simulate the growth and yield of each individual tree.

Types of Models

Growth and yield models are generally stand models or individual tree models. The main distinction between stand models and individual tree models is in the type of information needed to build the models and the detail of output they produce. Only stand data are needed to use stand models, whereas individual tree measurements are needed to use individual tree models. Stand models produce only aggregated stand estimates while tree models produce estimates for each tree in the stand. Some models, such as diameter distribution models or stand-table projection models produce a level of detail intermediate between whole stand and individual tree models. In table 1 we classify the models available for the central hardwood forest according to the resolution of detail they generate in projections.

Stand models compute future growth and yield using a few simple stand variables supplied by the user, such as stand age, site index, basal area per acre, and number of trees per acre. Output from these models predicts total stand growth and yield per acre in such terms as cubic-foot volume, basal area, board feet, number of trees, or tons of biomass. For many purposes average yields per acre are sufficient. Stand models are easy to use, require minimal input data, and operate very economically on hand-held or micro-computers.

Stand-tab/e projection models are more complex. Diameter distribution models, for example, are basically stand models with a useful feature that allows whole stand growth and yield to be distributed or allocated to each diameter class. These models compute growth and yield by user-specified species groups and size classes. Stand table projection models usually require you to specify appropriate growth rates by species and size class. They provide reliable yields for short projection periods, especially if the growth and mortality rates you supply are developed specifically for the projected stand. Projections longer than 15 to 20 years may have considerable error, unless growth and mortality rates are appropriately adjusted. With stand table projection models or diameter distribution techniques individual trees are not identified by species or d.b.h. class.

Table 1.-*Growth and yield models for the central hardwood region. Affiliation of contact person and expected application of model is shown.*

Model	Contact	Affiliation[1]	Hardware[2]	Application	Reference
		STAND LEVEL			
GROAK	Arlyn Perkey	NAS&PF	1	Upland oaks	Perkey (1986) Dale (1972)
———[3]	Harold Burkhart	VPI&SU	2	Yellow-poplar	Knoebel *et al.* (1986)
GROWPINE[4]	Arlyn Perkey	NAS&PF	2	White pine (Ohio plantations)	Perkey (in press)
		STAND-TABLE PROJECTION			
SILVAH	Dave Marquis	NEFES	2	Allegheny hardwoods (cherry, maple, oak)	Marquis (1986)
TIMPIS[5]	John Moser	Purdue Univ.	3	Mixed central hardwoods	Unpublished
		INDIVIDUAL TREE			
COPPICE	Paul Johnson	NCFES	2	Red oak stump sprouts (WI)	Johnson and Rogers (1984)
G-HAT	Harold Burkhart	VPI & su	2	Appalachian mixed hardwood stands	Harrison et *al. (1986)*
OAKSIM	Don Hilt	NEFES	2	Upland oaks	Hilt (1985a, b)
TWIGS[6] (Central States and Lake States)	Steve Shifley	NCFES	2	Mixed species stands (Central and Lake states)	Belcher (1982) Shifley (1987)
NE TWIGS (Northeastern States)	Don Hilt Richard Teck	NEFES	2	Mixed species stands (Northeast)	Hilt *eta/. (1987)*
SE TWIGS[4] (Southeastern States)	Ralph Meldahl	Auburn Univ.	2	Southeastern forest stands	Unpublished
		CONSOLIDATED			
ERGYS[4]	Tom Gullett	NCFES	2	——[7]	Gullett (1986)
YIELD	Todd Hepp	TVA	2	[8]	Hepp (1982)
YIELD-MS	Todd Hepp	TVA	2	[9]	Hepp (1986)

[1] NA S&PF-Northeastern Area, State and Private Forestry, Broomall, PA.
NEFES-Northeastern Forest Experiment Station, Broomall, PA.
NCFES-North Central Forest Experiment Station, St. Paul, MN.
TVA-Tennessee Valley Authority, Norris, TN.
VPI 7 SU-Virginia Institute and State University, Blacksburg, VA.

[2] Hardware: 1 = pocket computer or larger, 2 = micro- or larger, 3 = mini or mainframe.

[3] This model has no specific name (acronym). While it is based on stand level, projections, diameter distribution methods are used to obtain the number of trees in each diameter class.

[4] In development.

[5] Write for most recent cost information.

[6] Currently being distributed for a fee by the Forest Resources Systems Institute (FORS), 201 N. Pine Street, Suite 24, Florence, AL 35630. (205) 767-0250.

[7] ERGYS includes GROAK, SILVAH, OAKSIM, TWIGS and other models for the northeastern United States.

[8] YIELD includes GROAK, a yellow-poplar model, and other models for southern pines.

[9] YIELD-MS uses diameter growth and mortality rates from G-HAT, OAKSIM, SILVAH, and TWIGS. Also has option for using local growth rates.

Individual free *models* provide you with the greatest detail, but require more input data such as a tree list by species and diameter. Most require a micro- or larger computer to operate. You can generate a list of trees by species and size for any time during the projection period. This level of detail allows you to assign a tree grade or quality class to each tree and provides a framework to compute tree and stand dollar values for economic evaluations. Such models provide a powerful tool to evaluate various silvicultural treatments and to develop management guidelines.

Consolidated models like ERGYS (Eastern Region Growth and Yield Simulators), a user-friendly micro-computer program, are also available. YIELD-MS also incorporates several individual models, applicable to different species or regions, into a convenient and useful system. Such systems bring together many individual models into one user-friendly system and have special appeal to users dealing with many species, timber types, or broad regional areas.

Uses of Growth Models

You can use growth and yield models to:

- Evaluate the effect of various silvicultural prescriptions.
- Perform economic analyses of alternative management prescriptions.
- Forecast changes in timber supplies for large ownerships, as well as the timber supply outlook at local, regional, state, and national levels.

For some purposes aggregated stand data are adequate, such as the administrative use of models to aid in policy issues or in planning programs to deal with future timber resources on a state or national level. You need more detailed information on tree species and size in models used to evaluate the economics of applying various silvicultural treatments to a specific woodlot.

Keep in mind that virtually all growth and yield models are best suited to compare alternatives or answer ‘what if?” questions to help you select density levels, thinning intervals, rotation lengths, etc. While they are generally not well suited to predicting actual growth of a specific stand, they can be used with caution. Growth of actual stands is best estimated by an adequate inventory system.

Choosing a Model

Consider several factors before you choose a particular model:

- Select a model that can utilize the type of hardware or computer available to you.
- Select a model that uses the input data you have, or can obtain easily.
- Select a model that gives clear, concise output information in a form that is easy to apply in your work situation.
- Choose a model that has been developed for the same species or species groups in your area. Obviously, do not use a model developed for stands with 80 percent oak when your stand has a mixture of 20 percent oak and 80 percent yellow-poplar.

- Select a model that has been developed for your geographical area. For mixed oak stands in Ohio or Kentucky favor the OAKSIM model, but from Indiana to Missouri and Iowa consider Central States TWIGS model.
- Consider the availability of the program, ease of use, and cost of computing.

For example, if you only need stand estimates for your Ohio upland oak forest and your only hardware is a pocket computer, then the GROAK program is a logical choice. If you have a mainframe computer available and need greater detail about the species and size classes, then choose the OAKSIM model. Or if your stand is located in Missouri, or contains an uneven-aged mixture of species, then the Central States TWIGS model might be your best choice.

New models are becoming available quite rapidly. Current information regarding computer applications and software used in management of natural resources are listed in the Software Directory compiled by FORS (Forest Resources Systems Institute, see footnote 6 to table 1). FORS serves as a useful clearinghouse for available software, providing information about computer hardware requirements, software requirements, name and address of vendor, and price of system and options if appropriate.

References

Belcher, David M. 1982. TWIGS: the woodsman's ideal growth projection system. In: Proceedings, Microcomputers: a new tool for foresters; 1982 May 18-20; West Lafayette, IN: SAF Publ. 82-05. West Lafayette, IN: Purdue University: 70-95.

Dale, Martin E. 1972. Growth and yield predictions for upland oak stands 10 years after initial thinning. Res. Pap. NE-241. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 21 p.

Gullett, Thomas L. 1986. ERGYS-bringing growth and yield to the forest manager. In: Wiant, H.V.; Yandle, D.O.; Kidd, W.E., eds. Forestry microcomputer software symposium; 1986 June 29-July 2; Morgantown, WV. Morgantown, WV: West Virginia University: 203-218.

Harrison, Wade C.; Burkhart, H.E.; Burk, T.E.; Beck, D.E. 1986. Growth and yield of Appalachian mixed hardwoods after thinning. Res. Pub. FWS-1-86. Morgantown, WV: Virginia Polytechnic Institute and State University, School of Forestry and Wildlife. 48 p.

Hepp, Todd E. 1982. YIELD-timber yield forecasting and planning tool. Southern Journal of Applied Forestry. 6(3): 135-l 40.

Hepp, Todd E. 1986. An overview of YIELD-MS: timber yield planning tool for mixed stands. In: Wiant, H.V.; Yandle, D.O.; Kidd, W.E., eds. Forestry microcomputer software symposium; 1986 June 29-July 2; Morgantown, WV. morgantown, WV: West Virginia University: 169-l 87.

Hilt, Donald E. 1985a. OAKSIM: an individual-tree growth and yield simulator for managed, even-aged, upland oak stands. Res. Pap. NE-562. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 21 p.

Hilt, Donald E. 1985b. User's guide to OAKSIM: an individual-tree growth and yield simulator for managed, even-aged, upland oak stands. Gen. Tech. Rep. NE-104. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 22 p.

Hilt, Donald E.; Teck, Richard M.; Fuller, Leslie G. 1987. Generalized individual tree models for the northeast. The Compiler. 5(4): 17-27.

Johnson, Paul S.; Rogers, R. 1984. Predicting 25th-year diameters of thinned stump sprouts of northern red oak. Journal of Forestry. 82(10): 616-619.

Knoebel, Bruce R.; Burkhart, H.E.; Beck, D.E. 1986. A growth and yield model for thinned stands of yellow-poplar. Forest Science Monograph. 27: 62 p.

Marquis, David A. 1986. SILVAH: a stand analysis, prescription and management simulator program for hardwood stands in the Alleghenies. In: Wiant, H.V.; Yandle, D.O.; Kidd, W.E., eds. Forestry microcomputer software symposium; 1986 June 29-July 2; Morgantown, WV. Morgantown, WV: West Virginia University: 224-240.

Perkey, Arlyn W. 1986. Stand projection using GROAK and GROPOP. In: Wiant, H.V.; Yandle, D.O.; Kidd, W.E., eds. Forestry microcomputer software symposium; 1986 June 29-July 2; Morgantown, WV. Morgantown, WV: West Virginia University: 67-69.

Perkey, Arlyn W. 1986. GROWPINE (Grow White Pine) on a computer. Northern Journal of Applied Forestry.

Shifley, Stephen R. 1987. A generalized system of models forecasting Central States tree growth. Res. Pap. NC-279. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 10 p.

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