

TASS, SYLVER, TIPSY

Systems for predicting the impact of silvicultural practices on yield, lumber value, economic return and other benefits

FROM: Di Lucca, C.M.¹ 1999. TASS/SYLVER/TIPSY: systems for predicting the impact of silvicultural practices on yield, lumber value, economic return and other benefits. **In:** Stand Density Management Conference: Using the Planning Tools. November 23-24, 1998, Colin R. Bamsey [Ed.] Clear Lake Ltd., Edmonton, AB. pp. 7-16.

NOTE: Although the general concepts still apply, some information is out-of-date. More recent information can be found online at: <http://www.for.gov.bc.ca/hts/>

Abstract - Stand density management has become a very important issue in British Columbia and Alberta from the point of view of timber production and its implications on economics and forest level analysis. This paper describes three systems designed to assess the effects of density management on stand yield, product recovery and quality, and financial return. Forest managers responsible for stand density decision-making can use these systems to prescribe stand-specific treatments in support of production objectives.

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Introduction

This paper describes the main components and information which support three growth and yield systems used in British Columbia to predict potential yields of even-aged coniferous stands of commercial importance. The main difference between these systems is the type and complexity of information they require and produce. The Tree And Stand Simulator (TASS) generates growth and yield information for SYLVER and TIPSY. SYLVER evaluates the impact of Silviculture treatments on Yield, Lumber Value and Economic Return. It integrates the yield data from TASS and other sub-systems, and predicts wood quality, product recovery and financial return for various management regimes. Finally, TIPSY (Table Interpolation Program for Stand Yield) electronically accesses managed stand yield and product recovery tables generated by TASS and SYLVER, and performs economic analyses of the silvicultural treatments simulated.

Forest resource managers can use these systems to plan and execute stand density management prescriptions which might include different establishment densities and spatial distributions, and various silvicultural treatments (e.g. pre-commercial thinning and commercial thinning). This information can then be used for silvicultural decision-making, inventory and timber supply analysis.

The Forest Productivity and Decision Support Section (FPDS) of the British Columbia Ministry of Forests Research Branch directs the research, development and support of these systems, with input from other ministry staff and industry. The Province of British Columbia holds the copyright for these systems.

What is TASS?

TASS is a biologically oriented spatially explicit individual tree model. It was designed to produce potential growth and yield tables for even-aged managed stands. It is calibrated for four coastal and four interior species in British Columbia. TASS is driven by the height growth (i.e. it uses the Ministry recommended site index or height-age curves), branch extension and crown expansion of competing trees. The model grows trees and simulates crown competition in a three-dimensional growing space simulated within a computer. The crowns of individual trees add a shell of foliage each year and either expand or contract asymmetrically in response to internal growth processes, physical restrictions imposed by the crowns of competitors, environmental factors and cultural practices. The volume increment produced by the foliage is distributed over the bole annually, and is accumulated to provide tree and stand statistics. More information about TASS can be found in the publications by Mitchell (1975), Mitchell and Cameron (1985) and Mitchell (1986).

TASS generates the yield table database for TIPSY. It also incorporates a number of sub-

models such as ROTSIM (Mitchell and Bloomberg, 1986; Bloomberg, 1990) a laminated root-rot model, SWAT (Alfaro, 1996) a spruce weevil attack model, and tRAYci (Brunner, 1998) a light interception model. TASS is also the growth and yield component of SYLVER which is described in the next section.

Who developed TASS?

The construction of TASS began in 1963 by Dr. Kenneth J. Mitchell as a research project of the Canadian Forestry Service (Mitchell, 1969) with later support contributed by Yale University (Mitchell, 1975), University of Idaho (Goudie, 1980), British Columbia Ministry of Forests (Mitchell and Cameron, 1985), and other agencies.

What can it do?

TASS generates growth and yield information for even-aged stands of pure coniferous species of commercial importance in coastal and interior forests of British Columbia. It is mainly used for:

- stand level crop planning;
- stand level silvicultural treatment decision-making (e.g. espacement, fertilization, pruning, pre-commercial and commercial thinning);
- forest level planning including long-term timber supply projections for managed second-growth stands;
- pest and disease yield impact predictions (e.g. laminated root rot and spruce weevil);
- predicting height-growth repression in lodgepole pine stands;
- investigations of tree growth and stand dynamics;
- teaching growth and yield, and stand dynamics;
- generating stand density management diagrams; and
- wood quality predictions (i.e. size and distribution of branch knots and juvenile-mature wood distribution) used by SYLVER to determine product value and economic return.

The main limitation of TASS is that it does not predict the yield of complex stands (i.e. mixed-species and/or uneven-aged stands).

What data are behind TASS?

TASS is calibrated to conform with data from research trials and remeasured plots located in managed and unmanaged stands. Most of the biological growth relationships in TASS are derived from detailed stem analysis of tree boles, branches and foliage. A total of 11 989 permanent plots (i.e. comprised of 43 799 plot measurements) established for local species growing within British Columbia, Alberta, the Pacific Northwest region of the United States, Europe and New Zealand have been consistently summarized and classified by species and treatments including control, thinned and fertilized (Goudie, 1998). The number of plots and measurements from untreated natural stands and plantations is listed in Table 1.

Coastal			Interior		
Species	Number of Plots	Number of Plot Measurements	Species	Number of Plots	Number of Plot Measurements
Douglas-fir	885	4539	Lodgepole pine	2160	5351
Western hemlock	1115	4396	White spruce	456	1286
Sitka spruce	173	643	Douglas-fir	348	764
Western redcedar	38	163	Western hemlock	5	10
Total	2211	9795	Total	2969	7411

Table 1. Permanent Sample Plots Description

FPDS staff test and evaluate TASS on a regular basis using existing and new data. In a recent paper, Goudie (1998) compared model output with plot data from thinned stands to identify potential biases in the predictions. He concluded that the system generally performs very well, but slightly overestimates the response to thinning.

Input options

TASS input parameters are:

- species and stand origin (i.e. single species from natural or planted origin);
- initial number of trees per hectare;
- spatial tree distribution or optional tree map list (e.g. uniform, clump or any possible distribution);
- site index or a combination of height and age;
- volume merchantability limits (e.g. minimum quadratic diameter at breast height outside bark, top diameter inside bark, and stump height);
- operational adjustment factors;
- plot dimensions in meters;
- silvicultural treatments (e.g. pre-commercial and commercial thinning, pruning and fertilization); and
- output table specifications (i.e. height or age range of the simulation and steps).

Output options

Examples of yield tables, sample output images and information produced are presented in the TASS Web site at [/research/tass/](#). Some of these yield tables are described below.

Standard run summary managed stand yield tables including the following variables:

- stand age;
- stand site height;
- stand crown cover percent;
- stand basal area;
- total and merchantable stand volume per hectare;
- total and merchantable stand mean annual volume increment per hectare; and
- average tree statistics (i.e. basal area, top and predominant height, crown area, crown width, crown length, quadratic mean diameter at breast height, total and merchantable height, total and merchantable volume, foliar volume, and total and merchantable gross volume).

Stand tables: display the number of trees or tree count in 5-cm diameter size classes for each stand age requested.

Stock tables: display merchantable volume (0.0+) in 5-cm diameter size classes for each stand age requested.

Mortality tables: display a stand table of the number of trees that die both earlier due to non-competitive juvenile mortality, and later due to suppression between age steps by 5-cm diameter size classes.

Standing dead tree (snag) tables: display a stand table of standing dead trees per hectare by 5-cm diameter size classes. They show the number of dead trees that are still standing at each age step (i.e. a snapshot of standing dead trees).

Customized yield tables: clients may request a variety of yield data for custom spatial distributions, pruning, fertilization, pre-commercial and commercial thinning, root rot and spruce weevil infestation treatments. Response time varies from a day to several weeks depending upon the complexity of the task.

What is in TASS's future?

Current and future developments of TASS include:

- the calibration of tRAYci, the light interception model;
- a start-up routine to enter data from existing stands;
- a complex stands model for uneven-aged interior Douglas-fir stands in the IDF zone, and for even-aged mixed-species stands in the ICH zone;
- red alder calibration;
- internet on-line access to TASS with the support of the TASS Input Editor program (TASSIE);
- wildlife attributes and environmental indicators (e.g. pileated woodpecker, grizzly bear habitat, cougar, coarse woody debris and "old-growth" dependent values). See publication by Greenough and Kurz (1996);
- a mistletoe model for western hemlock; and
- further model calibration as data become available.

Perhaps one of the most important upgrade relates to the light and moisture components needed to simulate the development of complex stands. Light is necessary to model the variable crown structure found in mixed-species and uneven-aged stands. The dynamics of moisture within a complex stand is uncertain and is currently under investigation.

How to get TASS

TASS is only available in the Research Branch of the Ministry of Forests because it has substantial training and hardware requirements. TASS growth and yield predictions are available in two formats:

- by running the program TIPSY to obtain custom versions of the yield tables generated by TASS for a specific regime; and
- by requesting special TASS runs for yield table options that are not available within TIPSY.

More information about TASS can be found online and in publications by Mitchell (1969), Mitchell (1975), Mitchell (1980), Mitchell and Cameron (1985) and Mitchell (1986).

What is SYLVER?

SYLVER is a stand level system that helps forest managers evaluate the impact of Silvicultural treatments on Yield, Lumber Value, and Economic Return. The components and operation of SYLVER are illustrated in Figure 1.

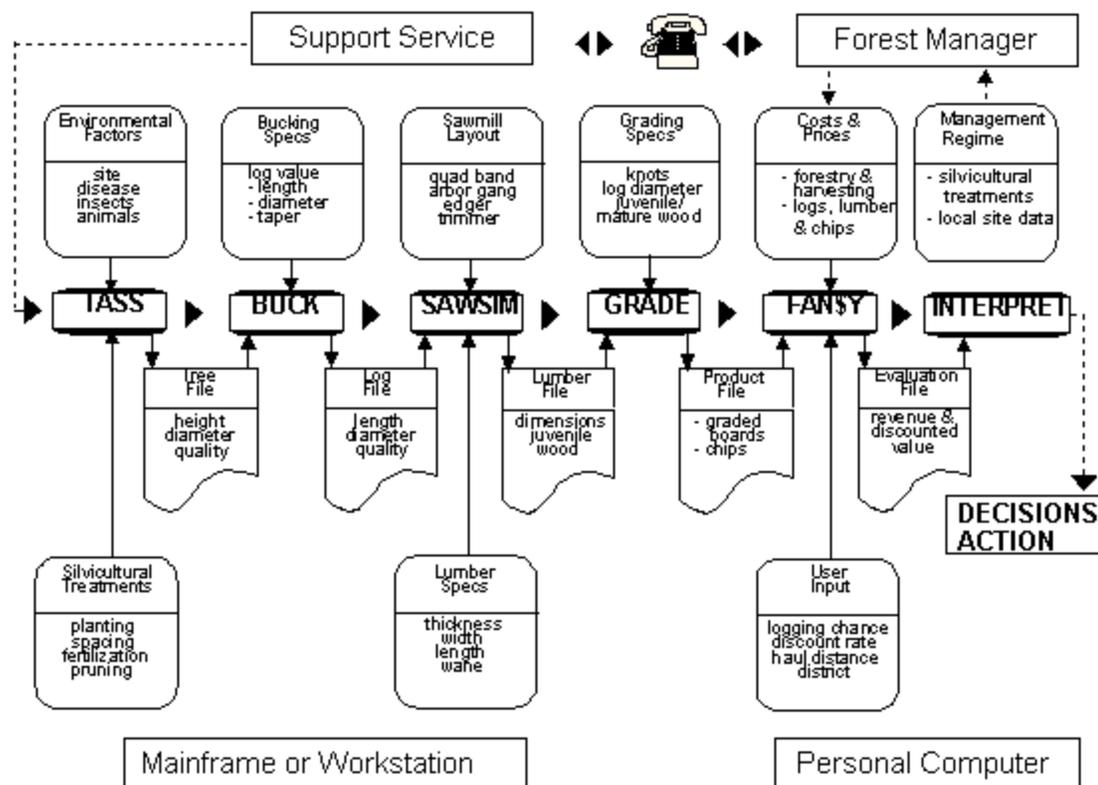


Figure 1: Components and Operation of SYLVER

Each element of SYLVER operates independently with information provided by the user or by the preceding elements of the system. The major components are:

- the Tree And Stand Simulator (TASS) that grows the stand and applies silvicultural treatments;
- the Bucking (BUCK) and Sawmill Simulation (SAWSIM) programs that produce logs and lumber from trees grown by TASS;
- the grading routine (GRADE) that classifies the logs and lumber according to quality; and
- the Financial Analysis System (FAN\$Y) that determines the discounted net revenue recovered from tending, harvesting and processing the stand.

Who developed SYLVER?

The development of SYLVER started in 1985 as a product of the Douglas-fir Task Force sponsored by Forintek Canada Corporation, Pulp and Paper Research Institute, British Columbia Ministry of Forests, The University of British Columbia, and industry (Kellogg, 1989). The Task Force was divided into 13 projects which studied the basic wood and pulp properties of second-growth stands of coastal Douglas-fir. The last project is the stand level system SYLVER that integrates silviculture and end-product value.

What can it do?

SYLVER predicts wood quality, product value and economic return in full for coastal Douglas-fir, and partially for coastal western hemlock, Sitka spruce, western redcedar, interior Douglas-fir, interior western hemlock, lodgepole pine and white spruce. The main applications of SYLVER are:

- stand level planning;
- silvicultural prescriptions decision-making (e.g. espacement, fertilization, pruning, pre-commercial and commercial thinning);
- forest level planning (e.g. long term timber supply projections from managed stands);
- pest and disease impact prediction (e.g. laminated root rot and spruce weevil);
- tree and stand dynamics, wood quality and economic investigations;
- stand level economics analysis; and
- education and teaching.

Some of the limitations of SYLVER are:

- it can not be distributed as an integrated stand-alone software package;
- it can not predict yield of complex stands (i.e. mixed-species and/or uneven-aged stands); and
- the lumber grade data required to calculate the select structural lumber volume is currently available only for coastal Douglas-fir.

What data are behind SYLVER?

The coastal Douglas-fir version of SYLVER is based on data from six 50-year-old stands representative of managed forests which will be harvested in the future located on Vancouver Island (Kellogg, 1989). The number of trees sampled for each project is outlined below.

- 300 trees were converted to lumber, and evaluated to estimate the log and lumber yield and grade recovery (Middleton and Munro, 1989), kiln drying degrade (Mackay, 1989), strength and stiffness of dimensional lumber (Barrett and Kellogg, 1989), and heartwood treatability (Ruddick, 1989);
- 60 trees to study the relative density distribution (Jozsa et al., 1989), chemical properties (Swan et al., 1989) and longitudinal shrinkage (Nault, 1989);
- 24 trees to study the juvenile-mature wood transition (Di Lucca, 1989);
- 17 trees to study fiber length (Hamm, 1989); and
- 9 trees to study density and chemical properties of juvenile, mature and top wood (Hatton and Hunt, 1989), unbleached Kraft pulp properties (Hatton and Hunt, 1989), and refiner mechanical pulp properties (Hatton and Johal, 1989).

Input options

The input parameters for the SYLVER components shown in Figure 1 are listed below.

TASS input parameters were mentioned in the previous section.

BUCK uses the tree list generated by TASS which contains the information about the tree heights, diameters inside and outside bark for the knotty and juvenile wood core, average size and distribution of knots, etc. This program bucks each tree according to specifications (i.e. log length, diameter and taper) that maximize the value of the logs or lumber.

SAWSIM uses the log information generated by BUCK and applies a series of predefined cutting patterns to each log, and selects the one that produces the maximum value based on the determined average market prices. SAWSIM input parameters include the mill configuration (i.e. type of machine and kerf) and lumber specifications (i.e. thickness, width and length). It is a proprietary program developed by Halco Software Systems, Ltd.

GRADE characterizes logs and lumber by quality class. The grading criteria for logs are: minimum length, average small-end diameter, maximum knot diameter and minimum number of annual growth rings per 2 cm. The grading criteria for clear and knotty lumber are: knot content percent, juvenile wood percent, dimensional lumber length, width and thickness.

FAN\$Y uses stand, treatment and product information to evaluate the impact of selected silvicultural treatments on the discounted value returned by end products. Some input parameters are:

- land manager (i.e. crown or private); land ownership (i.e. crown or private); and market type (i.e. log or lumber);
- forestry costs (e.g. survey, land rent, brushing and weeding, spacing, fertilization, root rot control, site preparation, planting, pruning, etc.);
- harvesting costs (e.g. infrastructure development, operation and administration overhead, tree-to-truck, hauling, etc.);
- manufacturing costs (e.g. milling, drying, machine stress rating, etc.);
- market prices for logs, lumber and wood chips; and
- financial parameters (e.g. discount rate, U.S. dollar exchange rate, inflation rate, taxes, adjustments factors for future costs and prices, lumber premiums, appraisal data, etc.).

Output options

SYLVER output integrates the yield information, product recovery and financial return from a variety of management regimes. SYLVER is not distributed as a stand-alone package because TASS, BUCK and SAWSIM must be operated by specialists on a powerful workstation. In contrast, most users have only personal computers and limited training time. To provide access to SYLVER, the Forest Productivity and Decision Support Section divided the operating responsibilities between the user support service and the forest manager as illustrated in Figure 1. Both formulate a series of relevant management regimes

and the specifications for bucking, sawing and grading. User support processes all regimes through to the generation of product files, which are forwarded to the forest manager for use with FAN\$Y on a personal computer. Then the forest manager can perform sensitivity analyses on the economic specifications to determine the most suitable prescription for local conditions.

What is in SYLVER's future?

Current and future developments of SYLVER include:

- lodgepole pine and coastal western hemlock;
- an employment generation module;
- the establishment of an expert user group for ongoing testing and development of FAN\$Y; and
- input options in TASSIE for specifying bucking, sawing and grading parameters.

How to get more information about SYLVER

More information can be found online and in the publications by Ken Mitchell, et al.(1989 and 1991).

What is TIPSYP?

The **T**able **I**nterpolation **P**rogram for **S**tand **Y**ield (TIPSYP) is not a growth and yield model because it only provides electronic access to the managed stand yield tables generated by TASS and SYLVER. TIPSYP retrieves and interpolates yield tables from its database, customizes the information and displays summaries and graphics for a specific site, species and management regime. Information can be entered and displayed in either metric or imperial units. Initial density (i.e. planted or naturally regenerated) and pre-commercial thinning are the primary management variables. It uses optional Operational Adjustment Factors (OAFs) to mimic operational conditions. Two types of OAFs are available in TIPSYP to account for elements that reduce potential yields. OAF 1 accounts for the reduction of physical growing space due to holes created by rock outcrops, swamps and non-commercial tree cover. OAF 2 accounts for pest damage that increases towards maturity. A detailed description of OAFs was prepared by Albert Nussbaum (1998). The current version of TIPSYP includes an economic analysis module, known as the TIPSYP Economist (Stone et al., 1996) which performs economic analyses on the silvicultural treatments simulated by TIPSYP. A batch version of TIPSYP is also available for processing a large number of stands for timber supply analyses. Batch TIPSYP is included in the program WOODLOT (B.C. Ministry of Forests, 1998) for calculating even-flow harvest rates for a planning period on woodlot licenses.

Who developed TIPSYP?

The original DOS version or Meta Model was developed by Forests Planning Systems, now part of Reid Collins and Associates. In 1990, RamSoft Systems Ltd. translated the program from BASIC to the C computer language and restructured it to accommodate the next generation of yield tables. The program was renamed to TIPSYS and distributed to forest managers across the province along with an user's guide (Mitchell et al., 1992). In 1993 Ramsoft Systems Ltd. rewrote TIPSYS to operate in the MS Windows environment and renamed it WinTIPSYS. This program was released in January 1996 as Version 1.3 (Mitchell and Grout, 1995). Soon after, the development of the DOS version was discontinued and WinTIPSYS became TIPSYS again. The current TIPSYS Version 2.1 was released in 1998 and is distributed free of charge at the discretion of the Ministry.

What can it do?

TIPSYS generates managed stand yield tables, including product recovery data, economic analysis, and supporting graphics for:

- stand level crop planning;
- silvicultural prescriptions (e.g. espacement and pre-commercial thinning);
- forest level planning for long term timber supply projections of managed stands. A multiple species feature aggregates stand types into the timber supply analysis units;
- repressed stands of lodgepole pine;
- dead trees (i.e. standing or fallen);
- investigations of tree growth and stand dynamic;
- generating stand density management diagrams; and
- educational and teaching purposes.

Some of the limitations of the current version of TIPSYS are:

- it does not predict the yield of complex stands (i.e. mixed-species and/or uneven-aged stands);
- it must initiate stand growth projections at age 0 (i.e. year of disturbance) since data from existing stands cannot be entered. However, establishment parameters can be interactively manipulated to approximate the existing stand conditions at a particular age;
- it allows for only one pre-commercial thinning entry, and it occurs only when stands reach a top height of 4 meters on the interior and 6 meters on the coast.
- it only has two spatial distributions. Planted stands have a nearly uniform square spacing and naturally regenerated stands have a random distribution of seedlings covering the entire site.

What data are behind TIPSYS?

TIPSYS's database includes 548 managed stand yield tables for: coastal Douglas-fir, coastal western hemlock, Sitka spruce, western red-cedar, interior Douglas-fir, interior western hemlock, lodgepole pine and white spruce. TIPSYS generates any table within a limited range of parameters provided by the user. If an identical yield table does not exist, TIPSYS will

interpolate between the closest yield tables and electronically retrieve stand yield information.

Input options

You can enter these parameters in TIPSYS:

- species and regeneration method (e.g. natural or planted). An optional multiple species feature will prorate the yields for up to a maximum of 5 species. This option was developed to aggregate stands for the benefit of timber supply planners. It is important to understand that TIPSYS does not simulate the growth of multiple species stands biologically. The only biological assumption is the site index conversion among species;
- initial number of trees per hectare;
- operational adjustment factors;
- site index or a combination of height and age;
- silvicultural treatments (e.g. pre-commercial thinning);
- merchantability limits for total volume and merchantable volume;
- the economic analysis will require:
 - stand geography (i.e. region, district, biogeoclimatic zone and average slope);
 - discount assumptions (i.e. discount rate, real price and cost increase, real increase duration, base age);
 - silvicultural costs for: surveys, site preparation, planting and pre-commercial thinning;
 - harvesting costs for: different harvesting systems, tree-to-truck, hauling, milling and other miscellaneous costs;
 - product prices for lumber, wood chips and logs; and
 - optional financial and sensitivity analyses.
- output table specifications (height or age range and steps).

Output options

TIPSYS generates the following yield tables and information.

Standard managed stand yield tables including:

- total age (i.e. age since disturbance);
- top height;
- gross, total and merchantable volume, and mean annual volume increment per hectare;
- stand basal area;
- quadratic mean diameter at breast height (DBH);
- crown cover percent; and
- for the largest 250 prime or crop trees: merchantable volume, quadratic mean diameter at breast height (DBH) and live crown percent.

Stand tables: display the number of trees by 5-cm diameter size classes for each stand age requested.

Stock tables: take the merchantable volume (12.5 cm+) from the yield table and display it in 5-cm diameter size classes for each stand age requested.

Stand and stock tables combined: display both the number of trees and the merchantable volume in 5-cm diameter size classes for each stand age requested.

Lumber tables: display the board-foot volume of dimensional lumber by 2-inch classes (2x4, 2x6, 2x8, and 2x10), bone dry units of chips, and lumber recovery in board feet per cubic meter.

Log tables: display the total scaled volume (12.5 cm+) of logs which are 2.5 meters (8 ft) or longer in length and its breakdown into standard log market grades.

Economic analysis tables: display the benefit/cost assumptions, net present values, site values and optional financial and sensitivity analyses of a particular management regime.

Mortality tables: display a stand table of the number of trees that die both earlier due to non-competitive juvenile mortality, and later due to suppression between age steps in 10-cm diameter size classes.

Standing dead tree (snag) tables: display a stand table of standing dead trees per hectare in 10-cm diameter size classes. They show the dead trees that are still standing at the age step (i.e. a snapshot of standing dead trees).

What is in TIPSY's future?

Current and future development plans for TIPSY include:

- new treatment options such as: commercial thinning, fertilization, jobs generated and coarse woody debris;
- incorporation of Batch TIPSY into the current interactive version;
- start-up routine to facilitate the entry of data from existing stands;
- incorporation of clumped spatial distributions; and
- the ability to create and save customized output table formats.

How to get TIPSY

There are three different ways to get your copy.

- If you work for the Ministry of Forests, check with your systems administrator.
- Others can download TIPSY online.

Regardless of how you get your copy of TIPSY, you should register with the Ministry as a

user. We will then be able to contact you about upgrades, bugs, and new products. If you download the software from our Web site, you will have the opportunity to register at the same time. If you do not get your copy from the Web site, you should still use our Web site to register without actually downloading.

More information about the TIPSYS can be found online and in the publication by Mitchell and Grout (1995). TIPSYS comes complete with a comprehensive on-line reference manual which includes a context-sensitive Help system as well as a directory of 'experts' who can be contacted regarding the specialized modules such as the TIPSYS Economist, snags, or lodgepole pine repression.

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