USDA Economic and Biophysical Simulation Models Useful For Assessing the Impact of Bioenergy Production

Agricultural Research Service

WholeFarm is a computer aided planning system designed by USDA-Agricultural Research Service that optimizes planning decisions by allowing managers to build a specific farm enterprise plans on a field-by-field basis for all crops and livestock components. WholeFarm generates a variety of reports accounting for acreage, rotations, and production histories, along with comprehensive variable and fixed costs analyses for total farm income and expense reports, twelve-month itemized cash flow statement, and in-season cost monitoring. Once the WholeFarm farm plan has been developed, empirical information from crop rotation research can be coupled with the rotation histories to allow producers to obtain mathematically optimized combinations of crops to produce. WholeFarm can help producers decide which crops to plant in which fields that will maximize profits. While the original intent of WholeFarm was to focus on improving crop rotations, numerous other applications have emerged including focusing on regional impacts of changes in farm structures, potential changes in cropping patterns based on climate forecasts, and recently to address the potential of on-farm or local based bioenergy production.

iFEAT is the iFARM Field Economic Analysis Tool developed by USDA-Agricultural Research Services as a decision support tool for farmers and ranchers on the Central Great Plains called iFARM. iFARM is the successor to GPFARM and was designed to provide strategic decision support while iFARM is designed as a tactical decisions support tool ideal for making decisions before the start of the growing season. With iFEAT, farmers can easily and quickly calculate the costs and benefits of current management options including crop rotations, insurance, lease options, government payments and others. iFEAT allows users to test "what if" scenarios to provide a form of risk assessment. iFEAT allows producers several types of printable reports including budget reports for different lease agreements and for farmer owned land. iFEAT is available for download at: http://arsagsoftware.ars.usda.gov/agsoftware/

LAM is the **L**and **A**llocation **M**odel, a matrix model developed by Agricultural Research Service to evaluate factors that drive land allocation decisions. The model uses producer derived information to evaluate environmental, economic, production, and producer preference factors that underlie land allocation decisions between enterprises. Environmental inputs include residue quantity and quality, number of operations, energy requirements, and degree of industrialization. Economic inputs include net return per acre and price coefficient of variation. The amount of annual rainfall required to grow a specified crop and the actual precipitation for the region are used to scale production. The model also includes the producer preference to contribute to actual land allocation each enterprise. This model assumes that all land within a producer's operation is suited for any of the four enterprises. It also assumes that the producer has equal management ability and financial means within each enterprise. The model incorporates information that is relevant to and easily accessed by producers. LAM was designed so that additional benefits and parameters could be incorporated into the modeling framework as needed. The model ultimately provides a means to optimize land allocation, evaluates factors that impact land allocation, and allows for the calculation of specific net returns that shift land allocation from one enterprise to another.

SWAT is the **S**oil and **W**ater **A**ssessment **T**ool, a river basin- or watershed-scale model developed by USDA-Agricultural Research Service to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods of time. SWAT is a physical based model that requires specific information about weather, soil properties, topography, vegetation, and land management practices occurring within the watershed. The physical processes associated with water movement, sediment movement, crop growth, nutrient cycling, and others are directly modeled by SWAT using these input data. http://www.ars.usda.gov/Research/docs.htm?docid=9793

Auto-calibration program for SWAT developed by USDA-Agricultural Research Service applies a multi-objective evolutionary algorithm (MOEA) using Pareto ordering optimization for the auto-calibration of the Soil and Water Assessment Tool (SWAT). The non-dominated sorting genetic algorithm (NSGA-II) is implemented in the statistical language R using a parallel message passing interface, and calls SWAT as a function. At convergence, the program provides the Pareto optimal solution set among multiple objectives, usually the minimization of prediction error for event driven flow and base flow. In one study for National Weather Service's Distributed Hydrologic Model Intercomparison Project (DMIP), more than 10,000 SWAT variables been simultaneously optimized with the calibration routine. The program results are a set of solutions that represent the optimal trade-offs among multiple objective across the feasible range of parameter values. Variations of the program allow for integrated modeling where SWAT is linked to mathematical programming models of economic decision making and environmental indicators. The results in this type of application provide stake-holders the best available trade-offs among conflicting objectives for an effectively infinite number of scenarios.

PGA-BIOECON is the **P**arallel **G**enetic **A**lgorithm for Computation of **Bio**physical and **Econ**omic Multi-objective Pareto Sets developed by USDA Agricultural Research Service applies a multi-objective evolutionary algorithm (MOEA) and Pareto ordering optimization for the computation of tradeoffs among economic, environmental, and policy efficiency objectives. The algorithm links SWAT to a farm level profit maximization model. The use of a genetic algorithm allows the economic model to calculate the profit maximizing inputs, which are then used to drive the SWAT model to simulate the environmental effects of the farm's decisions. The simplest application is to calculate the trade-offs between farm profit and the environmental quality. The computational framework is general, and any combination of physical and economic could used to specify the objectives. The algorithm is written in the R statistical language, and is implemented for parallel processing, but can also be used with a single processor. Whittaker et al., 2007, A Hybrid Genetic Algorithm for Multi-objective problems with activity analysis-based local search. European J. Operational Research, 193:195-203.

EPIC is the Environmental Policy Integrated Climate model. It was originally designed by the USDA-Agricultural Research Service to estimate erosion impacts on crop productivity. Later improvements incorporated functions to simulate environmental processes related to water quality and soil organic carbon dynamics. EPIC predicts the effects of management decisions on soil, water, nutrients and pesticide movements, as well as their combined impact on soil loss, water quality and crop yields for areas with homogeneous soils and management. Twelve plant species can be modeled at the same time, allowing inter-crop and cover-crop mixtures. Simulated processes include tillage effects on surface residue, soil bulk density, and mixing of residue and nutrients in the surface layer; along with wind and water erosion, hydrology, soil temperature, C, N, and P cycling, fertilizer and irrigation effects on crops, pesticide fate, and economics. http://www.brc.tamus.edu/epic/; http://www.public.iastate.edu/~tdc/i_epic_main.html.

WEPP is the **W**ater **E**rosion **P**rediction **P**roject model, a physically-based simulation tool for estimating the effects of land management practices on runoff, soil loss, and sediment yield from hillslope profiles and small watersheds. WEPP was developed by USDA-Agricultural Research Service in cooperation with USDA-Natural Resources Conservation Service, USDA-Forest Service, and USDI-Bureau of Land Management. The model has been successfully applied on croplands, rangelands, forestlands, and construction sites. Both single storm and continuous simulations can be conducted that provide spatial and temporal soil erosion prediction output results in graphical and tabular form. The physical processes accounted for by the tool include climate generation (precipitation occurrence, temperatures, and wind), water infiltration, percolation, and runoff, soil detachment by rainfall and flowing water, sediment transport, sediment deposition, plant growth, residue decomposition, soil disturbed by tillage and consolidation. Types of conservation management that can be evaluate with WEPP include conventional/conservation tillage, crop rotations, mulching, buffer strips and terracing. The model soil loss predictions have been validated in a number of research studies within the U.S. and internationally. Large databases are supplied for climate, soils, management, and topography, which make WEPP east to use in the U.S. A variety of model interfaces are available, including a Windows stand-alone program, the GIS-linked product ArcView/ArcGIS extension – GeoWEPP, and a series of Web-based interfaces for hill slope and GIS-watershed simulations. http://topsoil.nserl.purdue.edu/nserlweb/weppmain.

AGNPS is the **AG**ricultural **N**on-**P**oint **S**ource Pollution Model integrating a system of computer models jointly developed by the USDA-Agricultural Research Service and USDA-Natural Resources Conservation Service to predict non-point source pollutant loadings within agricultural watersheds. AGNPS contains a continuous simulation pollutant loading model (Annualized AGNPS, AnnAGNPS) designed to assess the effects of conservation management practices, the development of total minimum daily load limits, and for conducting risk and cost-benefit analyses. The input programs include a GIS-assisted computer program (TOPAZ-based interface to AGNPS) to develop terrain-based AnnAGNPS cells with all the needed hydrologic and hydraulic parameters calculated from readily available digital elevation models and an input editor to initialize, complete, and revise the input data. Outputs related to soluble & attached nutrients (nitrogen, phosphorus, and organic carbon) and pesticides are provided. Sediment sources include those by particle size class from sheet & rill, ephemeral gully, classical gully and channel erosion. The model provides the capability to track any pollutant source to any point in the watershed allowing for the assessment of appropriate conservation measures to resolve the particular pollutant problem. http://www.wsi.nrcs.usda.gov/products/w2q/h&h/tools_models/agnps/index.html

AGWA is the **A**utomated **G**eospatial **W**atershed **A**ssessment tool that was developed jointly by the ARS, EPA-ORD, and the University of Arizona (www.tucson.ars.ag.gov/agwa). AGWA is geospatial tool utilizing both ArcView and ArcGIS 9.x to rapidly parameterize, execute, and spatially display watershed model results for multiple models. Currently AGWA 2.0 supports the KINEROS2 distributed, physically-based, event rainfall runoff and erosion model (www.tucson.ars.ag.gov/kineros) and the

SWAT model described above. For SWAT, it includes a Climate Assessment Tool to assess of changes in watershed response as a consequence of user-defined climate change scenarios, including intensification of rainfall in a stochastically consistent fashion. AGWA 3.0, to be released in late 2009, will also support the coupled KINEROS2-OPUS2 (K2-O2). K2-O2 is a continuous physically-based distributed model that will simulate hydrology, energy balance, plant growth, erosion, nutrient cycling (N-P), carbon cycling, and pesticides, for a variety of cropland and rangeland management scenarios. Because KINEROS2 and K2-O2 model runoff-runon with interactive infiltration they can be used to evaluate the spatial placement and effects of best management practices and focused land use changes at, and downstream of, their location in the watershed. With these models, AGWA enables multi-scale analysis from large watersheds with SWAT (~ 6 digit HUC level) all the way down to field scale watersheds using KINEROS2 and K2-O2 to assess the relative impacts of land use/land cover change and simultaneously with simple climate change scenarios.

CQESTR is a process-based model developed by USDA-Agricultural Research Service that simulates the effects of climate, crop rotation, and tillage management practices, and soil amendment additions and losses on soil organic carbon (C). CQESTR, pronounced 'sequester', is a contraction of carbon sequestration, meaning carbon storage. It works on a daily time-step and can perform long-term 100-year simulations. Soil organic matter change is computed by maintaining a soil carbon budget for additions as a result of atmospheric carbon dioxide sequestration or added amendments like manure, and organic carbon losses through microbial decomposition. The identity for each organic input is initially maintained as composting residues over a 4-year period after which the organic input loses its identity and is placed into a mature soil organic matter pool in an abrupt step function. Both the composting residues and mature soil organic matter are decomposed daily using an exponential function driven by cumulative heat units with appropriate empirical coefficients for the type of residue, nitrogen content and incorporation into the soil by tillage. The model uses daily time steps to calculate heat units that are initiated for each organic input, typically after harvest of the crop. Other soil amendments are tracked similarly. When soil carbon is decomposed in soil to carbon dioxide, it is normally transported out of the soil in the gaseous phase by dispersion-diffusion and advection in air. A Web application was developed to facilitate inputs, model process execution, and displaying results. CQESTR requires input of initial soil organic matter content for each soil layer of interest, above- and below-ground crop biomass, dates of all residues or organic amendment additions and tillage operations, fraction of pre-tillage residue weight remaining on the soil surface after each tillage, depth of tillage, nitrogen content of residue at decomposition initiation, average daily air temperature expected throughout the period of interest, an approximate date for the first significant rain precipitation event after harvest, number and thickness of soil layers, organic matter content, and bulk density of each layer.

GLYCIM, GOSSYM, **MAIZSIM** and **SPUDSIM** are mechanistic models developed by USDA-Agricultural Research Service simulating soybean, cotton, maize (corn) and potato growth, development and yield, respectively. These models can simulate effects of temperature and CO_2 on photosynthesis. The models simulate light interception, photosynthesis, carbon partitioning in the plant, and two dimensional water and nitrogen uptake and movement in soil. GOSSYM and GLYCIM have seen extensive testing and application at the farm level. MAIZSIM and SPUDSIM are currently under development. Required inputs of these models include daily or hourly radiation and max-min or hourly temperatures, soil water parameters, and plant parameters as well as management information (planting and row spacing). Outputs

include biomass and yield components, soil water and nitrogen contents and fluxes. Additionally, MAIZSIM and SPUDSIM can provide information on soil carbon and nitrogen dynamics and energy balances. **MelonMan** is a simple, cultivar specific, cantaloupe phenology model that uses standard weather data to predict leaf appearance, crop developmental stages and final harvest date. **2DSOIL** is a comprehensive, modular, two-dimensional soil simulator that can simulate the major physical, chemical and biological processes in soil. Fully implemented, principles of modular modeling facilitate the addition and replacement of modules makes it make it easy to modify the model and incorporate it into plant models. 2DSOIL was incorporated the new ARS corn (MAIZSIM) and potato (SPUDSIM) models. **2DLEAF** is a comprehensive leaf gas exchange model that includes two-dimensional CO_2, O_2, and water vapor diffusion in the intercellular space schematized according to leaf anatomy, CO_2 assimilation by mesophyll cells, and stomatal movements as a regulating factor.
http://www.ars.usda.gov/Research/docs.htm?docid=6339

ALMANAC is the **A**gricultural **L**and **M**anagement **A**lternatives with **N**umerical **A**ssessment **C**riteria model. It is a process-based model designed by the USDA-Agricultural Research Service to simulate competition among plant species, specifically, weeds and crops or complex grassland communities. ALMANAC has recently proved to be a useful tool in simulating potential lignocellulosic biofuel species production, notably *Alamo* switchgrass. ALMANAC has been validated at diverse sites across the U.S. for switchgrass as well as potential sugar-based ethanol crops such as corn and sorghum. ALMANAC simulations provide a useful tool for determining optimal cropping strategies for cellulosic and sugar based ethanol biofuel production across the U.S. The model has been extensively validated for pasture grasses and row crops in a wide range of locations, drought conditions, and plant species. ALMANAC accurately simulated mean crop yields in nine states in the U.S. with diverse soils and climate. When applied to maize at eleven sites and sorghum at eight sites in Texas for the dry conditions of 1998, ALMANAC realistically simulated grain yields. ALMANAC simulates grasses, both in monoculture and polyculture. The model simulates grain and forage yields for a diverse set of ecological sites with two or more competing grass species competing across environmental extremes.
http://www.ars.usda.gov/Research/docs.htm?docid=9760

RZWQM2 is an enhanced version of the USDA-Agricultural Research Service Root Zone Water Quality Model (RZWQM). RZWQM2 simulates the effects of major agricultural management practices on physical-chemical processes and plant growth, and the movement of water, nutrients, and pesticides to runoff and through the crop-root zone to shallow groundwater. The model allows simulation and evaluation of a wide spectrum of management practices, such as no-tillage and residue cover versus conventional tillage; rates, methods, and timings of application of water, fertilizers, manures, and various pesticides; and different crop rotations. RZWQM2 contains special features simulating tile drainage and rapid transport of surface-applied chemicals through soil macropores to deep depths, groundwater, and tile flow. The model daily weather data requirements are maximum and minimum temperature, solar radiation, wind speed, relative humidity, and rainfall. General data requirements include soil texture, soil bulk density, soil hydraulic properties (if known), and management practices. RZWQM2 is a one-dimensional model with a pseudo two-dimensional drainage flow and water table fluctuation. Users have the options of using a generic plant growth model or the DSSAT4.0 plant models. Updated versions of RZWQM2 are delivered through the web at arsagsoftware.ars.usda.gov and is documented in a book, which can be purchased at http://www.wrpllc.com/books/rzwqm.html

The USDA-Agricultural Research Service **Crop Sequence Calculator** Version 3 (CSC) was developed was derived from no-till farming experiments conducted at the Northern Great Plains Research Laboratory near Mandan, North Dakota and applies the principles of dynamic cropping systems to help northern Great Plains producers select cropping sequences best suited to their particular situation. Knowledge of the sequence crops in rotation can be used to take advantage of crop synergism, nutrient cycling, and soil water, and capitalize on anticipated external resources such as weather, markets, and USDA Farm Bill programs. The CSC is user friendly and operates from the CD drive without using up any CPU disk space. Producers can compare yields from any crop sequence combination within a 16 crops portfolio. Producers have the opportunity to compare net returns for any of the crop sequence options by entering their own price and yields, government payments, and cost of production information customized to their own conditions. The Crop Sequence Calculator includes an extensive information system to help producers understand the biological and economic benefits and risks of different crop production combinations.

Economic Research Service

REAP is the **R**egional **E**nvironment and **A**griculture and **P**rogramming model developed by the USDA Economic Research Service. REAP is a price-endogenous mathematical programming model that incorporates the assumptions of neoclassical economics, supplemented by the best available estimated behavioral and biophysical relationships (e.g., for agricultural commodity supply and demand or nitrogen runoff). Many regularly updated data sets—production practices surveys, multiyear baselines, macroeconomic trend projections, and regional resource and land databases—are applied to construct and update REAP. To generate a baseline scenario, disaggregated regional data are used to map the baseline data projections into REAP's smaller units of analysis. The relationships between production practices and environmental performance indicators represented in the model are derived by using biophysical models. http://www.ers.usda.gov/publications/tb1916/

FARM II is the **F**uture **A**gricultural **R**esources **M**odel **II** developed by the USDA Economic Research Service. FARM II is an integrated modeling framework designed for analyzing global changes related to long-run agricultural and environmental sustainability. FARM II includes a new land and water resources database linked to production of agricultural and forestry commodities according to agro-ecological zones characterized by irrigated or rain-fed production conditions, length of growing seasons, temperature regime, and plant hardiness zones. This database has been incorporated into a computable general equilibrium (CGE) model of the global economy based on the GTAP 7 database modified to reflect FARM II's economic structure. FARM II is in the process of being adapted for the analysis of the implications of a bio-based global economy and it will provide a global framework with links between the agricultural and energy sectors, trade policy, and land and water resource use at a fine spatial scale. http://www.ers.usda.gov/Briefing/GlobalClimate/Questions/Cceqa3.htm

PEATSim is the **P**artial **E**quilibrium **A**griculture **T**rade **S**imulator developed by the USDA Economic Research Service. PEATSim is a partial equilibrium model that uses MCP to solve discontinuous functions associated with the TRQ schemes under the WTO. PEATSim is able to model domestic policies, including subsidies, price support, and loan rates. Countries included in PEATSim are the United States, European Union, Canada, Mexico, Japan, South Korea, Australia, New Zealand, China, Brazil, Argentina, and a Rest of the World region. PEATSim contains major crop and oilseed markets, oilseed product markets, sugar, livestock, and dairy. The model can be adapted to change or remove domestic policy levers to analyze the impact of biofuel policy changes. The impact of changing tariff and quota levels associated with products in the model can also be assessed. PEATSim has the flexibility to develop scenarios related to the demand for agricultural products for use in biofuels, and account for their byproducts in the feed and livestock sector.

USAGE-ERS is the **U.S**. **A**pplied **G**eneral **E**quilibrium model for the **E**conomic **R**esearch **S**ervice. USAGE is a 500-plus sector dynamic computable general equilibrium model of the United States using the GEMPACK software suite for solving. The model is a modified version for specific applications for agricultural and bioenergy analysis. A number of improvements have been made from the original version for agriculture and biofuels. New data from the Agricultural Resource Management Surveys (ARMS) and from the ERS's own official farm income and productivity accounts was embedded in the USAGE-ERS model, with detailed updates on output and cost for detailed farm commodity activities. Corn-wet milling is distinguished from corn dry-milling activity for the production of ethanol. Farm commodities were further split from their original aggregate (BEA) sectors in the USAGE model. The model interacts with the rest of the world with foreign trade and investment activities. Currently the model is used for incorporating long-term baseline projections and simulating economy-wide impacts from alternative energy policy.

The Food and Agricultural Policy Simulator (Fapsim) is an annual, dynamic econometric model of the U.S. agricultural sector. The model contains four broad types of relationships: definitional, institutional, behavioral, and temporal. Definitional equations include identities that reflect mathematical relationships that must hold among the data in the model. Various commodity and livestock submodels contain equations to estimate production, prices, and the different demand components. Fapsim also includes submodels to estimate the value of exports, net farm income, Government outlays on farm programs, retail food prices, and consumer expenditures on food. All of the submodels are linked together through the variables that they share in common with one another. Fapsim was originally constructed to be used as U.S. agricultural policy analysis tool. The model's structure therefore reflects many of the programs that influence the markets for the commodities contained in the model. Fapsim has been used to analyze a variety of other types of issues. These include analyses of the effects on the agricultural sector stemming from changes in the macroeconomic environment, weather conditions, and regulations governing the marketing of commodities. The model has also been used to project future agricultural prices and quantities. This information has served as input into a department-wide process that establishes the official USDA baseline. Fapsim has been solved in conjunction with a multi-commodity, multi-country model of the rest of the world to generate these projections. This procedure provides analysts with foreign regional detail that is useful to the baseline process.
http://insiders/mtedcommon/GAM/3_STAFF/Price/fapweb/overview/overview.pdf

United States Forest Service

FVS is the **F**orest **V**egetation **S**imulator model, a simulation tool for predicting forest stand dynamics throughout the United States and in several foreign countries. FVS was developed by the USDA Forest Service. Forest Managers use FVS extensively to summarize current stand conditions, predict future stand conditions under various management alternatives, and update inventory statistics. Output from the model is used as input to forest planning models and many other analysis tools. Other uses of FVS include considering how management practices affect stand structure and composition, determining suitability of stands for wildlife habitat, estimating hazard ratings for insect outbreaks or wildfires, and predicting losses from fire and insect outbreaks. FVS also produces optional carbon reports which can be used for carbon accounting and to assess the carbon additionality of various forest management practices. Twenty two variants of FVS have been calibrated for specific geographic areas of the United States. The FVS software package includes a windows-based graphical user interface, and various pre- and post-processing programs. http://www.fs.fed.us/fmsc

FRCS, the Fuel Reduction Cost Simulator (Fight et al., 2006) is a Microsoft® Excel® based model developed by the Pacific Northwest Research Station, U.S. Department of Agriculture, Forest Service that was originally developed to simulate fuel-reduction forest harvesting operations in the Interior West that are undertaken in an effort to reduce the risk of wildfire and to limit the extent of wildfire incidents. FRCS calculates the estimated costs of removing both small and large trees, either for a contemplated management operation at a specific site, or for larger areas where the costs of such operations are being evaluated as part of a policy study. During 2008 a major revision of the model has been undertaken so that it can be used throughout the United States, with separate variants for the West, South, and North (North Central and Northeast). Cost data have been updated to December 2007 from the 2004 base used in the original FRCS model, and harvesting technologies suitable for the South and North, and for the more humid parts of the West, have been added in the respective variants of the model. FRCS can either be run manually for an analysis related to a specific site, or it can be driven in batch mode by an external program using Excel's "automation" technology. Fight, R.D., et al., 2006. Users Guide for FRCS: Fuel Reduction Cost Simulator Software. Gen. Tech. Rep. PNW-GTR-668, Portland, OR, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

MyFTP, or My Fuel Treatment Planner (Biesecker and Fight 2006) is a Microsoft® Excel® based model was developed by the Pacific Northwest Research Station, U.S. Department of Agriculture, Forest Service and designed to help forest planners estimate the cost and benefits of undertaking mechanical fuel-reduction treatments in the fire-prone forests of the Interior West. MyFTP is based loosely on the FRCS model but goes further in that it includes a number of fuel-reduction treatments, such as mastication and prescribed burning, that are not considered directly in FRCS. MyFTP also permits planners to estimate benefits from fuel-reduction treatments, including the economic impacts of such treatments over wider areas, whereas FRCS focuses only on harvesting costs. The intent of MyFTP is to be used for site-specific management planning, rather than for policy evaluations involving large areas. Biesecker, R.L. and Right, R.D. 2006. My Fuel Treatment Planner: A User Guide. Gen. Tech. Rep. PNW-GTR-663. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

USFPM/GFPM is the Forest Service version of the **GFPM** (**G**lobal **F**orest **P**roducts **M**odel) that contains the **USFPM** (**U**nited **S**tates **F**orest **P**roducts **M**odule). USFPM/GFPM is a new price-endogenous mathematical programming model designed to provide long-range (50-year) projections of annual forest product market equilibria of the United States at the national and regional level for the 2010 RPA Forest Assessment. As such, USFPM/GFPM replaces earlier Forest Service national RPA assessment models (TAMM-NAPAP-ATLAS). USFPM/GFPM projects domestic and international market trends for all forest products, including lumber, plywood, other wood panels, paper, paperboard, wood pulp, other industrial roundwood, and wood fuel feedstock (wood used for fuelwood, biofuels and other biomass energy), as well as U.S. market trends for hardwood and softwood timber, logging residues, mill residues, short-rotation woody crops, and paper recovered for recycling. USFPM is a module that solves the partial market equilibria among U.S. regions for forest products, timber, wood residues, and recycled paper. USFPM includes a linkage via timber prices to the separate RPA forest dynamic model, which simulates forest biophysical transitions and the geographic allocation of timber harvest (supply) at projected timber price levels. USFPM cannot run independently, but instead operates only as a module within USFPM/GFPM, which simultaneously solves global trade equilibria for all countries worldwide. The model incorporates long-range global macroeconomic trend projections and global biomass energy scenarios derived from IPCC (Intergovernmental Panel on Climate Change). USFPM/GFPM and the forest dynamics model thus uniquely provide a detailed global and regional modeling system for projecting the competitive evolution of markets for U.S. forest products, wood energy, wood raw material demands, prices and resulting regional timber harvests and forest transitions. The model projections can also be used to derive projections of nationwide carbon sequestration and carbon flows in wood and wood products. USFPM/GFPM is being developed at the U.S. Forest Products Laboratory in collaboration with the Forest Service Southern Research Station and University of Wisconsin-Madison.

The **FASOMGHG (**Forest and Ag. Sector Optimization Model—GHG) model can identify optimal decisions regarding land use, forest management, and GHG mitigation/sequestration/offset (e.g., biofuels) strategies involving forestlands. Examples of associated decisions are possible use of small-diameter trees from public forests to reduce fire danger, logging residues, and biomass from other forestry and agricultural sources for use in heating homes, generating electricity, and powering vehicles. The model provides information on comparative advantages by identifying optimal strategies across regions, forest ownerships, forest types, and forest age classes. The model can identify an optimal portfolio of actions for society and where forests fit in that strategy. The FASOMGHG model can simulate use of removed wood for varying products, e.g., biofuels for energy, long-live wood products, and short-lived wood products. Sensitivity analysis would be conducted where there is notable uncertainty of forest management effects, e.g. the level of wildfire emissions, the level of insect and disease mortality. The model reflects market responses not captured in stand or landscape models, as such market responses can dictate whether biomass removal opportunities are economically optimal for society.

FoRTS is the Forest Residues Trucking Simulator developed by the USDA Forest Service, Forest Operations Research Unit. It is an Excel-based model that estimates biomass trucking and grinding costs. It accepts selection of alternative equipment for loading, processing and trucking. It also compares route and travel speed selections. While FoRTS can be used to estimate trucking costs for any conventional biomass transportation configuration, it is specifically designed to evaluate two-stage transportation options. In a two-stage system biomass is transported in one form to a processing site, processed into another form (i.e., chips) and reloaded for final transportation. The model and helps are available at: http://www.srs.fs.usda.gov/forestops/download.htm

MRCalculator is a machine costing tool developed by the USDA Forest Service, Forest Operations Research Unit. It is an Excel-based spreadsheet that uses a modified machine rate calculation to estimate average hourly owning and operating costs for forest machines. Based on the classical method outlined by Mathews, it incorporates a different capital costing approach that more accurately reflects recapture of salvage value. It also includes guides to current depreciation rates for forest machines. The model is available at: http://www.srs.fs.usda.gov/forestops/download.htm

Jeffrey Steiner, USDA-ARS
December 12, 2008