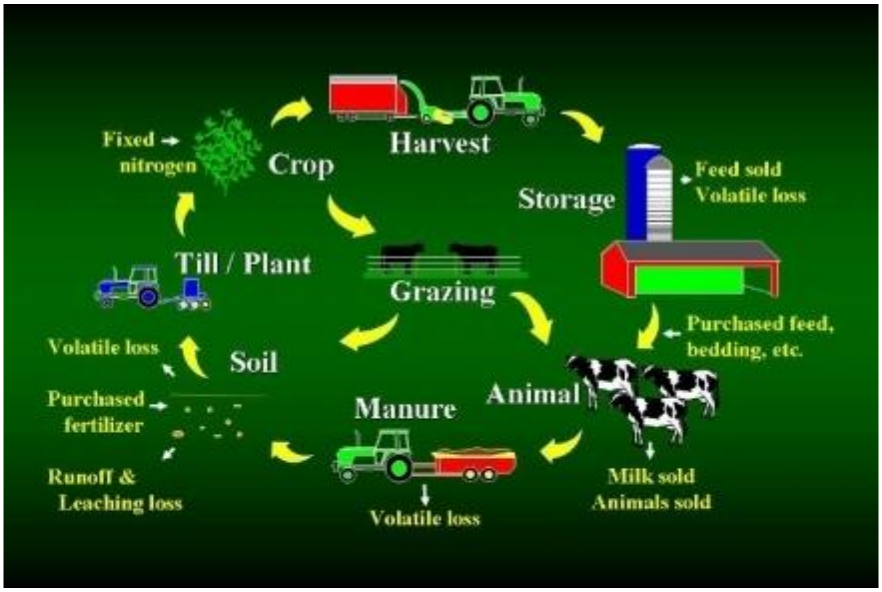
Integrated Farm System Model



Integrated Farm System Model Overview. Source: USDA.

The Integrated Farm System Model

With tighter profit margins and increasing environmental constraints, strategic planning of farm production systems is becoming both more important and more difficult. This is especially true for dairy and beef production. Livestock production is complex with a number of interacting processes that include crop and pasture production, crop harvest, feed storage, grazing, feeding, and manure handling. Computer simulation provides a useful procedure for integrating these processes to predict the long-term performance, environmental impact, and economics of production systems.

Development of a simulation model of the dairy forage system began in the early 1980’s. The model, known as the Dairy Forage System Model or DAFOSYM, linked alfalfa and corn production models with a dairy animal intake model to predict feed production and disappearance on the farm. This model was expanded with additional components for simulating feed storage and animal performance. Manure handling, tillage, and planting operations were then added to extend the model to a simulation of the full dairy farm. The dairy farm model was broadened further by adding components for simulating grass, small grain, and soybean growth, harvest, and storage. Through a major revision, a beef animal component was added along with a crop farm option (no animals) to form the Integrated Farm System Model or IFSM. This model has continued to grow as components were added to simulate environmental impacts including ammonia volatilization, nitrate leaching, phosphorus runoff, and greenhouse gas emissions.

Unlike most farm models, IFSM simulates all major farm components on a process level. This enables the integration and linking of components in a manner that adequately represents the major interactions among the many biological and physical processes on the farm. This provides a robust research and teaching tool for exploring the whole farm impact of changes in management and technology. Process level simulation remains an important goal as additional components are developed and added.

In an IFSM simulation, crop production, feed use, and the return of manure nutrients back to the land are simulated over many years of weather. Growth and development of alfalfa, grass, corn, soybean, and small grain crops are predicted on a daily time step based upon soil water and N availability, ambient temperature, and solar radiation. Performance and resource use in manure handling, tillage, planting, and harvest operations are functions of the size and type of machines used and daily weather. Field drying rate, harvest losses, and nutritive changes in crops are related to the weather, crop conditions, and machinery operations used. Losses and nutritive changes during storage are influenced by the characteristics of the harvested crop and the type and size of storage facility used.

Feed allocation and animal response are related to the nutritive value of available feeds and the nutrient requirements of up to six animal groups making up either dairy or beef herds. Diets for each group are formulated using a cost-minimizing linear programming approach, which makes the best use of homegrown feeds and purchased supplements. Protein and energy requirements are determined for each animal group based upon the characteristics of the average animal in the group. One or two protein supplements are used to balance rations. These can include both high and low rumen degradable protein feeds. Feed characteristics can be defined to describe essentially any supplement of each type including blended feeds. Supplemental P and K fed, if needed, is the difference between the requirement of each animal group and the sum of that contained in the feeds consumed.

Nutrient flows through the farm are modeled to predict potential nutrient accumulation in the soil and loss to the environment. The quantity and nutrient content of the manure produced is a function of the quantity and nutrient content of the feeds consumed. Nitrogen volatilization occurs in the barn, during storage, following field application, and during grazing. Denitrification and leaching losses from the soil are related to the rate of moisture movement and drainage from the soil profile as influenced by soil properties, rainfall, and the amount and timing of manure and fertilizer applications. Erosion of sediment is predicted as a function of daily runoff depth, peak runoff rate, field area, soil erodibility, slope, and soil cover. Phosphorus transformation and movement is simulated among surface and subsurface soil pools of organic and inorganic P. Edge-of-field runoff losses of sediment-bound P and soluble P are predicted as influenced by manure and tillage management as well as daily soil and weather conditions. Greenhouse gas emissions of carbon dioxide, methane, and nitrous oxide are estimated for all sources and sink including crop production, fuel combustion, the animals, the barn floor, and manure storage. Following the prediction of losses, whole-farm balances of N, P, K and C are determined as the sum of all nutrient imports in feed, fertilizer, deposition, and legume fixation minus the exports in milk, excess feed, animals, manure, and losses leaving the farm.

Simulated performance is used to determine production costs, incomes, and economic return for each year of weather. A whole-farm budget is used, which includes fixed and variable production costs. Annual fixed costs for equipment and structures are the product of their initial cost and a capital recovery factor where this factor is a function of an assigned economic life and real interest or discount rate. The resulting annual fixed costs are summed with predicted annual expenditures for labor, resources, and products used to obtain a total production cost. Labor cost accounts for all field, feeding, milking, and animal handling operations including charges for unpaid operator labor. This total cost is subtracted from the total income received for milk, animal, and excess feed sales to determine a net return to the herd and management.

By comparing simulation results for different production systems, the effects of system differences are determined, including resource use, production efficiency, environmental impact, production costs, and net return. Production systems are simulated over a 25 year sample of recent historical weather. All farm parameters, including prices, are held constant throughout the simulation so that the only source of variation among years is the effect of weather. Distribution of the annual values obtained describes possible performance outcomes as weather varies. Inter-year dynamics are not considered; initial conditions such as soil nutrient concentrations and feed inventories are reset each year. Therefore, the simulated data indicate the range of variation in economic and environmental performance that can occur given the variation in weather at the farm location, i.e. the distribution of simulated annual values indicates weather-related risk experienced by the simulated production system. A wide distribution in annual values implies a greater degree of risk.

The Integrated Farm System Model functions on all of the major Windows operating systems. Input information is supplied to the program through three parameter files. The farm parameter file contains data describing the farm such as crop areas, soil type, equipment and structures used, numbers of animals at various ages, harvest, tillage, and manure handling strategies, and prices for various farm inputs and outputs. The machinery file includes parameters for each machine available for use on a simulated farm. These parameters include machine size, initial cost, operating parameters, and repair factors. Most farm and machinery parameters are modified quickly and conveniently through dialog boxes in the user interface of the program. Many of these files can be created to store parameters for different farms and machinery sets for later use in other simulations. The weather file contains daily weather data for many years at a specific location. The daily data include the date, incident solar radiation, maximum and minimum temperatures, and total precipitation.

Simulation output is available in four files, which contain summary tables, report tables, optional tables, and parameter tables. The summary tables provide average performance, environmental impact, costs, and returns for the years simulated. These values consist of crop yields, feeds produced, feeds bought and sold, manure produced, nutrient losses to the environment, production costs, income from products sold, and the net return or profitability of the farm. Values are provided for the average and standard deviation of each over all simulated years. The report tables provide extensive output information including all the data given in the summary tables. In these tables, values are given for each simulated year of weather as well as the mean and variance over all simulated years. Optional tables are available for a closer inspection of how the components of the full simulation are functioning. These tables include very detailed data, often on a daily basis. Parameter tables summarize the input parameters specified for a given simulation. These tables provide a convenient method of documenting the parameter settings used for a simulation.

Reference Manual for IFSM

The reference manual provides a detailed description of the model including the algorithms and major functions used to simulate the performance, environmental impact and economics of farm production systems.

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