Farm-level Economic Model (FEM) Usage in NTT

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1. Introduction

Farm-level Economic Model (FEM) is a whole-farm annual economic simulation model that simulates the impacts of a wide range of scenarios on the economic indicators of farms. Development of FEM was initiated in 1992 as part of a National Pilot Project on Livestock and the Environmental (NPP; Jones et al., 1993). Initial versions of the model were built as General Algebraic Modeling System (GAMS; Brooke et al., 2002) applications. Subsequently, FEM was modified substantially to provide more flexibility to analyze a wide range of policies and practices of interest to agriculture.

Due to its history, FEM includes strong components related to the interface of environmental issues and agriculture. Elaborate tools and routines are available in the model for specifying manure handling practices and other farm specifications related to water and air quality concerns. FEM also contains special routines that are used to link the model to various environmental simulation models such as Agricultural Policy Environmental eXtender (APEX; Williams et al., 2000) and Soil and Water Assessment Tool (SWAT; Arnold et al., 1999). A recent example of an integrated economic and environmental simulation system including FEM and two or more environmental simulation models is CEEOT-SWAPP (Comprehensive Economic and Environmental Optimization Tool with SWAT/APEX Interface Program; Saleh et al., 2007).

Notwithstanding the emphasis on environmental issues during its development, FEM is also suited for other aspects of agricultural policy and farm analysis. The model can be used to evaluate the impacts of input taxes, government programs, change in input and output prices, and other exogenous factors on farm incomes and costs.

A key feature of FEM is its flexibility. Users can include any number of farms and any number of scenarios in an FEM project. Users are only limited by the computational resources at their disposal. Furthermore, users can define any single farm to include any combination of different crops and different livestock species. For instance, a single farm can include two fields, one planted in corn (for a corn-soybean rotation) and the other used as an alfalfa field. On the same farm, the user can include a large finishing hog operation and a small dairy operation. The flexibility afforded in FEM was included in its design for the purpose of ensuring that the wide diversity of farm types that may be studied can be accommodated within the model.

Economic output presented within the Nutrient Tracking Tool (NTT; Saleh et al., 2011) are obtain by FEM simulations. To simulate FEM, user data entered in NTT are transferred to FEM through a linkage routine within the NTT interface and in FEM. FEM simulates farms holistically, so regardless of the size of the area of interest, FEM simulates entire representative farms to capture the full economic effect of the scenario. A set of representative farms are already included within the NTT program for this purpose. Once economic simulations are completed in FEM, the output is read in by the NTT interface and presented to the user.

2. Overview of Program Structure

FEM consists of two main subprograms: a Visual Basic interface and a FORTRAN subprogram (Figure 2.1). The Visual Basic interface includes the linkage modules that connect FEM to NTT.. The Visual Basic interface also performs output processing and writes output data to Microsoft Access files that are subsequently read into the NTT screen by the NTT interface program.

FORTRAN Subprograms Visual Basic Interface

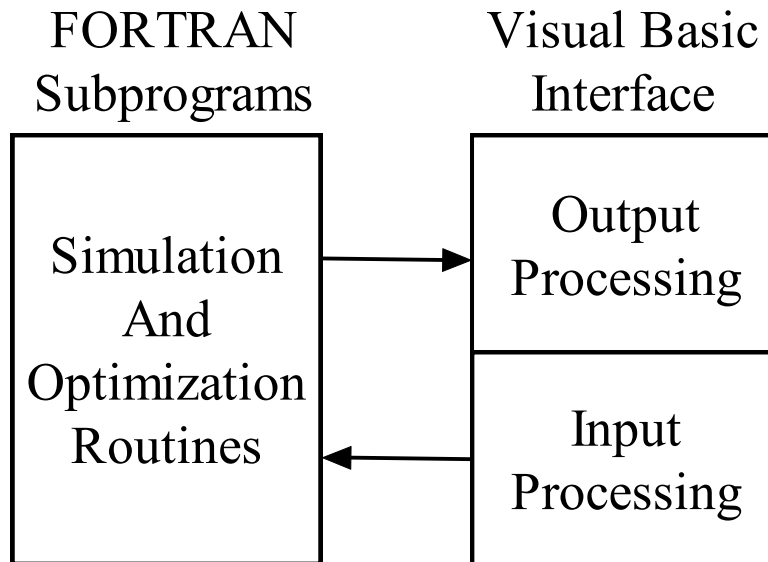| Simulation And Optimization Routines | Output Processing |
| | Input Processing |

Figure 2.1: Overview of FEM Model Structure

The FORTRAN subprogram includes simulation routines and optimization algorithms that are used to compute costs and returns for entire farms based on user specified and other program options. FEM also includes supporting FORTRAN dynamic link libraries (DLLs) that perform various functions. The main Visual Basic and FORTRAN procedures included in a simulation are outlined below.

Visual basic: Main steps in simulation: input data preparation
1. Determine if scenario applies to this farm
2. Determine feed ration options
3. Assemble land area and land use types, including manure types applied on land
4. Assemble and write cropping systems data
5. Assemble and write feed and feed characteristics data
6. Assemble and write equipment and facilities data
7. Assemble and write livestock systems data
8. Assemble and write manure characteristics
9. Write general farm properties
10. Write general FEM parameters
11. Call FORTRAN subprogram

FORTRAN: Main steps in simulation:
1. Read in input files
2. Determine time (simulation) horizon
3. Determine crops on fields for current year
4. Determine allocation of land uses and manure applications and rates for each field and portion of manure to be hauled off
5. Determine crop output, fertilizer nutrient rates, and complete operations for each field and land use
6. Determine fertilizer cost and cost of other crop inputs
7. Determine costs of all field operations and livestock operations
8. Determine machinery purchases or inventory changes
9. Determine fixed costs of all capital items
10. Determine feed costs, feed/grain/forage sales, feed purchases
11. Compile revenues and costs
12. Compute net farm returns and related economic indicators for current year of simulation
13. Write summary and detailed output for current year
14. Proceed to next year of simulation
15. Complete simulations and exit FORTRAN subprogram at end of simulation period (time horizon)

Visual basic: Main steps in simulation: output data processing
12. Read in output files from FORTRAN subprogram
13. Write annual output in MS Access format
14. Compute and write average annual values for all relevant indicators
15. Write simulation completion code to indicate successful completion of FEM runs
16. Exit simulation

3. Overview of Program Procedures and Algorithms

Economic results presented in the Nutrient Tracking Tool (NTT) are estimated by Farm-level Economic Model (FEM; Osei et al., 2000). FEM simulates farms holistically, accounting for all crop, livestock, facilities, and equipment on the operation.

3.1. Cropping Systems

Crop Growth

FEM does not provide formal modeling of crop growth. Crop yields are transferred to FEM as output from APEX simulations. Each cropping system produces an array of yields containing positive values for relevant crops or forages and null values elsewhere. For instance, Coastal bermuda grass overseeded with winter wheat may produce 6 tons per acre of bermuda grass hay and 8 tons per acre of winter wheat silage under favorable conditions in the Southern Plains. For that cropping pattern, the yields for all other feeds, crops or forages, is zero. FEM uses these crop yields in calculating livestock rations and crop/forage sales revenues.

Crop Nutrient Requirements

Crop nutrient requirements or agronomic rates are a function of yield. Once yield is determined, FEM calculates nutrient requirements based on crop nutrient requirement ratios established in the agronomic literature.

On-Farm Crop or Forage Use

Crop or forage output grown on-farm is either sold or fed to livestock raised on the farm. In the model, the decision to feed the crop to livestock or to sell the crop is based on a constrained optimization framework that mimics producer behavior. On livestock operations, producers are typically assumed to feed as much of the raised grain or forage as needed to their livestock and sell the remainder. Optimization routines within the GAMS application are used to determine how much of each feed is sold and how much is fed to each livestock species. Optional model parameters determine the outcome of the optimization process.

Crop or Forage Sales

On crop farms, virtually all raised grain or forage is sold. On livestock farms, a portion is fed to livestock and the remainder is sold. The sale of crop accrues revenues with some offsetting costs, which are accounted for in the model as marketing expenses. In some cases, marketing can be specified directly as an operation with a cost, such as a custom hired operation with a custom rate. For instance, marketing costs can be specified as a "field operation", just as drying and hauling operations are already common in many FEM applications involving grain. Simply add another management operation (after the harvest operation) and specify a custom rate per acre or per bushel if applicable.

Costs of field operations

Costs of field operations are computed for each individual operation. User specifications for each operation input into NTT are read in by FEM and used to compute fuel and lubrication requirements, labor hours, machinery usage, input use, costs of custom hired operations, and other costs as specified by the user.

Costs of operations performed by owner/operator

The hours of machinery use and labor hours are the primary information used within the model to compute costs of each operation performed by the owner/operator. The hours required to complete a field operation on an acre of land is given by the following equation:

$$h = [wse\theta]^{-1}$$

where h is the hours required per acre of land,
w is the width of the implement,
s is the field travel speed of the implement,
e is the implement field efficiency, and
$\theta = 8.25$, a unit conversion constant.

FEM keeps track of the hours h_{jit} required to complete each operation i in year t using machinery j. The above equation implies that the hours required for each field operation depend heavily on the characteristics of the equipment used to perform that operation. For operations involving multiple implements, the model computes the hours required as the hours associated with the slowest of the implements used for that operation.

Given the hours of use h_{jit} required for each operation i using machinery j in year t, repair and maintenance costs are given by the following adaptation from the ASABE Standards on repair and maintenance costs:

$$C_{jit} = \frac{h_{jit}}{h_{jt}} RF1_j P_j \left[\left(\frac{H_{jt}}{1000} \right)^{RF2_j} - \left(\frac{H_{jt-1}}{1000} \right)^{RF2_j} \right]$$

where C_{jit} is the repair and maintenance expense for machinery j when used in field operation i in year t,

h_{jit} is the hours required for machinery j to complete operation i in year t,

$h_{jt} = \sum_i h_{jit}$ is the hours of use of machinery j for all field operations in year t,

$RF1_j$ and $RF2_j$ are ASAE repair and maintenance factors,

P_j is the purchase price of machinery j, and

$H_{jt} = \sum_{z=0}^{t} h_{jz}$ is the cumulative hours of use of machinery j through the end of year t.

Fuel use is also computed in the model for each operation. Fuel use per hour is given by the formula:

$$f_h = cOg,$$

where f_h is the fuel cost per hour of use of the power equipment,
$c = 0.062$ for gasoline engines and 0.045 for diesel engines, a constant coefficient,
O is the horsepower rating of the power equipment, and
g is the fuel price per gallon.

The above formula for fuel use is also based on ASABE standards. Fuel cost per acre is computed for each operation by multiplying f_h by the hours required to perform the operation over an acre of land. Based again on ASABE standards, oil and other lubrication expenses are computed as a fixed ratio of fuel expenses, typically 15% of fuel expenses in FEM.

3.2. Livestock Systems

On farms with livestock or poultry, FEM provides for very flexible specifications of livestock on the farm. Any combination of livestock of different species can be specified for the same farm. In addition, users can differentiate between livestock of the same species that have different characteristics such as age, weight, productivity or management requirements. Most of the features available in FEM for livestock systems are simply ignored if the livestock component of an NTT application entails only grazing,

Determination of livestock rations and feed costs

The livestock nutrition module is perhaps the most demanding component of the model. The nutrition component accounts for ration choice and associated costs. The model calculates the amounts of various feeds used in the ration in conformance with general practice on livestock operations. On most livestock farms, feed rations are determined via a cost minimization process. Producers either solely or with the help of nutritionists or feed dealers, estimate how much of various feed items should be combined in the diet of each livestock species on the farm. Typically, desired yields or weight gains are

predetermined and the ration is calculated subject to those needs. The model mimics this constrained optimization behavior in order to account for the cost of the ration, purchase of feeds, and use and sale of raised feed. Because feed costs typically account for about a third to half of operating costs on livestock farms either directly or indirectly, this component is of prime importance.

The specifications and coefficients used in this component rely heavily on information and direction from professional nutritionists and National Research Council (NRC) publications on livestock nutrition. The model uses various defaults in an attempt to mimic various livestock systems as closely as possible. However, enormous flexibility is afforded so that the application can be customized to specific needs. Specification of the nutrition component involves the three main feed and nutrient constraints – livestock nutrient requirements and bounds, livestock feed restrictions, and livestock feed group restrictions – as well as data on feed nutrient contents, which is specified in the cropping systems section.

Formulas for estimating nutrient requirements of livestock species as well as tabulated values are provided in National Research Council's reference publications. The model calculates nutrient requirements based on the livestock species or products raised on the operation. For dairy cattle in lactation, nutrient requirements are a function of milk production levels, and to a lesser degree, maintenance and body weight gain. For other livestock species, nutrient requirements are primarily a function of body weight gain and to a lesser degree, other livestock byproducts.

During simulations, the model computes a feed ration for each livestock species on the farm. This is a cost-minimizing bundle of feeds that supplies all the nutrients required for each species, subject to various other restrictions as indicated above.

Feed ration optimizations are performed by using an automated linear programming routine written in the General Algebraic Modeling System (GAMS; Brooke et al., 1993) format. FEM compiles all nutrient requirements and bounds, feed restrictions, and other constraints indicated by the user's choice of livestock systems. All the constraints are written to a GAMS format by the FORTRAN subprogram prior to the GAMS call. Data required for the feed ration optimization is also written out in the required GAMS input format.

3.3. Manure Management

The manure management section of FEM provides users with flexible options for simulating how manure is collected, stored, handled or utilized on a farm or transferred for off-farm uses. The model assembles all manure production data based on the information specified for livestock raised on the farm. However, in a typical NTT application, manure management is not specified, so these detailed options and utilities within FEM are simply ignored. In more complex livestock management applications in

NTT, these options are available to enable robust estimation of economic impacts of alternative scenarios.

The manure management module comprises three main sections: manure collection (Pre-Handling), manure handling, and manure utilization (Post-Handling). The manure collection section contains options for combining various manure types into groups if they are handled in the same fashion on the farm. The manure handling section, which forms the bulk of this module, provides very flexible options for capturing how manure is handled on the farm. Finally, the manure utilization section provides options for combining manure types after handling if they are utilized in the same fashion.

The manure handling section of the Manure Management module provides flexible options for specifying how each of the groups of manure types is handled. Manure handling options are the essence of manure handling on a farm. Any number of handling options can be specified for each manure handling group. For instance, liquid manure can be filtered through a solids separator, the solids subsequently stockpiled and liquid portion stored in a lagoon. Each handling option has a potential impact on each of the manure characteristics and these are accounted for within the model.

The model calculates the impacts of the handling options cumulatively so that the total impact of all handling options will be applied to the manure handling group prior to its final utilization. For instance, suppose that there are k handling options for the handling group in question. The impact of the handling process on the manure phosphorus (P) content of this handling group is given as:

Manure P after Handling = Manure P before handling $X(100-ImpactP1)*(100-ImpactP2)*...*(100-ImpactPk)/100^k$

Losses During and After Land Application

The following two types of losses or adjustments can be applied to manure nutrients in order to estimate the effective nutrient rates available for crop uptake. However, they are not the default specification in economic simulations in NTT.

Volatilization Losses

Manure nitrogen volatilization occurs when nitrogen is lost from the soil profile to the atmosphere. When solid manure is incorporated or liquid manure injected, these losses can be minimized substantially.

Plant Available Nutrients

This aspect of model specification also deals primarily with nitrogen, as some component of manure nitrogen, though in the soil profile, is not immediately available for plant uptake.

Cropping System and Fields for Manure Utilization

The model also accounts for subset of cropping systems or fields on the farm that are available for manure utilization. Based on the size of crop or forage fields, manure applications might require more than one disposal field. FEM uses an allocation routine that permits selection of fields for manure application according to user-specified priorities.

3.4. Land Areas (fields) and Uses

The Land Areas and Uses module of FEM deals with the sizes and types of fields available to the farm, their characteristics, and how they are used. In this module, Fem tracks the total land area on the farm and the specifications for each field owned or leased by the farm. The term Land Area is used in the model in reference to a specific field used by the farm, whether owned or leased. The term Land Use in FEM is a reference to any of the types of uses to which land on the farm is put. FEM includes field allocation algorithms that allow for flexible specification of land use for manure utilization and calculates the portion of manure that needs to be hauled offsite as dictated by the nutrient management plan or compliance requirement.

3.5. Machinery and Equipment

The machinery and equipment section provides users with the option of adding machinery to the list of farm machinery and specifying the characteristics of machinery or equipment on the farm. A specific input screen in NTT allows users to edit machinery or equipment characteristics. Structures and facilities such as buildings and earthen structures are specified in the structures and facilities section. The following are the key specifications for machinery and equipment on the farm[1].

1. Name – Name of the machine or equipment
2. OwnedOrLeased – Value indicating whether this equipment is owned (1) or leased (2)
3. LeaseRate – Annual lease rate of this equipment if leased
4. NewPrice – Price of this equipment when purchased new
5. NewHours – Useful life of this equipment when new, expressed in hours
6. CurrentPrice – Current market price of this equipment, reflecting its current condition
7. HoursRemaining – Current hours of use remaining for this machine, reflective of its use to date.
8. Width – Width of this machine in feet
9. Speed – In-field travel speed of this machine (numeric)

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[1] Not all of these specifications are currently available through the NTT interface.

10. SpeedUnit – Unit corresponding to the In-Field travel speed value expressed in Speed (Default = mph)
11. FieldEfficiency – The field efficiency of this equipment expressed as a percentage
12. HorsePower – The horsepower rating of this equipment if it is a power machine; if it is not a power machine, the value should be set to zero.
13. RF1 – Repair factor 1 – One of two American Society of Agricultural and Biological Engineers (ASABE) repair factors for this machine. Repair factors are used in calculating maintenance and repair expenses based on hours of use.
14. RF2 – Repair factor 2 – One of two ASABE repair factors for this machine. Repair factors are used in calculating maintenance and repair expenses based on hours of use.
Repair factors RF1 and RF2 are used in calculating equipment repair and maintenance expenses based on formula documented in the ASABE standards, as indicated in a previous section.
15. IRLoan – Interest rate on loan used to finance purchase of this machine, expressed as the annual percentage rate.
16. LLoan – Length in years of loan used to finance purchase of this machine
17. IREquity – Interest rate (opportunity cost of capital) used to calculate opportunity cost of equity capital invested in the purchase of this equipment, expressed as the annual percentage rate.
18. PDebt – Proportion of the total price of this machine that was debt financed
19. Year – Age of this equipment in years at the time of purchase
20. RV1 – Remaining Value Factor 1 – One of two remaining value factors used to calculate the remaining (salvage) value of the equipment using an optional formula.
21. RV2 – Remaining Value Factor 2 – One of two remaining value factors used to calculate the remaining (salvage) value of the equipment using an optional formula.

Purchase/replacement of machinery and equipment
The more frequently a machine is used, the sooner it needs to be replaced. The model does not assume a fixed economic life in years for machinery. Rather, based on usage characteristics economic life in hours is used to estimate economic life in years. The model registers the number of hours of use for all machinery each year. It also computes the average number of hours of use per year since the machinery was first bought for farm use. When the remaining economic life in hours is less than the average hours of use per year, the model simulates a purchase decision. A new machine is bought and the old one is sold at the salvage value. The default salvage value is zero.

User specified machinery characteristics indicate how much of the cost of purchased machinery is equity financed as opposed to loan financed. For the proportion financed by debt, the terms of debt payment determine how much is paid annually and for how long. The payment period or number of payment years is not necessarily the same as the economic life in years of the equipment. Thus, it is possible to have a machine that has

been paid off and is still being used, or one that has been used up and is no longer useful, but has not been paid off. The rules for determining payment terms are based on debt payment terms that can be modified by users.

Total machinery debt payment is obtained by summing up debt payments for all the machinery and equipment on the farm. Two components of debt payment, interest payments and principal payments, are recorded separately.

The model also computes an opportunity cost of equity for each machine based on the proportion of purchase cost financed by owner's equity. Total opportunity cost for equity for farm machinery is obtained by summing across all machinery on the farm.

3.6. Structures and Facilities

Users can add or modify facilities and structures available on the farm. Structures and facilities include farm buildings and relatively permanent structures such as lagoons, sediment basins, berms, and ponds. Specifications entered here are used by the model to determine replacement rules and ownership costs, as well as maintenance costs, as applicable. Most of the specifications for structures and facilities are similar to the characteristics of farm equipment. Farm machinery and equipment are detailed in the Machinery and Equipment section. The specifications for structures and facilities are the following.

1. Properties – Any one of a number of user specified properties for this structure. Properties for this structure are specified with the following parameters
   Name – The name of the property
   Value – The value of the property
   Unit – The unit of the property
2. Name – Unique name of the structure or facility
3. Ownership – Value indicating whether this structure is owned or leased
4. Lease Rate – The annual lease rate of the structure if leased
5. New Price – The cost of the entire structure when newly constructed or purchased and installed
6. New Life – The expected economic life of the structure (expressed in years) when newly constructed or purchased and installed
7. Current Price – The current value of the structure based on its current condition
8. Life Remaining – The remaining economic life in years of the structure given its past use and current condition
9. Maintenance Coefficient – The annual repair and maintenance cost of the structure expressed as a percentage of New Price. In an application, this coefficient could be augmented to include operating costs as well, thus reflecting total annual operating and maintenance costs.
10. Loan Interest Rate – Interest rate on the loan used to finance the construction or purchase and installation of this structure, expressed as the annual percentage rate.

11. Length of Loan – The length in years of the loan used to finance the construction or purchase and installation of this structure
12. Interest Rate On Equity – The interest rate (opportunity cost of capital), which is used to calculate the opportunity cost of the equity capital invested in the purchase and installation or construction of this structure.
13. Proportion of Debt – The proportion of total cost of this structure that was debt financed
14. Year – Age of this structure in years at the time of purchase or acquisition

Purchase/Replacement of Structures and Facilities

Replacement of buildings is treated differently from that of machinery. In the case of buildings, users can specify a fixed economic life in years. Once that life is reached, a new building investment decision is simulated. The assumption is that the old building is completely replaced by the new one. The default salvage value is zero.

As with machinery, farm buildings may be financed by owner's equity or by means of debt. User-specified borrowing terms are used to compute debt payment terms for facilities and structures. Similarly, characteristics such as the economic life of buildings are used to determine the opportunity cost of equity. The model computes total debt payment and total opportunity cost of equity by summing across all facilities on the farm for each cost item. In this manner, the model accounts for explicit as well as implicit costs.

3.7. Fixed costs of equipment and facilities

Fixed costs associated with farm machinery, livestock, farm structures, and other capital assets on farms consist primarily of interest and principal payments on debt. In addition, FEM accounts for the opportunity cost of equity capital. In order for the model to compute these economic indicators, users need to specify the proportion of an investment or purchase that is financed by debt as opposed to the portion financed by equity.

Debt Payments

Debt payments consist of principal and interest. Total debt payments in each payment period are computed as follows:

$$PMT = \frac{D}{PVIFA(k,n)}$$

where PMT is the total debt payment in each period,
D is the total initial debt (principal value), and

$PVIFA(k,n)$ is the present value interest factor based on a discount factor (interest rate) of k and n number of periods.

The present value interest factor of an annuity is given as:

$$PVIFA(k,n) = [1 - (1 + k)^{-n}] / k$$

Interest payment on the debt in every period is given as:

$$IPMT = B_t * k$$

where B_t is the principal balance at the beginning of period t. B_t is calculated as

$$B_t = D - \sum_{i=0}^{t-1} PPMT(k,i)$$

where $PPMT(k,i) = PMT - IPMT(k,i)$ is the principal payment in period i.

Opportunity Cost of Equity Capital

In financial accounting a depreciable asset is depreciated over its expected useful life. In addition to depreciation, economic analysis includes the opportunity cost of equity capital, which is based on a reasonable rate of return that is expected in competing investment opportunities. The opportunity cost of equity capital is computed as

$$O = E * r$$

where O is the opportunity cost of the equity capital,
E is the total equity capital portion of the investment, and
r is the expected rate of return in competing industries (the opportunity cost of equity expressed as a percentage).

In FEM, actual depreciation in a given period is given as

$$DEP = \frac{K}{L}$$

where DEP is actual depreciation,
K is the initial capital asset value, and
L is the economic life of the asset, expressed in terms of the number of periods (years) it is expected to last.

For facilities and structures, L is a fixed value provided by the user. For machinery and equipment, L is by default computed in the model based on simulated annual hours of use and total useful life expressed in hours.

3.8. Allocation of fields to land uses

FEM provides for very flexible allocation of fields to land uses. The model does not impose any limits on type of use for any field type. Typical land uses for various fields are solid manure application, liquid manure application, non-manure use, livestock grazing, conservation reserve, and buffer or filter strips.

The following table illustrates a matrix of type and use combinations for a hypothetical farm with five fields (land areas) – two crop fields, one hay field, and two pasture fields.

	Crop field 1	Crop field 2	Hay field 1	Pasture 1	Pasture 2
Owned acreage	50	40	20	15	15
Leased acreage	60	20	30	0	0
Solid manure	X	X	X	0	0
Liquid manure	X	X	X	0	0
Dry cow grazing	0	0	X	X	X
Beef cattle grazing					
No manure	X	X	X	0	0
Filter strip	X	x	X	X	X

FEM allows for constraints to be imposed on the allocation of the fields to each of the land uses applicable to a farm. In the above illustration, we use an X to indicate that the field can be allocated to the land use, while a zero, "0" means it cannot, for this hypothetical farm. The model allocates field areas to the uses subject to the constraints specified. In addition, neighboring acreage (outside the farm) may also be specified in the event that the total existing land area on the farm is insufficient for some mandatory use such as solid or liquid manure application at pre-determined rates.

Cropping System Or Crop Preference Order

FEM provides options for specifying a preference order of cropping systems or crops for land uses such as manure disposal. Thus, for any given year within a simulation, the land use allocation sequence among fields may change depending on crop location within a dynamic sequence. For instance, suppose manure is applied first on corn, then on soybeans, if no other corn acreage is available. Suppose further that two fields exist, A and B, each 50 acres in size and that a corn-soybean rotation is practiced on this livestock farm. Assume that the manure application rate is set to 20 tons per acre, requiring 40 acres for a hypothetical manure production level of 800 tons per year. Finally, suppose that in the initial year, corn is on field A and soybeans on field B. Then, in year 1, manure is applied on 40 acres of field A, while in year 2 it would go on 40 acres of field B.

Acreage Calculations For Manure Applications

Once the cropping systems have been selected for various fields, manure application rates and areas are estimated based on the options specified for manure disposal. If manure application is pegged to crop agronomic rates, the rates are based on relevant crop agronomic requirements and acreage allocations are determined accordingly. If manure application rates are set to some arbitrarily specified levels, then those rates are maintained and acreage required for disposal is calculated appropriately.

Example[2]: Suppose the manure application rate is set arbitrarily to 20 tons per acre annually, and total manure production on a farm is 6000 tons. This requires 300 acres for disposal. On the other hand, suppose that the application rate is pegged to the nitrogen agronomic rate of a crop or forage and that the 6000 tons of manure contains 60,000 pounds of nitrogen. If, after accounting for the plant unavailable component and all pre- and post-land application losses, only 50 percent of the nitrogen is available for plant uptake, then, on coastal Bermuda grass fields requiring 300 pounds of N per acre annually, the area needed is 100 acres with an implied manure application rate of 60 tons per acre[3].

Sometimes users may need to have different manure application criteria for various fields. For instance, it may be required that manure be applied at an arbitrarily specified rate on solid manure fields, at the nitrogen agronomic rate on liquid manure fields, and that livestock grazing pastures be stocked at a density that supplies all pasture phosphorus requirements from manure inorganic phosphorus. The allocation routines in FEM fully account for these variants. If manure application criteria are not specified for each field of interest, the model defaults would be used.

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[2] Figures used in this example as well as other illustrations in this manual are not suggestive of recommendations for any given watershed or study area. Assumptions vary widely from one watershed to another and should be handled on a case by case basis.

[3] This assumes that the losses suggested for manure nitrogen do not entail any significant reduction in total manure weight.

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