Animal disease examination in the ASM context - Data structure

11/28/07

When one wants to simulate animal disease in ASM one needs to manipulate the internal set of livestock budgets. This memo shows what those are and where budgets are defined.

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1 General form of livestock budgets

The Agricultural Sector Model (ASM), which is part of the Forestry and Agricultural Sector Optimization Model (FASOM), contains budgets for beef, dairy, hogs, sheep, broilers, turkeys, egg layers and horses although the last category is treated in a very cursory fashion. Within the beef and hog operations a number of intermediate budgets are represented to separate out important stages of production. Each of these major categories of animal types are discussed below.

For simplicity, we will give national average budgets for the continental US; however, ASM also runs on a regional basis. The full ASM runs over 11 regions and 63 sub-regions. Some of the averages may appear to be smaller than expected (for example $9 per acre for rental of wheat pasture for stockers), but this is because it is averaged over regions that don't use winter wheat pasture. Negative numbers indicate an input being moved from another area of the model. The ASM model can portray simultaneous market equilibrium over a 70-100 year time period.

1.1 Beef

Beef animals generate fed and no fed beef with intermediate outputs of heifer and steer calves, heifer and steer yearlings and cull cows. We model production at the cow-calf, stocker and feedlot stages plus an infusion of calves and cull cows from the dairy herd. Specifically we represent

- cow/calf operations,
- steer and heifer calves in stocker operations,
- steer and heifer yearlings in stocker operations,
- beef yearlings in feedlots, and
- beef calves in feedlots.

A graphic displaying the representation is given in Figure 1.

The budgets for this portrayal depict several major categories of items

- production of beef or intermediate animals in cwt – net of usage of animals for replacements
- use of intermediate animals (negative sign in table) in cwt
- use of feed in cwt
- use of pasture in acres
- use of grazing in animal unit months (aum)
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The Budgets for beef on a one head basis are given in annex A.

Within these budgets there are alternative specifications for operations that are defined to represent enteric fermentation alternatives. For the cow/calf operations alternative specifications include intensive grazing operations (IG) and the reduction of herd size by 20% (Herd20). Under the beef yearlings in feedlots group there is specification for a shortened time on feed—from 128 days to 115 days—reducing costs by 27% (YFeed27). Under the beef calves in feedlots budget there is also a shortened feed time (CFeed27). This budget contains three “direct feed” specifications for steers (SCalfDirect), heifers (HCalfDirect), and dairy (DCalfDirect) which indicate cattle are fed from weaning to finishing without being transported to another group. The first specification in each table (base) is the baseline specification before any of the above adjustments are made.

1.2 Dairy

Dairy animals generate milk and calves with intermediate outputs of cull cows. We model production just at the production stage

A graphic displaying the representation is given in Figure 2.

The budgets for this portrayal depict several major categories of items

- production of milk or intermediate animals in cwt – net of usage of animals for replacements
- use of feed in cwt
- use of pasture in acres
- use of grazing in aum
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The budgets for dairy on a one head of dairy cow basis are given in annex B.

Within these budgets there are alternative specifications for operations that are defined to represent enteric fermentation alternatives. The dairy budget contains specifications for operations using bovine somatotropin (BST), which is a growth hormone that increases milk production. It also has a specification for increasing productivity of the milk herd by 20% through the use of selective genetics (Genetic20) and a specification for reducing herd size by 20% (Herd20). The first specification in each table (base) is the baseline specification before any of the above adjustments are made.

1.3 Hogs

Hogs generate fed hogs with intermediate outputs of feeder pigs and cull sows. We model production at the

- farrowing,
- finishing and

- farrow to finish stages.

A graphic displaying the representation is given in Figure 3.

The budgets for this portrayal depict several major categories of items

- production of fed hogs or intermediate animals in cwt – net of usage of animals for replacements
- use of intermediate animals (negative sign in table) in cwt
- use of feed in cwt
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The budgets for hogs on a one head of sows or pigs in feeding basis are given in annex C.

1.4 Sheep

Sheep generate wool, lamb and cull ewes. We model production just at the production stage

A graphic displaying the representation is given in Figure 4.

The budgets for this portrayal depict several major categories of items

- production of wool, lambs and cull ewes in cwt – net of usage of animals for replacements
- use of feed in cwt
- use of pasture in acres
- use of grazing in aum
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The budgets for sheep on a one ewe basis are given in annex D.

1.5 Turkeys

Turkeys generate turkeys. We model production just at the production stage.

The budgets for this portrayal depict several major categories of items

- production of turkeys in cwt – net of usage of animals for replacements
- use of feed in cwt
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The budget for turkey on a one bird basis is given in annex E.

1.6 Broilers

Broilers generate broilers. We model production just at the production stage.

The budgets for this portrayal depict several major categories of items

- production of broilers in cwt – net of usage of animals for replacements
- use of feed in cwt
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The budget for broilers on a one bird basis is given in annex F.

1.7 Egg Production

Hens generate eggs. A single laying hen on average produces 257 eggs or just over 21 dozen per year. We model production just at the production stage.

The budgets for this portrayal depict several major categories of items

- production of eggs in dozens of eggs
- use of feed in cwt
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The budget for eggs on a one laying hen basis is given in annex G.

1.8 Horses and Mules

Horses and mules produce horses and mules. We model production just at the production stage.

The budgets for this portrayal depict several major categories of items

- production of horses in heads
- use of feed ingredients in bushels
- use of pasture in acres
- use of grazing in aum
- use of other inputs in $
- use of cost in $
- greenhouse gas emissions in metric tons

The budgets for horses and mules are on a one horse/mule basis are given in annex H.

2 Geographic specification in FASOM

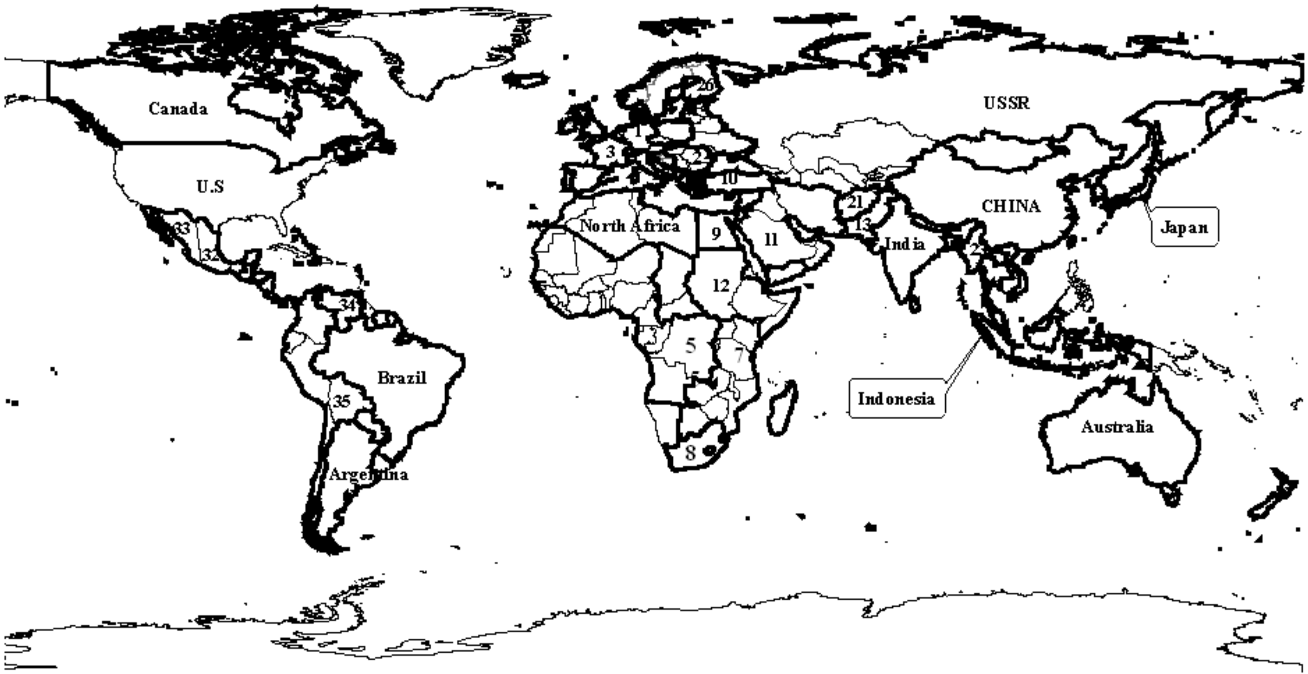
FASOM is breaks the continental US into 11 market regions and 66 production sub-regions. Figure 2.2 gives the 11 region breakdown. The 66 sub-regions consist of one sub-region for each continental US state except for further breakdowns in California, Illinois, Indiana, Iowa, Ohio, Oregon, Oklahoma, Texas and Washington. These states have sub-state production regions based on differences in production conditions. In addition below figures provide a closer view of where the sub-state dividing lines fall.

In addition to the trade of goods within the US regions and sub-regions, FASOM also allows trade flow with 37 international regions listed below. Figure 2.1 gives a map of these regions. Within the model, animal products the US imports are eggs, wool, non-fed beef, fed beef, pork, secondary dairy products (i.e. butter, cheese, dry milk), and some live cattle. The US exports of animal products are eggs, fed beef, wool, pork, secondary dairy products, chicken and turkey.

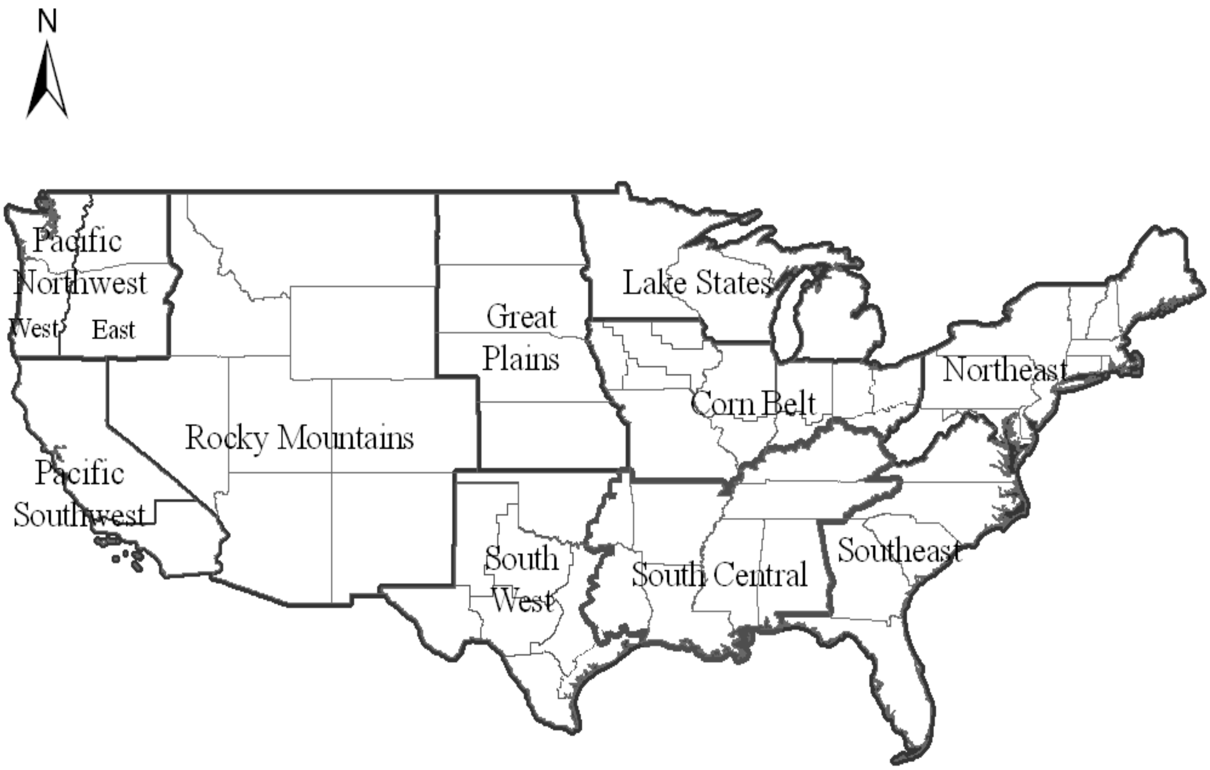
Key	Region	Countries
1	NORTH CENTRAL EUROPE	Austria, Belgium, Germany, Netherlands, Switzerland
2	EAST BLOCK EUROPE	Bulgaria, Czechoslovak, Hungary, Poland, Romania, Yugoslavia
3	SOUTH WESTERN EUROPE	France, Italy, Malta, Portugal, Spain, Others
4	EEC	European Economic Community
5	WEST AFRICA	Angola, Benin, Cameroon, Canary Island, Ghana, Guinea, Ivory Coast, Liberia, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Burkina, Zaire
6	NORTH AFRICA	Algeria, Libya, Morocco, Tunisia
7	EAST AFRICA	Botswana, Malawi, Kenya, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Rwanda, Madagascar, Swaziland, Lesotho, Burundi
8	SOUTH AFRICA	South Africa
9	EAST MEDITERRANEAN	Egypt, Israel, Lebanon, Syria
10	ADRIATIC	Cyprus, Greece, Turkey.

11	PERSIAN GULF	Iran, Iraq, Kuwait, Saudi Arabia, Bahrain, Oman, United Arab Emirates
12	RED SEA	Ethiopia, Somalia, Sudan, Yemen.
13	PAKISTAN	Pakistan
14	USSR	Former United Soviet Socialist Republic
15	TAIWAN	Taiwan
16	SOUTH KOREA	South Korea
17	KOREAN REPUBLIC	Korean Republic
18	VIETNAM	Vietnam
19	JAPAN	Japan
20	CHINA	China
21	WEST ASIA	Afghanistan, Nepal, Sri Lanka
22	SOUTHEAST ASIA	Hong Kong, Malaysia, New Zealand, Okinawa, Singapore, French Pacific Islands, South Pacific Islands, Other Pacific Islands.
23	MYANMAR	Myanmar
24	INDIA	India
25	BANGLADESH	Bangladesh
26	INDONESIA	Indonesia
27	PHILLIPPINES	Philippines
28	THAILAND	Thailand
29	AUSTRALIA	Australia
30	CANADA	Canada
31	CARRIBEAN	Leeward Islands, Bahamas, Barbados, Dominican Republic, French West Indies, Haiti, Trinidad, Jamaica.
32	EAST MEXICO	Mexico
33	WEST MEXICO	Mexico
34	EAST-SOUTH AMERICA	Belize, Brazil, Costa Rica, El Salvador, Curacao, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Suriname, Uruguay, Venezuela, French Guiana.
35	WEST-SOUTH AMERICA	Bolivia, Chile, Colombia, Ecuador, Peru
36	BRAZIL	Brazil
37	ARGENTINA	Argentina

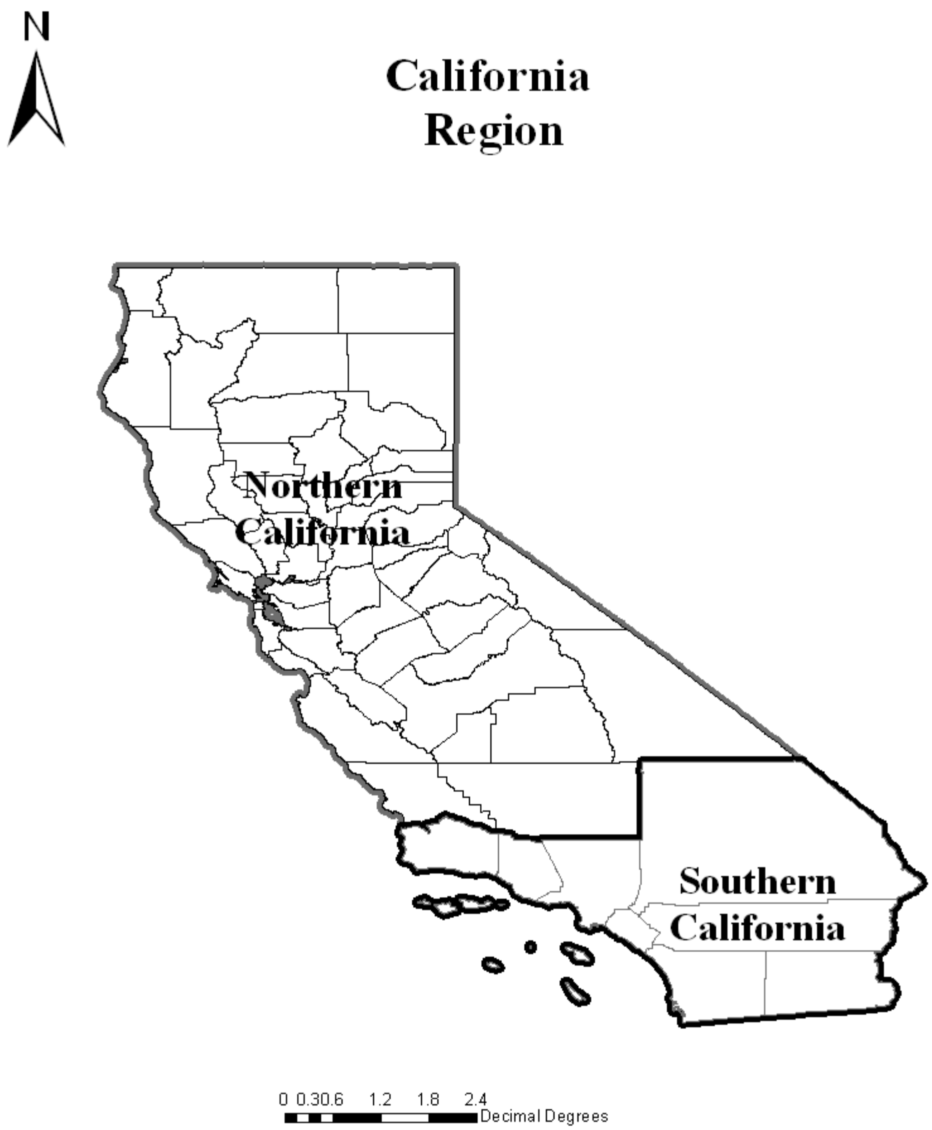
2.1 Figure 1: International Trade Regions in ASM



2.2 Figure 2: Market Regions in ASM



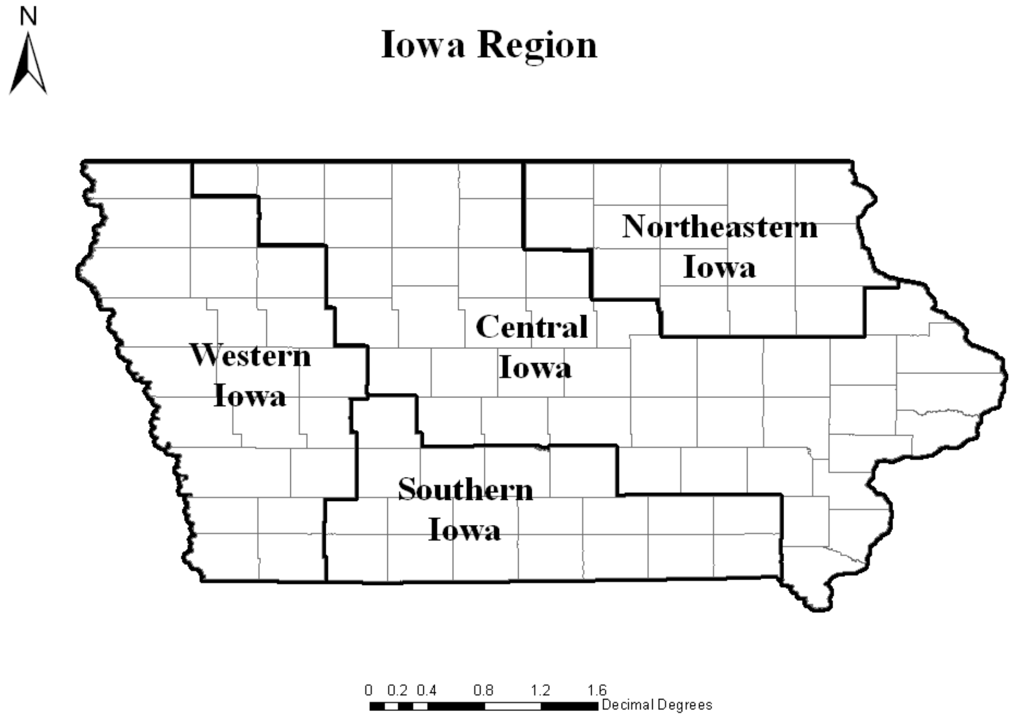
2.3 Figure 3: California breakdown



2.4 Figure 4: Illinois breakdown

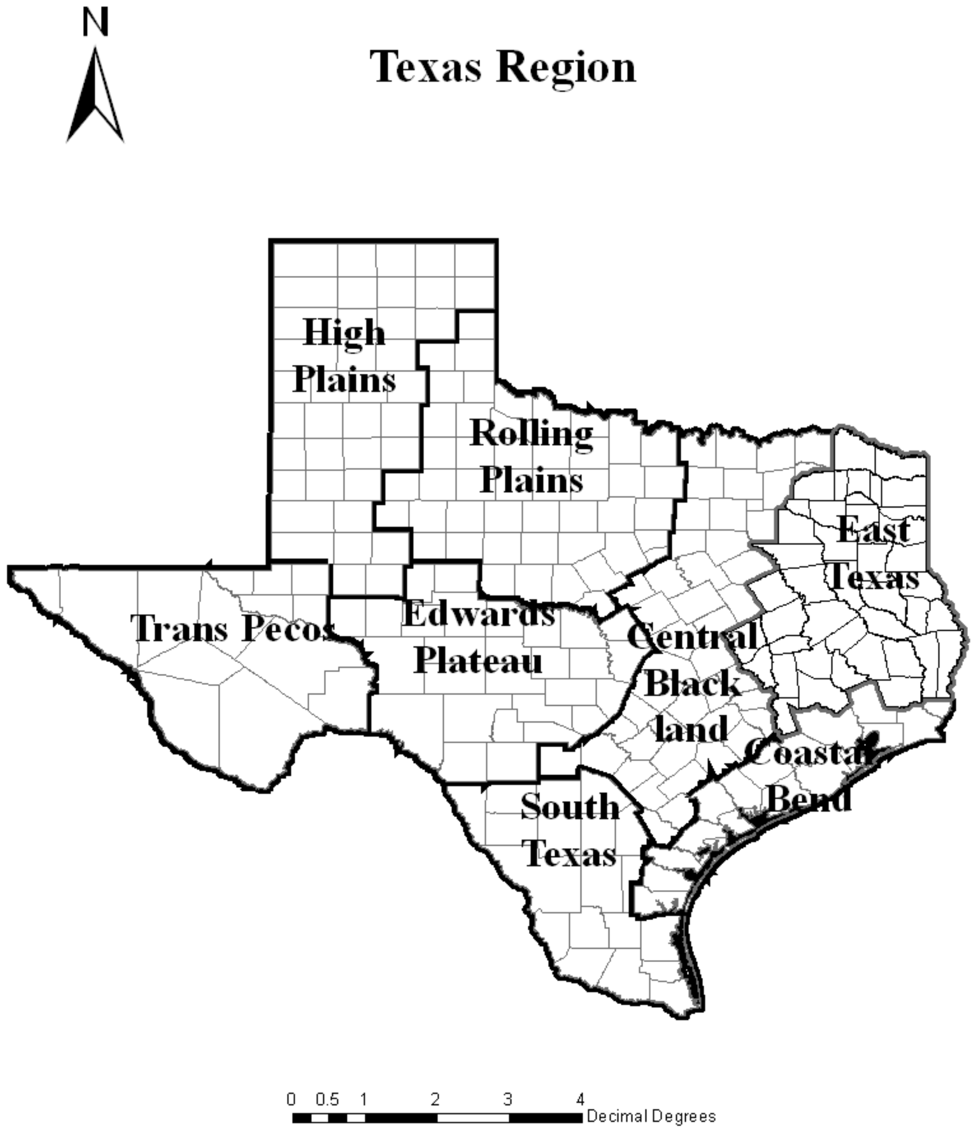
2.5 Figure 5: Indiana breakdown

2.6 Figure 6: Iowa breakdown



2.7 Figure 7: Ohio breakdown

2.8 *Figure 8: Texas breakdown*



The grey line above indicates the dividing line between the South West and South Central Regions. South West sub-regions are: High Plains, Trans Pecos, Rolling Plains, Edwards Plateau, Central Black Land, South Texas and Coastal Bend. The East Texas Sub-region falls in the South Central Region.

3 Imposing animal disease – Rift Valley example

A recent study on rift valley fever (RVF) provides an example of appraising animal disease using the model. Imposing a shock like an animal disease is typically done using a data file from an epidemic model that specifies animal mortality, infected animals, extent of treatment activities etc. In turn, specialized code is written that makes adjustments to the previously discussed budgets in modeled production regions. For the Rift Valley model, epidemic model results under outbreak scenarios that were defined at the state level give the percentage of animals in the select herd types (Cattle and dairy animals) that fall into the categories of young-infected, young-dead, abortions, pregnant-dead, pregnant-infected, adult-infected and adult dead. In this way, the epidemic model accounted for direct death losses and treatment costs, as well as impacts from changes in reproduction rates (i.e. abortions or future infertility) that reduced the animals being born in the next period. The availability of these results caused changes in several categories of production and indicated in the lists below.

3.1 Changes in the beef herd

The number of adults in the beef herd was adjusted to reflect reactions due to adult death and adult infection when accompanied by culling, young animal deaths and the abortion rate. This necessitated changes in cow calf production, stocker operations and feedlot operations.

3.1.1 Changes in the cow calf herd

The size of the cow/calf herd was held fixed to reflect the short term impact of the outbreak without long-term adjustment. As a consequence of this, cow calf production cannot be expanded outside the infected region for replacements or animals for slaughter. (See further discussion below in the "Why Use ASM/FASOM" section.) Without this limitation the model would move the locus of cattle production to other regions and transfer land in the infected area from beef production to alternative efficient uses. This would be appropriate in an endemic case but not for the short run analysis.

RVF was imposed as a direct death effect and a reduction in calf production. In addition, animals infected with RVF that do not die, but aborted or were forecast as exhibiting future infertility were culled. This had a further effect on the number of beef calves available. In particular herds routinely retain replacement animals from the calves; ordinarily the portion of heifer calves not retained are sent to fed-beef, but the additional demand for replacements diverts these animals to replenish breeding stock levels.

The direct cost incurred as a result of a RVF outbreak has two components. The first component is the disease management cost, which is the number of animals infected times the cost per head of disease management. This is added to the second element, which is the cost of carcass disposal. Adult-dead and pregnant-dead animals were assumed to have a disposal cost of $50 per head, and young-dead (calves) were disposed at the same cost.

3.1.2 Changes in the stocker operation

Referring to the flow chart of the ASM beef model in Figure 1, the imposition of RVF at the cow/calf level decreased the number of steers and heifers that flow into the first and second grazing programs of the stocker operation. This is due to both death loss and increased replacement need as discussed above. The yield of stocked calves and stocked yearlings subsequently declined. The number of cull cows increased from the pre-disease levels. As a result, the amount of non-fed beef increased. The disease also caused direct death loss in the stocker operations. Stocker operations incur the cost of disease management and carcass disposal as discussed in 3.1.1 for cow/calf operations.

Unlike the cow/calf operations which are fixed spatially, the stocked calves can move across regions. This implies calves bound for Texas prior to the RVF outbreak can be diverted to Kansas or Colorado stocker operations in order to avoid undue infection by moving healthy animals into a diseased zone.

3.1.3 Changes in the feedlot operation

Like stocker operations, feedlots were not spatially fixed. The amount of fed beef declined due to the reduced number of steers and heifers coming out of the stocker operations and direct from cow/calf operators. The increased number of cull cows did not have an effect on fed beef since cull cows are assumed to go directly to non-fed beef. In addition to the reduced number of cattle available for feeding, there was a direct death loss of animals in the feedlot. The feedlot incurred the cost of disease management as well as the cost of carcass disposal as discussed in 3.1.1 for cow/calf operations. The cost of disease management in a single feedlot was high due to the proximity of the animals to each other.

3.2 Changes in the Dairy herd

The changes in the dairy herd as the result of a RVF outbreak are similar to those in the beef herd. Like the cow/calf herd, the number of cows in the dairy herd was spatially fixed preventing the model from shifting production to non infected areas. The dairy herd experienced a rise in the number of abortions, death of pregnant cows, death of adult cows and death of young calves. The infected animals that recovered but experienced abortions and reduction in productivity were culled. The number of culls leaving the herd and entering non-fed beef increased. Cost of the disease for dairy herds was the same as beef herds. Total cost was the number of infected animals times the cost if disease management plus the $50 per head cost of carcass disposal.

Like the cow/calf operation the yield of dairy calves declined due to death loss and replacement needs. The number of dairy steer calves entering the fed and non-fed beef markets declined. The number of dairy heifers that entered the beef feeding chain was assumed to be miniscule since the majority of heifers are used as replacements in the milk herd. Therefore, the impact of reduced yield of heifer calves had two effects. The first was the decline in the number of available replacements. Since few heifers enter the beef chain, the herd cannot be replenished by diverting heifers from beef production. Second, the lack of available replacements compounded with the loss of milking adult females reduced the amount of fluid milk available for sale. The milk reduction occurred from not only from the dead cows but also from those culled.

3.3 Integration of herd data into model

A series of scenarios were then defined based on the above information to determine the effects of alternative points of introduction, alternative region of introduction, and alternative disease interventions. Based on these scenarios, an evaluation of the per herd/flock consequences to the value of lost animals, degraded productivity and lost use of production facilities can be retrieved.

4 Why use ASM/FASOM

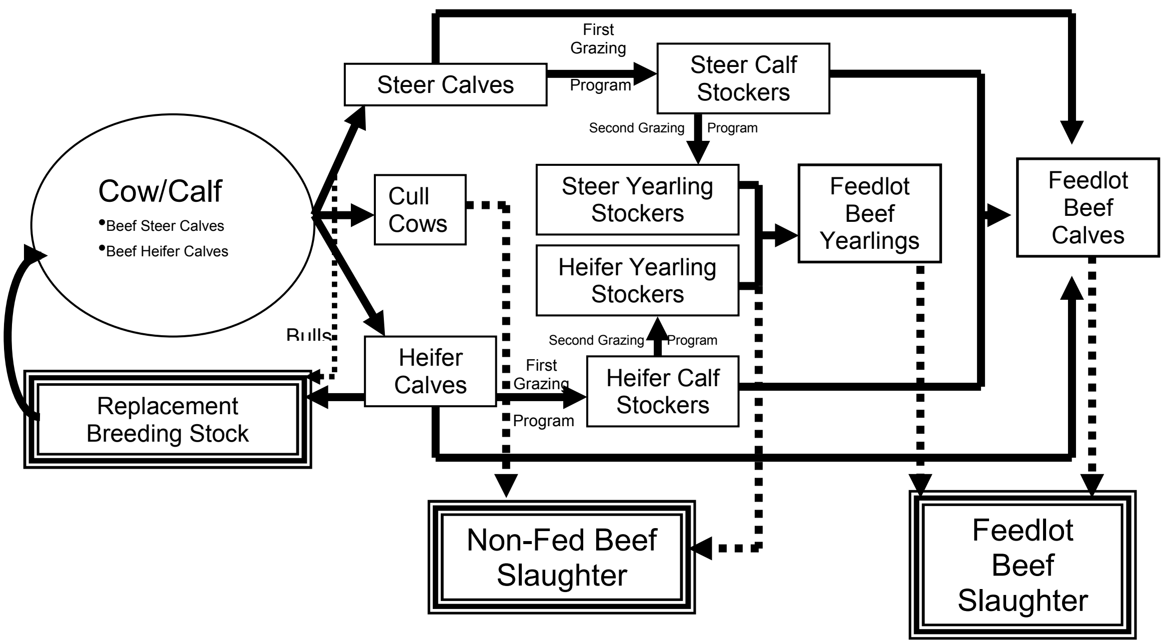
ASM has several benefits in this type of analysis. First, it provides a great deal of detail in the effects of a disease outbreak. In the Rift Valley model there was an immediate death loss, but there is also a reduction in the animals entering the meat chain in later periods due to the need to replace breeding stock. For example, in beef cattle, heifers that would have been fed out are instead diverted to replacement breeding stock. This more fully captures, not just the one shot death loss of the disease, but also the long term recovery of the industry from the disease.

The regional structure also allows more detail since a disease shock can be confined (quarantined) to a single region or sub-region and system resilience can be reflected with readjustments in the locus of production. Also inputs like feed are diverted to alternative beneficial uses.

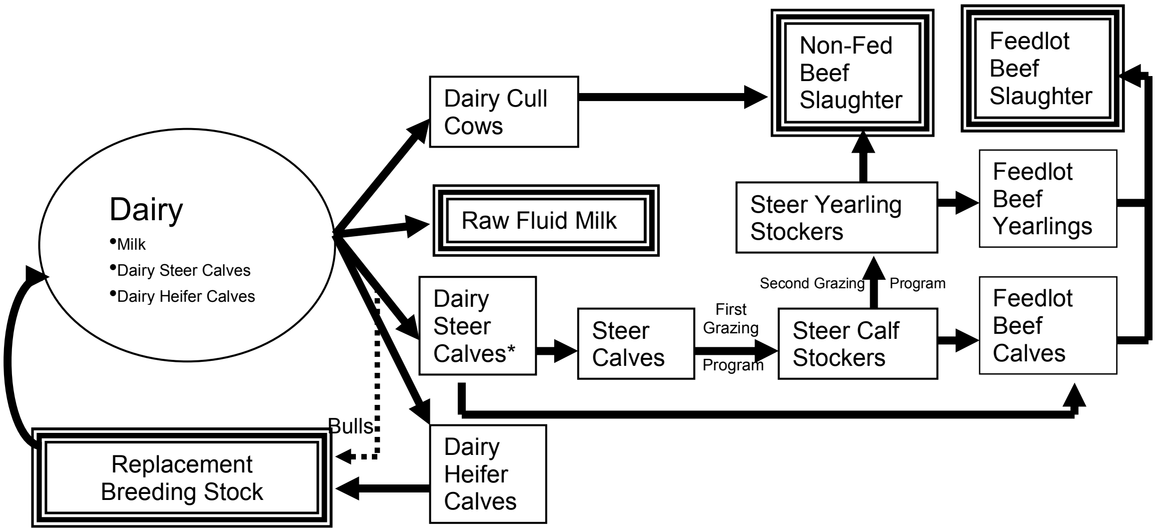
In the case of RVF the regional aspect was also utilized by introducing the disease in regions where it is most likely to occur (Florida, Texas, and California). The ASM model also captures the change in welfare from an animal disease because it calculates a dollar loss of value added net income and a cost of commodity prices rising. The trade impacts can also be estimated within ASM.

5 ASM Flow Figures

5.1 Figure 1: ASM Beef Cattle Flow

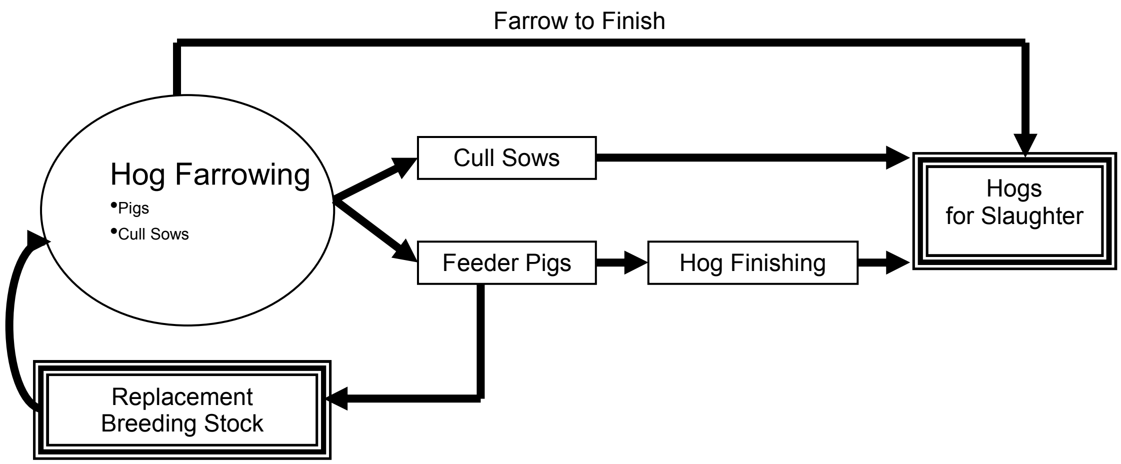


5.2 *Figure 2: ASM Dairy Cattle Flow*

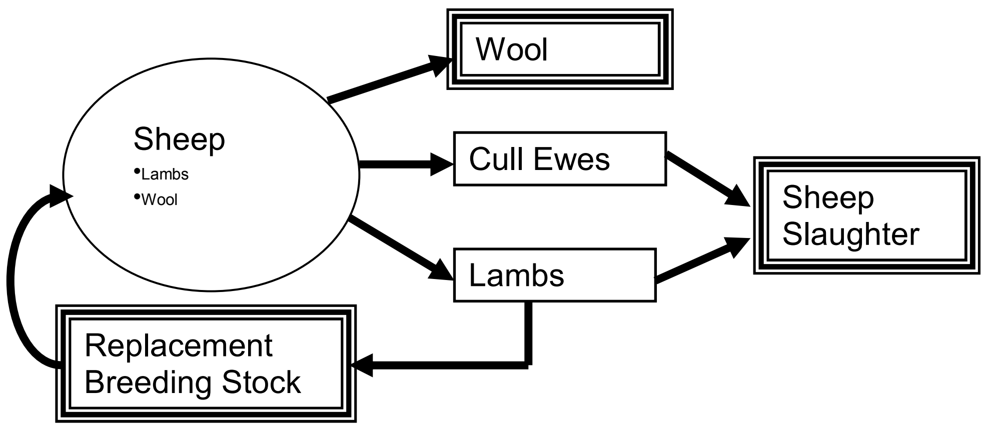


*Dairy Steer Calves merge in with the Steer Calves in the Beef Cattle Flow

5.3 *Figure 3: ASM Hog Flow*



5.4 Figure 4: ASM Sheep Flow



6 Attachment A: Beef production budgets

Here we give Beef budget categories with national averages, units and description of the variable.

6.1 Table A-1: National Average Budget for Cow/Calf on a one cow basis

Baseline specification	National Average of data in this category	Units / Description
base.Hay	-0.782	US tons of hay used in production
base.CullBeefCo	0.664	100 lbs of cull been cow on the hoof
base.SteerCalve	2.022	100 lbs of steer calves
base.HeifCalve	1.251	100 lbs of heifer calves
base.CowGrain0	0.771	100 lbs grain blend for cow/calf operation
base.CowHiPro0	0.574	100 lbs protein blend for cow/calf operation
base.Pasture	4.908	Acres of pasture land
base.AUMS	0.754	Animal unit months
base.Labor	8.317	Hours
base.SaltMiner	4.891	Dollar cost of salt and minerals
base.CottonSeed	2.222	Lbs of cottonseed
base.othercosts	201.778	Dollars
base.Profit	188.441	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.045	Metric tons methane from enteric fermentation
base.Methane_Manure	0.002	Metric tons methane from manure management
base.NitrousOxide_Manure	.00023	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	4.260	Metric tons of volatile solids from manure management
base.Head	1.000	Budget is for one animal

6.2 Table A-2: National average budget for Steer Calf Stocker per calf

Baseline Specification	Average	Units / Description
base.Hay	-0.022	US tons of hay used in stocker operation
base.SteerCalve	-4.241	100 lbs steer calf input into stocker op
base.StockedSCalf	5.843	100 lbs of steer calves after first stocker phase ready to feed
base.StockPro0	0.362	100 lbs protein blend for stocker cattle
base.Pasture	0.789	Acres of pasture land
base.AUMS	0.631	Animal unit months
base.Labor	1.578	Hours
base.SaltMiner	0.419	Dollar cost of salt and minerals
base.WheatPastu	9.496	Dollar rental rate of green wheat pasture
base.othercosts	60.728	Dollars
base.Profit	67.577	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.045	Metric tons methane from enteric fermentation
base.Methane_Manure	0.002	Metric tons methane from manure management
base.NitrousOxide_Manure	2.300000E-4	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	0.795	Metric tons of volatile solids from manure management
base.Head	1.000	Budget is for one animal

6.3 Table A-3: National average budget for Heifer Calf Stocker per calf

Baseline Specification	Average	Units / Description
base.Hay	-0.031	US tons of hay used in stocker operation
base.HeifCalve	-4.023	100 lbs heifer calf input into stocker op
base.StockedHCalf	5.454	100 lbs of heifer calves after first stocker phase ready to feed
base.StockPro0	0.375	100 lbs protein blend for stocker cattle
base.Pasture	0.789	Acres
base.AUMS	0.498	Animal unit months
base.Labor	1.578	Hours
base.SaltMiner	0.419	Dollar cost of salt and minerals
base.WheatPastu	9.496	Dollar rental rate of green wheat pasture
base.othercosts	60.728	Dollars
base.Profit	54.483	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.045	Metric tons methane from enteric fermentation
base.Methane_Manure	0.002	Metric tons methane from manure management
base.NitrousOxide_Manure	2.300000E-4	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	0.991	Metric tons of volatile solids from manure management
base.Head	1.000	Budget is for one animal

6.4 Table A-4: National average budget for Steer Yearling Stocker per yearling

Baseline Specification	Average	Units / Description
base.Hay	-0.022	US tons used for yearling stocker ops
base.StockedSCalf	-5.780	100 lbs of steer calves after first stocker phase ready to feed that are input
base.StockedSYearl	8.757	100 lbs of yearling steer calves after second stocker phase ready to feed or slaughter
base.StockPro0	0.241	100 lbs protein blend feed for stockers
base.Pasture	1.334	Acres of pasture land
base.AUMS	0.793	Animal unit months
base.Labor	1.765	Hours
base.SaltMiner	0.519	Dollar cost of salt and minerals
base.WheatPastu	9.626	Dollar rental rate of green wheat pasture
base.othercosts	53.401	Dollars
base.Profit	137.470	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.045	Metric tons methane from enteric fermentation
base.Methane_Manure	0.002	Metric tons methane from manure management
base.NitrousOxide_Manure	2.300000E-4	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	0.786	Metric tons of volatile solids from manure management
base.Head	1.000	Budget is for one animal

6.5 Table A-5: National average budget for Heifer Yearling Stocker per yearling

Heifer Yearling Stocker		
Baseline Specification	Average	Units / Description
base.Hay	-0.022	US tons used for yearling stocker ops
base.StockedHCalf	-5.615	100 lbs of heifer calves after first stocker phase ready to feed
base.StockedHYearl	8.342	100 lbs of yearling heifer calves after second stocker phase ready to feed
base.StockPro0	0.139	100 lbs protein blend feed for stockers
base.Pasture	1.394	Acres of pasture
base.AUMS	0.625	Animal unit months
base.Labor	1.781	Hours
base.SaltMiner	0.597	Dollar cost of salt and minerals
base.WheatPastu	9.966	Dollar rental rate of green wheat pasture
base.othercosts	59.071	Dollars
base.Profit	120.049	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.045	Metric tons methane from enteric fermentation
base.Methane_Manure	0.002	Metric tons methane from manure management
base.NitrousOxide_Manure	2.300000E-4	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	0.965	Metric tons of volatile solids from manure management
base.Head	1.000	Budget is for one animal

6.6 Table A-6: National average budget for Calf in feedlot per calf

Feedlot Beef Calves		
Baseline Specification	Average	Units / Description
base.Silage	-0.815	US tons of silage used in feedlot
base.Hay	-0.446	US tons of hay used in feedlot
base.FeedlotBeefSlaughter	11.968	100 lbs fed beef on the hoof
base.StockedCalf	-5.888	100 lbs of calves after first stocker phase ready to feed
base.biomanure	0.714	US tons manure available for bioprocesses
base.CatGrain0	38.991	100 lbs grain blend for finishing cattle
base.HighProtCa	3.233	100 lbs protein blend for finishing cattle
base.Pasture	0.006	Acres of pasture land
base.Labor	3.328	Hours
base.othercosts	89.487	Dollars
base.Profit	-27.280	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.045	Metric tons methane from enteric fermentation
base.Methane_Manure	0.002	Metric tons methane from manure management
base.NitrousOxide_Manure	2.300000 E-4	Metric tons nitrous oxide from manure management
base.ManageManureFrac	0.106	Portion of manure managed in a manure management system
base.VolatileSolidsinManure	0.875	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	0.880	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.006	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal
Alternative Feedlot specification in which steer calves go direct to feedlot		
SCalfDirect.Silage	-0.744	US tons of silage used in feedlot
SCalfDirect.Hay	-0.407	US tons of hay used in feedlot
SCalfDirect.FeedlotBeefSlaughter	11.968	100 lbs fed beef on the hoof
SCalfDirect.SteerCalve	-4.350	100 lbs of steer calves
SCalfDirect.biomanure	0.653	US tons manure available for bioprocesses
SCalfDirect.CatGrain0	35.632	100 lbs grain blend for finishing cattle
SCalfDirect.HighProtCa	2.955	100 lbs protein blend for finishing cattle
SCalfDirect.Pasture	0.006	Acres of pasture land
SCalfDirect.Labor	3.041	Hours
SCalfDirect.othercosts	81.765	Dollars
SCalfDirect.Profit	-27.280	Dollar difference between revenues and costs
SCalfDirect.Methane_EntericFerment	0.041	Metric tons methane from enteric fermentation
SCalfDirect.Methane_Manure	0.002	Metric tons methane from manure management
SCalfDirect.NitrousOxide_Manure	.00021019	Metric tons nitrous oxide from manure management
SCalfDirect.ManageManureFrac	0.106	Portion of manure managed in a manure management system
SCalfDirect.VolatileSolidsinManure	0.800	Metric tons of volatile solids from manure management
SCalfDirect.LiquidVSManureVolume	0.804	Liquid volatile solids from manure management
SCalfDirect.HeadinLiquidSystems	0.919	Head involved in liquid management systems
SCalfDirect.Head	1.000	Budget is for one animal
Alternative Feedlot specification in which heifer calves go direct to feedlot		
HCalfDirect.Silage	-0.734	US tons of silage used in feedlot

HCalfDirect.Hay	-0.402	US tons of hay used in feedlot
HCalfDirect.FeedlotBeefSlaughter	11.968	100 lbs fed beef on the hoof
HCalfDirect.HeifCalve	-4.126	100 lbs of heifer calves
HCalfDirect.biomanure	0.644	US tons manure available for bioprocesses
HCalfDirect.CatGrain0	35.143	100 lbs grain blend for finishing cattle
HCalfDirect.HighProtCa	2.914	100 lbs protein blend for finishing cattle
HCalfDirect.Pasture	0.006	Acres of Pasture land
HCalfDirect.Labor	3.000	Hours
HCalfDirect.othercosts	80.642	Dollars
HCalfDirect.Profit	-27.280	Dollar difference between revenues and costs
HCalfDirect.Methane_EntericFerment	0.041	Metric tons methane from enteric fermentation
HCalfDirect.Methane_Manure	0.002	Metric tons methane from manure management
HCalfDirect.NitrousOxide_Manure	.000207	Metric tons nitrous oxide from manure management
HCalfDirect.ManageManureFrac	0.106	Portion of manure managed in a manure management system
HCalfDirect.VolatileSolidsinManure	0.789	Metric tons of volatile solids from manure management
HCalfDirect.LiquidVSManureVolume	0.793	Liquid volatile solids from manure management
HCalfDirect.HeadinLiquidSystems	0.906	Head involved in liquid management systems
HCalfDirect.Head	1.000	Budget is for one animal
Alternative Feedlot specification in which dairy calves go direct to feedlot		
DCalfDirect.Silage	-0.744	US tons of silage used in feedlot
DCalfDirect.Hay	-0.407	US tons of hay used in feedlot
DCalfDirect.FeedlotBeefSlaughter	11.968	100 lbs fed beef on the hoof
DCalfDirect.DairyCalves	-4.350	100 lbs of dairy calves
DCalfDirect.biomanure	0.653	US tons manure available for bioprocesses
DCalfDirect.CatGrain0	35.632	100 lbs grain blend for finishing cattle
DCalfDirect.HighProtCa	2.955	100 lbs protein blend for finishing cattle
DCalfDirect.Pasture	0.006	Acres of pasture land
DCalfDirect.Labor	3.041	Hours
DCalfDirect.othercosts	81.765	Dollars
DCalfDirect.Profit	-27.280	Dollar difference between revenues and costs
DCalfDirect.Methane_EntericFerment	0.041	Metric tons methane from enteric fermentation
DCalfDirect.Methane_Manure	0.002	Metric tons methane from manure management
DCalfDirect.NitrousOxide_Manure	.0002102	Metric tons nitrous oxide from manure management
DCalfDirect.ManageManureFrac	0.106	Portion of manure managed in a manure management system
DCalfDirect.VolatileSolidsinManure	0.800	Metric tons of volatile solids from manure management
DCalfDirect.LiquidVSManureVolume	0.804	Liquid volatile solids from manure management
DCalfDirect.HeadinLiquidSystems	0.919	Head involved in liquid management systems
DCalfDirect.Head	1.000	Budget is for one animal
Alternative Feedlot specification with shorter feeding budget on calves (115 vs. 128 days)		
CFeed27.Silage	-0.760	US tons of silage used in feedlot
CFeed27.Hay	-0.416	US tons of hay used in feedlot
CFeed27.FeedlotBeefSlaughter	11.578	100 lbs fed beef on the hoof
CFeed27.StockedCalf	-5.888	100 lbs of calves after first stocker phase ready to feed
CFeed27.biomanure	0.666	US tons manure available for bioprocesses
CFeed27.CatGrain0	36.364	100 lbs grain blend for finishing cattle
CFeed27.HighProtCa	3.016	100 lbs protein blend for finishing cattle
CFeed27.Pasture	0.006	Acres of pasture land

CFeed27.Labor	3.104	Hours
CFeed27.othercosts	83.460	Dollars
CFeed27.Profit	-27.280	Dollar difference between revenues and costs
CFeed27.Methane_EntericFerment	0.042	Metric tons methane from enteric fermentation
CFeed27.Methane_Manure	0.002	Metric tons methane from manure management
CFeed27.NitrousOxide_Manure	2.145078 E-4	Metric tons nitrous oxide from manure management
CFeed27.ManageManureFrac	0.106	Portion of manure managed in a manure management system
CFeed27.VolatileSolidsinManure	0.816	Metric tons of volatile solids from manure management
CFeed27.LiquidVSManureVolume	0.821	Liquid volatile solids from manure management
CFeed27.HeadinLiquidSystems	0.938	Head involved in liquid management systems
CFeed27.Head	1.000	Budget is for one animal

6.7 Table A-7: National average budget for Yearling in feedlot per yearling

Feedlot Beef Yearlings		
Baseline Specification	Average	Units / Description
base.Silage	-0.075	US tons of silage used in feedlot
base.Hay	-0.115	US tons of hay used in feedlot
base.FeedlotBeefSlaughter	10.336	100 lbs fed beef on the hoof
base.StockedYearling	-8.320	100 lbs of yearlings after second phase ready to feed
base.biomanure	0.477	US tons manure available for bioprocesses
base.CatGrain0	28.442	100 lbs grain blend for finishing cattle
base.HighProtCa	2.466	100 lbs protein blend for finishing cattle
base.Labor	1.792	Hours
base.othercosts	64.261	Dollars
base.Profit	-164.485	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.045	Metric tons methane from enteric fermentation
base.Methane_Manure	0.002	Metric tons methane from manure management
base.NitrousOxide_Manure	.00023	Metric tons nitrous oxide from manure management
base.ManageManureFrac	0.106	Portion of manure managed in a manure management system
base.VolatileSolidsinManure	0.563	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	0.567	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.006	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal
Alternative Feedlot Beef specification with a shorter yearling feeding budget (115 vs. 128 days)		
YFeed27.Silage	-0.067	US tons of silage used in feedlot
YFeed27.Hay	-0.103	US tons of hay used in feedlot
YFeed27.FeedlotBeefSlaughter	9.946	100 lbs fed beef on the hoof
YFeed27.StockedYearling	-8.320	100 lbs of yearlings after second phase ready to feed
YFeed27.biomanure	0.428	US tons manure available for bioprocesses
YFeed27.CatGrain0	25.553	100 lbs grain blend for finishing cattle
YFeed27.HighProtCa	2.215	100 lbs protein blend for finishing cattle
YFeed27.Labor	1.610	Hours
YFeed27.othercosts	57.734	Dollars
YFeed27.Profit	-164.485	Dollar difference between revenues and costs
YFeed27.Methane_EntericFerment	0.041	Metric tons methane from enteric fermentation
YFeed27.Methane_Manure	0.002	Metric tons methane from manure management
YFeed27.NitrousOxide_Manure	.0002066	Metric tons nitrous oxide from manure management
YFeed27.ManageManureFrac	0.106	Portion of manure managed in a manure management system
YFeed27.VolatileSolidsinManure	0.506	Metric tons of volatile solids from manure management
YFeed27.LiquidVSManureVolume	0.509	Liquid volatile solids from manure management
YFeed27.HeadinLiquidSystems	0.903	Head involved in liquid management systems
YFeed27.Head	1.000	Budget is for one animal

7 Attachment B: Dairy production budget

Here we give Dairy budget categories with national averages, units and description of the variable.

7.1 Table B-1: National Average Budget for Dairy on a one cow basis

Baseline Specification	Average	Units / Description
base.Silage	-6.600	US tons for dairy production
base.Hay	-5.060	US tons for dairy production
base.Milk	193.906	100 lbs of raw milk
base.CullDairyCows	1.657	100 lbs of cull dairy calves
base.DairyCalves	2.057	100 lbs of dairy calves
base.biomanure	4.940	US tons manure available for bioprocesses
base.SoybeanMeal	0.860	US tons soybean meal
base.DairyCon0	108.529	100 lbs grain blend for dairy cattle
base.Pasture	1.750	Acres of pasture land
base.Labor	31.587	Hours
base.othercosts	1272.391	Dollars
base.Profit	1435.851	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.138	Metric tons methane from enteric fermentation
base.Methane_Manure	0.077	Metric tons methane from manure management
base.NitrousOxide_Manure	0.001	Metric tons nitrous oxide from manure management
base.ManageManureFrac	0.039	Portion of manure managed in a manure management system
base.VolatileSolidsinManure	6.698	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	6.707	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.000	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal
Alternative Specification utilizing BST (Bovine Somatotropin: a growth hormone that increases milk production)		
BST.Silage	-7.590	US tons for dairy production
BST.Hay	-5.819	US tons for dairy production
BST.Milk	213.296	100 lbs of raw milk
BST.CullDairyCows	1.657	100 lbs of cull dairy calves
BST.DairyCalves	2.057	100 lbs of dairy calves
BST.biomanure	5.682	US tons manure available for bioprocesses
BST.SoybeanMeal	0.989	US tons soybean meal
BST.DairyCon0	124.808	100 lbs grain blend for dairy cattle
BST.Pasture	1.750	Acres of pasture land
BST.Labor	31.587	Hours
BST.othercosts	1272.391	Dollars
BST.Profit	1435.851	Dollar difference between revenues and costs
BST.Methane_EntericFerment	0.010	Metric tons methane from enteric fermentation
BST.Methane_Manure	0.077	Metric tons methane from manure management
BST.NitrousOxide_Manure	0.001	Metric tons nitrous oxide from manure management
BST.ManageManureFrac	0.039	Portion of manure managed in a manure management system
BST.VolatileSolidsinManure	6.698	Metric tons of volatile solids from manure management

BST.LiquidVSManureVolume	6.707	Liquid volatile solids from manure management
BST.HeadinLiquidSystems	1.000	Head involved in liquid management systems
BST.Head	1.000	Budget is for one animal
Alternative Specification in which a 20% increase in productivity is achieved through genetic selection		
Genetic20.Silage	-7.920	US tons for dairy production
Genetic20.Hay	-6.072	US tons for dairy production
Genetic20.Milk	232.687	100 lbs of raw milk
Genetic20.CullDairyCows	1.657	100 lbs of cull dairy calves
Genetic20.DairyCalves	2.057	100 lbs of dairy calves
Genetic20.biomanure	4.940	US tons manure available for bioprocesses
Genetic20.SoybeanMeal	1.032	US tons soybean meal
Genetic20.DairyCon0	130.235	100 lbs grain blend for dairy cattle
Genetic20.Pasture	2.100	Acres of pasture land
Genetic20.Labor	31.587	Hours
Genetic20.othercosts	1272.391	Dollars
Genetic20.Profit	1435.851	Dollar difference between revenues and costs
Genetic20.Methane_EntericFerment	0.138	Metric tons methane from enteric fermentation
Genetic20.Methane_Manure	0.077	Metric tons methane from manure management
Genetic20.NitrousOxide_Manure	0.001	Metric tons nitrous oxide from manure management
Genetic20.ManageManureFrac	0.039	Portion of manure managed in a manure management system
Genetic20.VolatileSolidsinManure	6.698	Metric tons of volatile solids from manure management
Genetic20.LiquidVSManureVolume	6.707	Liquid volatile solids from manure management
Genetic20.HeadinLiquidSystems	1.000	Head involved in liquid management systems
Genetic20.Head	1.000	Budget is for one animal
Alternative Specification in which the diary herd size is reduced by 20%		
Herd20.Silage	-6.600	US tons for dairy production
Herd20.Hay	-5.060	US tons for dairy production
Herd20.Milk	234.626	100 lbs of raw milk
Herd20.CullDairyCows	1.657	100 lbs of cull dairy calves
Herd20.DairyCalves	2.057	100 lbs of dairy calves
Herd20.biomanure	4.940	US tons manure available for bioprocesses
Herd20.SoybeanMeal	0.860	US tons soybean meal
Herd20.DairyCon0	108.529	100 lbs grain blend for dairy cattle
Herd20.Pasture	1.750	Acres of Pasture land
Herd20.Labor	30.008	Hours
Herd20.othercosts	1336.010	Dollars
Herd20.Profit	1435.851	Dollar difference between revenues and costs
Herd20.Methane_EntericFerment	0.138	Metric tons methane from enteric fermentation
Herd20.Methane_Manure	0.077	Metric tons methane from manure management
Herd20.NitrousOxide_Manure	0.001	Metric tons nitrous oxide from manure management
Herd20.ManageManureFrac	0.039	Portion of manure managed in a manure management system
Herd20.VolatileSolidsinManure	6.698	Metric tons of volatile solids from manure management
Herd20.LiquidVSManureVolume	6.707	Liquid volatile solids from manure management
Herd20.HeadinLiquidSystems	1.000	Head involved in liquid management systems
Herd20.Head	1.000	Budget is for one animal

8 Attachment C: Hog production budgets

Here we give Hog budget categories with national averages, units and description of the variable.

8.1 Table C-1: National Budget for Hog Farrow to Finish on a one sow basis

Baseline Specification	Average	Units / Description
base.HogsforSlaughter	2.899	100 lbs live weight of pigs for slaughter
base.CullSow	0.169	100 lbs live weight of cull sows
base.biomanure	0.109	US tons manure available for bioprocesses
base.FarGrain0	13.431	100 lbs grain blend for farrowing ops
base.FarProSwn0	2.678	100 lbs protein blend for farrowing ops
base.Labor	3.269	Hours
base.Profit	19.731	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.001	Metric tons methane from enteric fermentation
base.Methane_Manure	0.010	Metric tons methane from manure management
base.NitrousOxide_Manure	.00002	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	0.154	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	0.154	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.000	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal

8.2 Table C-2: National Budget for Feeder Pig Production on a one sow basis

Baseline Specification	Average	Units / Description
base.FeederPig	8.798	100 lbs live weight of feeder pigs
base.CullSow	2.289	100 lbs live weight of cull sows
base.biomanure	1.966	US tons manure available for bioprocesses
base.FPGGrain0	47.655	100 lbs grain blend for feeder pigs
base.FPGProSwn0	11.043	100 lbs protein blend for feeder pigs
base.Labor	46.327	Hours
base.FeedMix	23.314	Dollar cost of feed blending
base.othercosts	359.592	Dollars
base.Profit	373.218	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.001	Metric tons methane from enteric fermentation
base.Methane_Manure	0.010	Metric tons methane from manure management
base.NitrousOxide_Manure	0.00002	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	2.987	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	2.989	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.001	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal

8.3 Table C-3: National Budget for Pig Finishing on a one feeder pig basis

Baseline Specification	Average	Units / Description
base.HogsforSlaughter	2.899	100 lbs live weight of pigs for slaughter
base.FeederPig	-0.500	100 lbs live weight of feeder pigs
base.biomanure	0.086	US tons manure available for bioprocesses
base.FinGrain0	10.312	100 lbs grain blend for finishing ops
base.FinProSwn0	1.851	100 lbs protein blend for finishing ops
base.Labor	1.095	Hours
base.FeedMix	0.688	Dollar cost of feed blending
base.othercosts	17.706	Dollars
base.Profit	1.283	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.001	Metric tons methane from enteric fermentation
base.Methane_Manure	0.010	Metric tons methane from manure management
base.NitrousOxide_Manure	.00002	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	0.123	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	0.124	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.002	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal

9 Attachment D: Sheep production budgets

Here we give Sheep budget categories with national averages, units and description of the variable.

9.1 Table D-1: National Average Budget for Sheep on a one ewe basis

Baseline Specification	Average	Units / Description
base.LambSlaugh	1.541	100 lbs live wt of slaughter lambs
base.CullEwes	0.663	100 lbs live wt of cull ewes
base.Wool	31.124	Lbs raw wool
base.SheepGrn0	1.349	100 lbs grain blend feed for sheep
base.SheepPro0	1.238	100 lbs protein blend feed for sheep
base.Pasture	2.215	Acres of pasture land
base.AUMS	2.714	Animal unit months
base.Labor	4.792	Hours
base.SaltMiner	6.688	Dollar cost of salt and minerals
base.othercosts	47.485	Dollars
base.Profit	62.694	Dollar difference between revenues and costs
base.Methane_EntericFerment	0.012	Metric tons methane from enteric fermentation
base.Methane_Manure	0.001	Metric tons methane from manure management
base.NitrousOxide_Manure	.000007	Metric tons nitrous oxide from manure management
base.VolatileSolidsinManure	0.257	Metric tons of volatile solids from manure management
base.Head	1.000	Budget is for one animal

10 Attachment E: Turkey budgets

Here we give Turkey budget categories with national averages, units and description of the variable.

10.1 Table E-1: National Average Budget for Turkeys on a one turkey basis

Baseline Specification	Average	Units / Description
base.Turkeys	0.270	100 lbs live weight of turkeys
base.biomanure	0.021	US tons manure available for bioprocesses
base.TurkeyGrn0	0.682	100 lbs grain blend for turkeys
base.TurkeyPro0	0.252	100 lbs grain blend for turkeys
base.Proteinsup	0.005	Cost of protein supplement
base.othercosts	1.544	Dollars
base.Profit	5.621	Dollar difference between revenues and costs
base.Methane_Manure	2.000000E-5	Metric tons methane from manure management
base.VolatileSolidsinManure	0.022	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	0.022	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.000	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal

11 Attachment F: Broiler budgets

Here we give Broiler budget categories with national averages, units and description of the variable.

11.1 Table F-1: National Average Budget for Broilers on a one chicken basis

Baseline Specification	Average	Units / Description
base.Broilers	0.051	100 lbs live weight in broilers
base.biomanure	0.002	US tons manure available for bioprocesses
base.BroilGrn0	0.078	100 lbs grain blend for broilers
base.BroilPro0	0.029	100 lbs protein blend for broilers
base.Proteinsup	0.007	Cost of protein supplement
base.othercosts	0.177	Dollars
base.Profit	1.416	Dollar difference between revenues and costs
base.Methane_Manure	2.000000E-5	Metric tons methane from manure management
base.VolatileSolidsinManure	0.002	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	0.002	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.000	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal

12 Attachment G: Egg production budgets

Here we give Egg production budget categories with national averages, units and description of the variable.

12.1 Table G-1: National Average Budget for Egg Production on a one hen basis

Baseline Specification	Average	Units / Description
base.Eggs	22.102	Dozens of eggs at farm level
base.EggGrain0	1.082	100 lbs grain blend for hens in egg production
base.EggPro0	0.219	100 lbs protein blend for hens in egg production
base.Proteinsup	0.294	Dollar cost of protein supplement for hens
base.othercosts	3.353	Dollars
base.Profit	7.370	Dollar difference between revenues and costs
base.Methane_Manure	2.000000E-5	Metric tons methane from manure management
base.ManageManureFrac	0.031	Portion of manure managed in a manure management system
base.VolatileSolidsinManure	0.019	Metric tons of volatile solids from manure management
base.LiquidVSManureVolume	0.019	Liquid volatile solids from manure management
base.HeadinLiquidSystems	1.000	Head involved in liquid management systems
base.Head	1.000	Budget is for one animal

13 Attachment H: Horse and Mule budgets

Here we give Horse and Mule budget categories with national averages, units and description of the variable.

13.1 Table H-1: National Average Budget for Horses and Mules on a one animal basis

Baseline Specification	Average	Units / Description
base.Corn	-2.311	Bushels of corn for horse & mule prod
base.Oats	-28.609	Bushels of oats for horse & mule prod
base.Barley	-0.359	Bushels of barley for horse & mule prod
base.Hay	-1.056	US tons of hay for horse & mule prod
base.HorsesandMules	1.000	Head of horse and mules
base.SoybeanMeal	0.793	US tons of soybean meal
base.othercosts	3995.310	Dollars
base.Profit	423.949	Dollar difference between revenues and costs
base.VolatileSolidsinManure	4.500	Metric tons of volatile solids from manure management
base.wheat	-0.207	Bushels of wheat for horse & mule prod
base.Head	1.000	Budget is for one animal