SHADES OF GREEN: Quantifying the Benefits of Organic Dairy Production

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Executive Summary

Consumer awareness – and concern – is growing over the impacts of food production on environmental quality and personal health. The average Joe, public health specialists, and a diversity of organizations are asking more probing, sophisticated questions about these impacts and placing pressure on retailers and the food industry to purchase and sell food from farmers who are committed to long-term sustainability, humane animal care, and planetary health.

In this era of heightened scrutiny on how food is produced, American agriculture is evolving toward extremes. The number and importance of very small farms, and very large ones is growing. The number of mid-size farms is declining, as is their share of total production.

In the dairy industry, cow numbers have been increasing for close to 20 years in arid parts of the west, especially in states like Idaho and New Mexico, where large industrial dairy farms manage one to several thousand cows in feedlot-based farms. Most of these cows do not have access to sufficient pasture to contribute significantly to their daily feed intakes. Grain-based rations and high-quality alfalfa hay form the backbone of the cows' diet. The number of mid-sized dairies in New England and through much of the Midwest has been declining, replaced by larger farms in these regions or newly established farms in the west.

Bucking these trends, the number and importance of small to moderate-scale organic dairy farms is increasing nationwide, as well as in both New England and the Midwest. The most successful operations grow all or most of their feed on or near the home farm. In addition, pasture and grazing contributes significantly to daily feed intakes in those parts of the year when the weather supports active forage plant growth. On conventional, feedlot-based industrial dairies, corn and other corn-based feeds typically account for around two-thirds of a cow's diet, whereas on grazing-based organic farms, pasture and forage-based feeds typically account for at least two-thirds of daily feed intake, and corn in all its forms less than one-quarter.

On large conventional dairies, artificial insemination is used on mostly purebred Holstein cows. Each milking dairy animal with a future in the herd produces a minimum of 22,000 pounds of milk during a 305-day lactation. A range of drugs are routinely administered to these animals to help them fight infections, efficiently digest their energy-dense, low-fiber feed, and to help synchronize artificial insemination breeding attempts.

On most small and moderate scale organic dairies, production levels are lower, averaging closer to 17,000 pounds per year. Breeds of cattle other than Holsteins, as well as crossbreed cattle are common and artificial insemination is a tool used on many farms, but has not displaced bulls and traditional breeding programs.

No artificial hormones or antibiotics are administered to animals on organic dairy farms, unless returning a cow to good health requires treatment with an animal drug not approved for use on organic farms. In such circumstances, the organic rules codified by the USDA's National Organic Program require a farmer to proceed with treatment and remove the cow forever from the herd producing certified organic milk.

The environmental impacts of large, confinement based conventional dairies are much different than those associated with small and mid-sized organic dairies. One set of the impacts is linked to how cows are managed and how their manure is handled and utilized. These impacts mostly occur in the vicinity of where the cows are housed and milked on a daily basis. Moreover, large confinement-based dairies often are clustered in the same regions where combinations of available feed, climate, accessible land for manure applications, and lenient environmental regulations have collectively created a favorable business climate.

For these reasons, impacts stemming from how cows are managed and housed are far more concentrated geographically than the impacts stemming from how and where the feed is grown for a given dairy herd. Dairy farm feed production can occur on or near the farm, but for most large dairies in the west, occurs hundreds of or even thousands of miles away.

Some of the major differences between conventional and organic dairy farms, in terms of animal husbandry and health care, food safety, and environmental quality, stem from animal drugs and crop production inputs that are routinely used on conventional dairy farms but are prohibited on organic farms. The major classes of inputs are:

- Fertilizer nutrients applied to increase crop yields, and in particular, nitrogen;
- Pesticides applied to manage weeds and control insects; and
- Animal drugs administered to fight infections (antibiotics), boost milk production (rbGH), or hormones given to increase success when artificial insemination is the preferred method of impregnating cows.

Drawing on data from the U.S. Department of Agriculture and the dairy science literature, a calculator has been developed which estimates the above three categories of "avoided impacts," along with the acres required to produce organic dairy feeds, when a cow on a typical conventional dairy farm is switched to organic management. The calculator can be used to quantity the pounds of fertilizers and pesticides not applied when a milking dairy animal, or a herd of cows of known size, is shifted to organic production, as well as the number of doses of certain animal drugs that will not be administered.

The calculator is accessible free of charge through The Organic Center's website (go to http://www.organic-center.org/science.environment.php?action=view&report_id=139). The values of a number of key input variables have been set at typical, or default levels to produce average estimates of expected, avoided impacts. Users of the calculator can replace these input variable values with data specific to a given farm or a group of farms.

There are nine steps, each accomplished in a different table, required to estimate the avoided impacts stemming from the conversion of a single conventional milking cow to organic management. The tenth step and table provides a way to estimate the avoided impacts from the conversion of a known number of milking dairy cows to organic management.

For example, there are about 120,000 lactating animals on organic dairy farms in the United States today, presenting about 1.5% of the nation's total herd of about 8.5 million milking dairy animals. These 120,000 cows on organic farms account for the following avoided impacts in 2008:

- Over 761,000 acres of land were managed organically in producing the forages, feed grains, and protein supplements fed to the 120,000 organic dairy cows (6.3 acres per cow);
- Some 40 million pounds of synthetic nitrogen was not applied;
- Over 785,000 pounds of pesticides were not sprayed on crop fields, mostly herbicides; and
- Cows were administered 1,776,000 fewer treatments (usually injections) of hormones used as reproductive aids, a genetically-engineered hormone to boost production, and antibiotics.

More work is needed to refine the equations built into the calculator; the data on crop yields and input use; and, to expand the calculator to encompass additional avoided impacts, such as those involving green house gas emissions. Some of this work is underway (see the Center's website for details). In the interim, this calculator can be used and/or adapted to produce estimates of the above avoided impacts on one or several dairy farms anywhere in the United States.

I. Why This Study?

Buyers of organic dairy products are asking suppliers to help them project the environmental benefits of organic dairy production. In response, dairy processors are working toward methods to estimate various environmental impacts associated with organic milk production, in contrast to conventional dairy operations. Some processors are also carrying out or sponsoring research on specific environmental impacts, such as greenhouse gas emissions, in order to generate the data and methods needed to more accurately assess the relative impacts of different types of dairy farm management systems.

In March 2008 Stonyfield Farm requested that the Center develop and propose a methodology to project the avoided impacts of organic dairy farming and provided funding to support the project. The project has been carried out in cooperation with several major organic dairy processors.

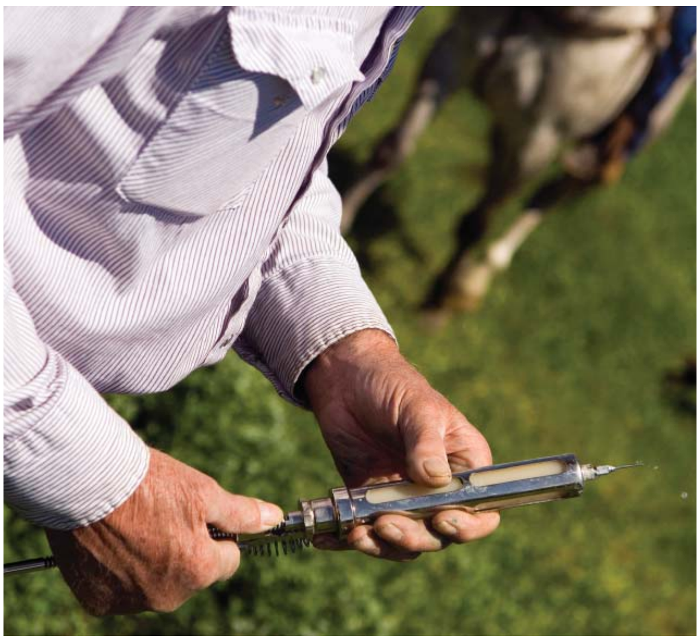
The methodology that follows is limited in scope to pesticides and nitrogen fertilizer, and the use of certain animal drugs. It does not cover several other important components of the impact of organic and conventional dairy production on the environment and human health (e.g., climate change, food miles, food safety, energy use, water pollution, and manure management).

The goal is to produce an easy-to-use methodology that can be applied consistently across the industry. Reaching common ground on the data, equations, and assumptions embedded in such a methodology will foster public understanding of, and confidence in the results emerging from applications of the methodology.

To facilitate widespread use of the methodology, the Center will provide free of charge an Excel-based calculator which can be used to apply the methodology on a given farm, or across multiple farms. The calculator allows users to enter information specific to their farm, dairy herd, or region, as well as farm-specific information on production levels, feed rations, and crop yields. Access the calculator and instructions on how to use it on the Center's website under the "State of Science" section, in the "Environment" category, or at http://www.organic-center.org/science.environment.php?action=view&report_id=139.

II. Scope and Focus of an "Avoided Impacts" Methodology

In this project and calculator, "avoided impacts" are those triggered by, or associated with the use of production inputs and practices that are not allowed on certified organic dairy farms. Avoided impacts can stem from use of toxic synthetic pesticides, conventional fertilizers, and animal drugs including production-enhancing hormones and antibiotics that cannot be used on farms producing certified organic milk.



It remains difficult, and in most cases impossible to quantify with precision the adverse impacts on people or the environment triggered by any specific use of conventional pesticides, fertilizers, and animal drugs, or all uses in an area or nationwide. These production inputs have widely variable impacts that are specific to particular uses, regions, and circumstances. The frequency and spatial intensity of their use drives the magnitude of several adverse impacts, as does the skill and discipline of the farmers or herd managers using the inputs and technologies.

For example on conventional farms, applications of a given herbicide once every few years on a small percent of the cropland in a watershed poses little risk of contamination in an underlying aquifer, whereas annual use of the same herbicide over a significant percentage of the watershed's cropland may lead to detectable levels in ground water. Such has been the case with several corn herbicides including atrazine, acetochlor, and metolachlor.

When an acre of corn is transitioned to organic production and not sprayed with any synthetic pesticides, it is relatively easy to quantify the pounds of pesticides not applied as a result. This quantity is one category of avoided impacts included in the methodology. It is much more complicated to take the analysis the next step, by estimating the actual environmental or human health damage linked to a given application of a pesticide. Doing so requires considerable site-specific information on soil types, pesticide use patterns (i.e., when, how, and at what rate a pesticide is applied), worker exposures, pesticide residues in surface and drinking water and food, exposures to non target organisms like birds and beneficial insects, and weather patterns.

In the case of animal drugs not permitted for use on organic dairy farms, data compiled by the U.S. Department of Agriculture (USDA) can be drawn upon in quantifying the number of drug "doses avoided." The potential adverse impacts of animal drugs on treated cows are also reasonably well characterized in most cases and are described on animal drug product labels.

Projecting the benefits to human health from animal drug "doses avoided" is, again, much more complicated. Impacts like the emergence of

antibiotic resistance have received much attention in recent years. While the general connection between sub-therapeutic antibiotic use in livestock production and antibiotic resistance in human pathogens is now proven and widely accepted (although not universally), it remains impossible to estimate the antibiotic resistance-impacts of a given course of treatment on a specific farm.

To quantify such impacts, a carefully designed on-farm study would need to be carried out that entails, among other things, collecting blood, urine, and/or manure samples before and after treatment to compare the degree of resistance in cultured bacteria. Fortunately, some studies of this nature have been carried out or are currently underway, and will set the stage for incrementally more accurate estimates of the impacts of antibiotic use on livestock farms and human health.

Scope and Focus of Assessments

For the purposes of this methodology, we focus on pounds of production inputs not applied, and doses of animal drugs not administered. Whatever the actual adverse impacts of these production inputs and practices turn out to be on a specific conventional farm, organic dairy production prevents or avoids such impacts.

The scope and sophistication of methodologies used to project the avoided impacts of alternative dairy production systems vary in terms of:

- the environmental and public health impacts encompassed by the methodology;
- whether and how transportation costs and energy use are included in the analysis;
- the geographic focus of the assessment;
- how variability across the dairy farms in the organic sector is handled, as well as variability across conventional dairy farms; and
- whether and how milk production levels, cull rates, birth rates, cow replacement procedures, and animal breed is taken into account.

Some methods focus just on certain production inputs and/or practices that are avoided or prohibited in organic production, while other analyses strive to encompass the full "life-cycle" of a product. The scope of an analysis will play a big role in determining outcomes. For example, methods that include the longer-term soil quality impacts of organic farming will produce estimates of avoided impacts generally more favorable to organic production than methods that do not.

Many of the avoided impacts from conversion of a conventional dairy farm to organic management will be linked to the production of organic animal feed. These impacts may or may not occur on the farms converting to organic milk production. The benefits from reduced pesticide and fertilizer use sometimes materialize, at least in part, hundreds or even thousands of miles away, where organic corn, soybeans, and other feed grains are grown. Water quality benefits often accrue many miles away from an organic crop farm. The current analysis and proposed methodology only estimates simple and immediate avoided impacts linked to input use, not the full range of short-term and longer-run impacts, nor where impacts are likely to occur.

Levels of Precision

Trade-offs are unavoidable between accuracy and expediency in developing estimates of the impacts of organic versus conventional dairy production. Years of work could be invested in a given region in carrying out a detailed field study of the environmental impacts of a single organic or conventional dairy operation. Even when sharply focused in a region and on a set of farms with comparable soils and climate, impacts on organically versus conventionally managed farms will vary as a function of type of barns and milking schedules, animal breed, weather patterns, and the prices for various animal feeds and production inputs.

Changes in farm policy, new regulatory initiatives, or changing consumer preferences can also alter the estimates of impacts in one or both farming systems. For example, a dramatic increase in the cost of commercial, grain-based dairy feeds could trigger a move on both conventional and organic farms toward greater reliance on pasture and locally-grown forages.

III. "Avoided Impacts" Calculator Methodology - Step-by-Step

In the methodology outlined herein, nine steps are required to calculate the "avoided impacts" of a single lactating (milking) dairy cow on an organic dairy farm. The calculator has been developed within a Microsoft Excel workbook that contains worksheets numbered one through ten. The worksheets are linked together, in that input variable values from the worksheet labeled as Step 1 are used in calculations in the Step 2 and subsequent worksheets. Values calculated in the Step 3 worksheet are used in the Step 4 and Step 9 worksheets, and so on.

A Step 10 table provides the user of the calculator with a simple way to estimate the avoided impacts of a herd of milking cows of known size (a 100 cow milking herd is used in the example of a Step 10 table at the end of this report; any other herd size can be used as the input variable).

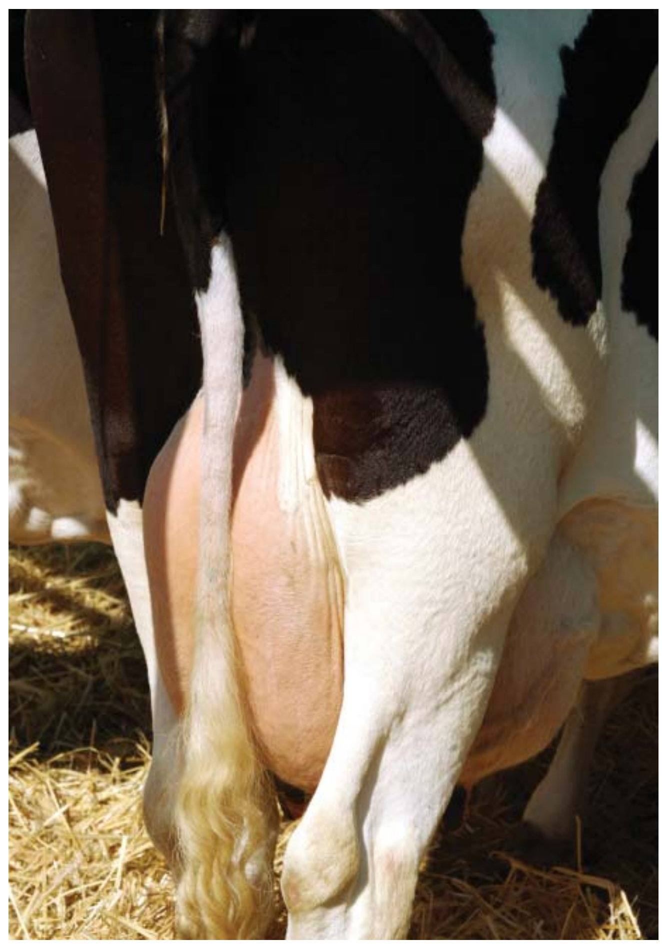
When a value of an input parameter like daily milk production levels or percent of Dry Matter Intake (DMI) from pasture is changed in one worksheet, the formulas and relationships embedded in the Excel workbook automatically recalculate all subsequent values dependent on these input variables.

Each step contains a combination of input variables and calculated values. Users of the calculator are encouraged to replace the default values currently in the workbook with values based on a specific farm, set of herds, or region. We have chosen average default values for required input parameters in order to demonstrate how the calculator works, and recognize that these default values will vary for any specific herd or region of the country.

Four steps are required to calculate the acres needed to produce the feed needed to support a single milking cow on a conventional dairy farm, as well as the pounds of synthetic nitrogen fertilizer, pesticides, and animal drugs likely administered to that cow. Each of these four steps is now described.

Step 1. Estimating the Feed Needed to Support One Milking Cow

In order to sustain a given number of milking cows in a herd on a year-round basis, a dairy farmer must also feed and manage dry cows, young heifers (some of which will become replacement cows), and bulls for breeding purposes. Step 1 in the methodology provides the basis for estimating the number of "milking cow equivalents" that must be fed to support one milking cow for a year.



In some cases, these additional animals will live on the farm where the milking cow is in production, while in other cases, some or all of these animals might be raised elsewhere. Dairy calf ranches have grown in popularity, for example, and provide dairy farmers an option to "farm out" the time-consuming task of raising young animals.

Many dairy farmers use a combination of natural breeding with bulls and artificial insemination. Some farmers sell all or most calves soon after birth, and buy mature, bred replacements. But for the purpose of estimating the avoided impacts associated with the conversion of a conventionally managed cow to organic production, dry cows, replacement animals, calves, and bulls must be raised somewhere.

In order to sustain milk production for 365 days from a single cow, we assume that there is a need for the dairy farmer to also feed:

- 0.2 mature dry cows;
- 0.4 heifers under one year of age;
- 0.5 heifers over one year old, but not yet milking; and
- 0.05 bulls.

These estimates of the number of animals needed to support a milking cow for a year are derived from a variety of dairy sector sources and published studies. Clearly, many management-related factors can change these parameter values on a specific farm. Examples include replacement strategies, cull rates, the market for calves, and the average number of lactations per cow prior to culling. The more lactations per cow, the fewer replacement animals needed, leading to a reduction in the overall feed and land required to support a single cow.

This is why users of the calculator have the ability to alter these default assumptions if they have data specific to their farm, a group of farmers (e.g., all operations shipping to a given processor), or a region (e.g., all dairies in Oregon or Wisconsin).

Feed Consumed by Different Classes of Animals

Many of the avoided impacts of organic dairy production are linked to the production of organic animal feed. To estimate these impacts, we must first calculate the total quantity of feed required to support a lactating dairy animal. Doing so requires factoring in the different amounts of feed required to support different groups and ages of animals.

Heifers and dry cows, for example, consume less feed than a mature milking cow. Again, there are a variety of conversion factors in the dairy science literature that estimate feed needs of dry cows and heifers compared to milk cows. Based on a review of a variety of such estimates, we project that on average:

- the typical dry cow consumes on average 50% of the Dry Matter Intake (DMI) of a milking cow;
- heifers under one year old consume an average 30% of the DMI of a milking cow;
- heifers older than one year old consume on average 63% of the DMI of a milking cow; and
- a bull consumes an estimated 80% of a milking cows typical DMI, taking into account that bulls consume less feed than milking cows but have to be fed for 14-18 months before reaching breeding age.

The calculator provides users the option to alter these input variables with hard data derived from records on a specific farm, a group of farms, or other data sources. Based on the above default assumptions, we project that an average 1.58 milking cow feed equivalents are needed to sustain a single milking cow in production for 305 days in a calendar year, as shown in the Step 1 worksheet below.

Step 1 also includes two other important input variables – average pounds of milk per day per cow, and average days per lactation. Production per milking cow per year is calculated by multiplying these two input variables, as shown at the bottom of the Step 1 worksheet. The default assumption for average daily milk production per cow on conventional farms is 70 pounds. The default assumption for the length of a lactation is 305 days, resulting in total milk production per cow per year of 21,350 pounds.

Table 1. Estimating the Milking Cow Feed Equivalents Needed to Support One Milking Cow on a Conventional Dairy Farm, and Cow Milk Production Levels

	Animal Units Based on Milking Cow Equivalents	Default Percent of Milking Cow Feed Intake	Estimated Milking Cow Feed Equivalents	Notes and Basis for Default Values [Replace default value(s) when more accurate or farm-specific data is available]
Average milking cow	1	100%	1	
Dry cows	0.2	50%	0.1	Default values: 0.2 dry cow for each milking cow; dry cows consume 50% of the feed intake of milking cows.
Heifers <1 year	0.4	30%	0.12	Default values: 0.4 heifers <1 year for each milking cow; heifers <1 year consume 30% of the feed intake of milking cows.
Heifers >1 year	0.5	63%	0.32	Default values: 0.5 heifers >1 year per milking cow; heifers >1 year consume 63% of the feed intake of milking cows.
Bulls	0.05	80%	0.04	Default values: 0.05 bulls per milking cow; bulls consume 80% of the feed intake of milking cows. Estimate of bulls required per cow will vary depending on whether natural breeding or artifical insemination is used.
Milking cow feed equivalents to sustain one milking cow			1.58	[Sum of milking cow animal equivalents]
MILK PRODUCTION LEVEL				
Pounds milk per cow per day (default value = 70)	70			[Use farm or herd specific value, if known]
Average days in lactation (default value = 305)	305			[Use farm or herd specific value, if known]
Production per cow per lactation (pounds)	21,350			[Pounds milk per day x average days in lactation]

This level of production is close to the average across all U.S. conventional dairy farms at the present time. Again, alternative values can be inserted in the calculator for both daily production and length of lactation. These changes will alter the total amount of DMI needed to support a milking cow, and hence the acres of various crops needed to support a cow.

Step 2. Dry Matter Intake Needs per Milking Cow Equivalent

Step 2 builds into the calculator the average amount of Dry Matter Intake (DMI) required by lactating dairy cows per pound of milk produced. Dairy nutritionists and farmers use DMI as a standard metric in estimating total feed needs for an animal or herd. Many organizations, including the National Academy of Sciences, have issued detailed conversion tables that report the DMI equivalents of, for example, a pound of ground corn, or corn silage, hay, wheat, or cottonseed meal.

The feed required to support a milking cow for a day is a complex function of the cow's breed, age, health status, the stage in the lactation, the degree of nutritional balance across the cow's total diet, feed quality, and her milk production level. A principle goal of dairy farm managers is to reduce as far as possible the DMI required to sustain a given level of production. In general, farmers can minimize the DMI required per pound of milk by keeping cows healthy, minimizing sources of stress, and providing the milking herd with consistent and high quality feed, as well as clean and accessible drinking water.

Dairy scientists have developed many different cow nutrition models to estimate the pounds of DMI required to produce a pound of milk. A series of estimates of dietary needs were developed using the Cornell–Penn-Minor Dairy (CPM-Dairy) model. CPM-Dairy computes dairy cattle feed requirements based on the characteristics of the animal, rations, stage of lactation, and production levels. The CPM-Dairy model is used by veterinarians, dairy nutrition consultants, and the feed industry in evaluating alternative rations for dairy herds (Chalupa et al., 2004).

The CPM-Dairy model was used to estimate feed needs on conventional and organic dairies at five levels of daily milk production: 55, 60, 65, 70, and 75 pounds. On both conventional and organic farms,

the assumptions used in making these projections include a lactating animal weight of 1,395 pounds, and a cow in her third lactation.

The estimates for the conventional cows include the feeding of a total mixed ration and use of routine feed supplements (e.g., rumensin) and bypass fats (e.g. Megalac, a concentrated source of digestible undegradable energy) that are designed to increase feed efficiency.

The estimates of the DMI required per pound of milk produced on organic dairies includes the assumption that cows are on a high forage, pasture-based diet. This requires animals to walk, on average, 1 mile per day to reach pasture and return to the barn, and actively graze.

Significantly different mixes of feeds on the conventional and organic dairies were used in this modeling exercise. For example, on a conventional dairy with the average cow producing 60 pounds of milk per day, corn silage would often make up 43% of DMI, and corn another 22%, for a total of two-thirds total DMI from corn-based feeds. Alfalfa hay would contribute another 8% of DMI. On an organic dairy with cows also producing 60 pounds of milk daily, pasture would account for an annual average of 20% of DMI and alfalfa hay another 27%, for a total of 47% from pasture and hay. Ground corn would provide another 36%.

The CPM-Dairy model projects that a cow on a high-energy, total mixed ration on a conventional dairy will require 0.6 pounds of DMI per pound of milk produced. This estimate is for a cow that is 160 Days in Milk (DIM), with a Body Condition Score of 3.5, and daytime average temperature of 65 degrees, nighttime temperature of 55 degrees, and 50% humidity. This value is incorporated in the Step 2 table below as a basic input variable.

The Step 2 table also calculates the pounds of DMI needed per milking cow per day, by multiplying the pounds of milk produced per day (from the Step 1 table), by the DMI required per pound of milk (0.6). The pounds of DMI required per day for one milking cow equivalent is also calculated in the Step 2 table. Based on the default values in the Step 1 and 2 tables, 66.36 pounds of DMI is required per day per milking cow equivalent.

Step 2. Total Dry Matter Intake Needs per Average Conventional Milking Cow Equivalent			
	Parameter Value	**Units**	**Notes**
DRY MATTER INTAKE REQUIRED PER POUND OF MILK			
*Default value 0.6	0.6	Pounds	[Replace default value if other value is known and applicable]
Dry matter needed per day per milking cow	42,0	Pounds	[DMI per pound x pounds milk per day]
Dry matter needed per day to sustain one milking cow	66.36	Pounds	[DMI per milking cow x milking cow equivalents in herd]

Step 3. Composition of Feeds in Cow Rations and Estimates of Crop Acres Needed

In Step 2 the total Dry Matter Intake required to support a milking cow, and a milking cow equivalent, were estimated. The next step in projecting avoided impacts is determining the mix of feedstuffs that contribute to each day's DMI, and then the acres of land required to produce the individual feeds and all feeds collectively. This is accomplished in Step 3.

The average daily diet of a milking dairy cow is highly variable across the country, from season to season, and by type of farm. Some operations rely largely on pasture and forages harvested from the farm, or nearby, while others are fully, or largely dependent on grains and supplements produced off the farm.

It would be a mammoth job to take into account all of the differences in dairy cow rations across the country and between the spring, summer, fall, and winter seasons. For this reason, we have developed a typical dairy cow ration that reflects average conditions on conventional dairy farms.

Twelve major dairy cow feed components in three categories – forage based feeds, grains, and protein supplements – are included in the Step 3a and 3b tables. These feeds were chosen to encompass as fully as possible, in a relatively simple model, the major feedstuffs supporting conventional dairy cow production on a year-round basis. The initial, default breakdown of DMI across these categories, and the feeds within each category, appear below and in the Step 3a table; percent dry matter and yield data is presented in the Step 3b table.

Forages, total of 45% DMI:

- Dry hay (typically alfalfa), 5%
- Hay silage or baleage, 5%
- Corn silage, 25%
- Other dry hay, 5%
- Pasture, 3%
- Greenchop, 2%

Grains, total of 45% DMI:

- Corn (all forms), 35%
- Barley, 2%
- Oats, 5%
- Wheat, 3%

Protein supplements, total of 10% DMI:

- Soybeans, 7%
- Other supplements, 3%

Note that pasture accounts for only 3% of DMI. In the 2002 National Animal Health Monitoring System survey of dairy cow management, the USDA reports that 75.3% of all cows "Did not rely on pasture for any part of lactating cows' rations" (see the report, "Dairy 2002, Part I: Reference of Dairy Health and Management in the United States," 2002). On the one-quarter of conventional dairy farms that do graze, we estimate that pasture contributes about 10% of average daily DMI, resulting in about 3% reliance on pasture across all farms.

Note as well that following the convention in most analyses of dairy cow nutrition, corn silage is

Step 3a. Composition of Feeds in Conventional Milking Cow Rations as a Percent of Dry Matter Intake and Estimation of Acres of Crops Needed to Supply Feed for One Milking Cow Equivalent (see notes)									
	Percent of Daily DMI	DMI per Cow Equivalent per Day	DMI to Pounds of Raw Feed Conversion	Adjustment Factor to Account for Storage and Feeding Losses	Pounds Feed Required per Day	Average Yield per Acre	Acres Required to Produce Feed per Day	Milking Days per Lactation	Acres Required per Milking Cow Equivalent per Lactation
Forage Feeds									
Dry alfalfa hay	5%	3.32	3.69	1.1	4.06	8,000	0.0005	305	0.15
Hay silage or baleage	5%	3.32	11.06	1.15	12.72	15,000	0.0008	305	0.26
Corn silage	25%	16.59	50.27	1.17	58.82	35,000	0.0017	305	0.51
Other dry hay	5%	3.32	3.69	1.1	4.06	6,000	0.0007	305	0.21
Pasture	3%	1.99	6.64	1	6.64	8,000	0.0008	305	0.25
Greenchop	2%	1.33	4.42	1.1	4.87	6,000	0.0008	305	0.25
[Add more forage here]									
Total Forages	**45%**	**29.86**	**79.77**		**91.15**		**0.0054**		**1.63**
Grain									
Corn	35%	23.23	26.39	1.08	28.5	8,456	0.003	305	1.03
Barley	2%	1.33	1.51	1.08	1.63	1,920	0.001	305	0.26
Oats	5%	3.32	3.73	1.08	4.03	1,280	0.003	305	0.96
Wheat	3%	1.99	2.26	1.45	3.28	2,700	0.001	305	0.37
{Add other grains here}									
Total Grains	**45%**	**29.86**	**33.89**		**37.44**		**0.01**		**2.62**
Protein Supplements									
Soybeans	7%	4.65	5.16	1.1	5.63	2,460	0.002	305	0.70
Other protein sources	3%	1.99	2.21	1.1	2.43	2,400	0.001	305	0.31
[Add more prot. feeds here]									
Total Protein Supplements	**10%**	**6.64**	**7.37**		**8.11**		**0.003**		**1.01**
Sum of Percents by Type of Feed (value should equal 100%)	**100%**								
Total Acres Required							**0.0312**		**5.26**

Notes: Small grain and other feed weight per bushel equals appears in the Step 3b table.

Sources:

1. "Percent of Daily DMI" - Established by user, reflecting the average daily ration of a specific herd, or average daily rations across a set of herds. Default value based on a typical conventional industry total mixed ration.
2. "DMI per Cow Equivalent per Day" - Calculated value based on "Percent of Daily DMI" for a given feedstuff, multiplied by the total DMI required per day to sustain a milking cow equivalent.
3. "DMI to Pounds of Raw Feed Conversion" - Conversion of the pounds of DMI required per day of a given feedstuff, to actual pounds of the feedstuff taking into account the percent of DMI in a pound of feedstuff. Data on "Percent Dry Matter" per pound of feedstuff is from "Nutrient Requirements of Dairy Cattle," National Research Council, 1988 edition.
4. "Adjustment to Account for Storage and Feeding Loses" – Established by user reflecting conditions on a farm or across a set of herds. Default values are from "Planning the Yearly Forage and Commodity Needs for a Dairy Herd," ASC-160, Cooperative Extension Service, University of Kentucky.
5. "Pounds Feed Required per Day" – Calculated value (pounds raw feed needed, multiplied by storage and feeding loss adjustment factor).
6. "Average Yield per Acre" – When known, user should insert farm specific, or average regional crop yields. Default values are national average yields from the USDA's National Agricultural Statistics Service publications.
7. "Acres Required to Produce Feed per Day" – Calculated value (pounds feed required per day divided by yield per acre).
8. "Milking Days per Lactation" – User should insert farm specific or average herd value, when known. Default value based on a typical lactation.
9. "Acres Required per Milking Cow Equivalent per Lactation" – Calculated value (acres required to produce feed per day, multiplied by milking days per lactation).

Step 3b. Yield Assumptions and DMI Conversion					
Crop	**Percent Dry Matter**	**Yield per Acre**	**Units**	**Pounds per Acre**	**Notes**
Dry alfalfa hay	90%	4	Tons	8,000	NASS
Other dry hay	90%	3	Tons	6,000	Yield = Dry hay x adjustment factor
Hay silage of baleage	30%	7.5	Tons	15,000	Yield = 2.5 x other dry hay
Pasture	30%	4	Ton	8,000	Yield = 0.7 x other dry hay
Greenchop	30%	3	Tons	6,000	Yield = Other dry hay
Corn silage	33%	17.5	Tons	35,000	NASS
Corn	88%	151	Bushels	8,456	NASS; Bushel conversion = 56 pounds
Barley	88%	40	Bushels	1,920	NASS; Bushel conversion = 48 pounds
Oats	89%	40	Bushels	1,280	NASS; Bushel conversion = 32 pounds
Wheat	88%	45	Bushels	2,700	NASS; Bushel conversion = 60 pounds
Soybeans	90%	41	Bushels	2,460	NASS; Bushel conversion = 60 pounds
Other protein	90%	40	Bushels	2,400	Not yet defined; Bushel conversion = 60
[Add more crops here]					

included under forages. Together with corn grain, corn provides 60% of daily DMI under the default values incorporated in Step 3. Again, these values can be changed by users when farm-specific data are available. In addition, users of the calculator can change any of these feeds, feed forms, and/or percentages of DMI, as long as the sum of all feeds still adds up to 100% of DMI.

If new feeds are added to the calculator (e.g., green bean processing wastes), corresponding changes must be made in subsequent tables in order for the calculator to project the acres required to grow the added feedstuffs, and the impacts of agricultural chemical use on those acres. These data must include:

- percent DMI in a pound of feed;
- yields per acre;
- storage and feeding losses;
- synthetic nitrogen fertilizer applied per acre; and
- pounds of herbicide and insecticide active ingredients applied per acre.

In some cases, accurate data on additional feedstuffs will be readily available to augment the tables in the calculator, while in other cases necessary information may be difficult to obtain. For example, a dairy farmer would know the total pounds of waste from a green bean processing plant that are being fed to the milking herd on a given day, but the farmer might not know how many acre-equivalents of green beans that volume of processing waste represents. Once the acre-equivalents of green beans are known, accessing data on the average number of pounds of pesticides and fertilizers applied on an acre of processing green beans will usually be relatively straightforward in the case of major field, row, fruit and vegetable crops.

Converting from Dry Matter Intake (DMI) to Pounds of Feed

Dry feeds have relatively higher percentages of DMI – dry hay is generally listed as 90% DMI, as are soybeans and most other protein supplements. Wetter feeds, like silage, have much lower percents of DMI – corn silage is rated as 33% DMI, while hay silage is 30%.

The values for percent of DMI in a pound of the 12 basic dairy cow feedstuffs are shown in the Step 3a table. These values are taken from the feed composition tables in the National Research Council's report *Nutrient Requirements of Dairy Cattle*, Sixth Revised Edition (1988). Based on the fact that dry hay contains 90% DMI, a cow getting 5% of her total DMI from dry alfalfa hay must consume 3.38 pounds of hay to consume 3.04 pounds of DMI (3.38 multiplied by 90%), as shown in the first row of values in the Step 3a table. Likewise, it takes 30.42 pounds of hay silage to deliver to the cow 9.12 pounds of DMI (30.42 pounds of silage multiplied by 30%).

Adjustments for Storage and Feeding Losses

A second adjustment is required to take into account losses of feed in storage and during the feeding process. Estimates have been made of these average losses by several universities. The values in the Step 3a table are from *"Planning the Yearly Forage and Commodity Needs for a Dairy Herd,"* a University of Kentucky Cooperative Extension publication (ASC-160).

Storage and feeding losses vary from 8% in the case of corn and small grains, to 17% for corn silage, as shown in the Step 3a table. As with other input parameters, these values reflect typical and average conditions, and can be altered in the calculator to reflect actual values on a given farm, a group of farms, or region. The last column in the Step 3a table calculates the acres of cropland that must be planted to a given crop to meet the fed needs of a milking cow equivalent. The yield assumptions that are embedded in these estimates of required acreage are shown in the Step 3b table. Crop yields are clearly a key parameter that varies from farm to farm, by soil type, and across the country. The values in the calculator reflect recent national averages as reported in annual surveys carried out by USDA's National Agricultural Statistics Service, but can be changed by users with yield data specific to their operation or region.

Grains (small grains and corn) are the most important crops in terms of acres planted to support one conventional milking cow equivalent – accounting for 2.62 acres. Forages require another 1.63 acres, and protein supplements, 1.01 acres, mostly for soybeans. The total acres required to support one milking cow equivalent is estimated to be 5.26.

Step 4. Nitrogen Fertilizer and Pesticides Required to Feed One Conventional Milking Cow Equivalent

We estimate that on average across the country, 5.26 acres of cropland and pasture is required to produce the feed needed to sustain one milking cow equivalent on a conventional dairy farm that is producing 21,350 pounds of milk per 305 day lactation. This acreage might be on the farm, in the county, or hundreds or even thousands of miles away. In highly productive regions like the irrigated west, fewer acres will be required because of higher than average yields, while in northern areas with marginal soils, significantly more acres will be necessary to support a milking cow for one year.

The farther animal feed must be transported (organic or conventional), the greater the environmental footprint and cost per pound of DMI. Feedstuffs like baleage and silage are generally not transported very far because their high moisture content vastly adds to weight and transportation costs. Multiple studies have concluded that dairy farms that make heavy use of on-farm pasture and locally grown forages use less energy per hundred weight of milk than operations feeding predominantly grain based rations, especially when the grains are trucked many miles to reach the farm.

Avoided Pesticide and Fertilizer Impacts

Estimating the total quantity of toxic synthetic pesticides and conventional fertilizers applied on 5.26 acres of land supporting a conventional dairy cow equivalent is reasonably simple. Data are available from the USDA's National Agricultural Statistics Service (NASS) on the average pounds of fertilizers and pesticides applied on different crops, both by state and nationally. For the purpose of this report, and our initial projections of average or typical avoided impacts, we use average pesticide and fertilizer application rates at the national level for the 12 crops currently included in the calculator.

The Step 4 table on page 18, presents these calculations, drawing on the acreage figures from the Step 3a table for each feedstuff. The bottom part of the table reports the average pounds of nitrogen fertilizer, herbicides, and insecticides applied per acre by crop, based on USDA-NASS data. Fungicide use is minimal on these crops, and is excluded at this stage.

Clearly, the 12 feedstuffs included in the Step 4 table do not reflect the diversity of feeds given to dairy cattle across the country, but do account for the bulk of dairy farm feedstuffs. Based on the 12 feeds in the Step 3a and 4 tables and the other assumptions and input variables noted above, each conventional dairy cow equivalent requires 337.8 pounds of nitrogen fertilizer, 5.9 pounds of herbicides, and 0.59 pounds of insecticides to sustain production for a year, and over time.

Fertilizer and pesticide inputs on corn and soybeans account for the bulk of these totals. Over one-half of the 338 pounds of nitrogen fertilizer needed to support a conventional dairy animal for a year is applied to corn for grain and silage. Corn production also accounts for just over one-half of the herbicides applied, or about 3.2 pounds per acre for corn grain and silage.

Step 4. Estimates of Nitrogen Fertilizer and Pesticides Required to Produce Feed for One Conventional Milking Cow Equivalent (see notes)				
	Acres per Cow	Nitrogen Fertilizer (pounds N)	Herbicides (pounds A.I.)	Insecticides (pounds A.I.)
Forage Feeds				
Dry alfalfa hay	0.15	-	0.046	0.03
Hay silage or baleage	0.26	20.48	0.078	0.05
Corn silage	0.51	67.66	1.076	0.10
Other dry hay	0.21	16.33	0.062	0.04
Pasture	0.25	10.02	-	-
Greenchop	0.25	9.80	0.074	0.05
[Add other forage feed(s) here]				
Total Forages	1.63	124.28	1.336	0.28
Grains				
Corn	1.03	135.71	2.159	0.21
Barley	0.26	14.75	0.181	0.03
Oats	0.96	23.99	0.959	0.03
Wheat	0.37	21.49	0.148	0.001
[Add other grain feed(s) here]				
Total Grains	**2.62**	**195.94**	**3.448**	**0.26**
Protein Supplements				
Soybeans	0.7	2.11	0.704	0.02
Other	0.31	15.46	0.464	0.03
[Add other protein feed(s) here]				
Total Protein Supplements	1.01	17.57	1.168	0.05
Total All Feeds	**5.26**	**337.80**	**5.95**	**0.59**

National Average Input Use per Acre of Crop	Year; Data Source	Nitrogen Fertilizer per Acre (pounds N)	Herbicides per Acre (pounds A.I.)	Insecticides per Acre (pounds A.I.)
Dry alfalfa hay	**Estimate**	**0**	**0.3**	**0.2**
Hay silage or baleage	**Estimate**	**79.2**	**0.3**	**0.2**
Corn silage	**USDA, 2005**	**132.0**	**2.1**	**0.2**
Other dry hay	**Estimate**	**79.2**	**0.3**	**0.2**
Pasture	**Estimate**	**39.6**	**-**	**-**
Greenchop	**Estimate**	**39.6**	**0.3**	**0.2**
Corn	**Estimate**	**132.0**	**2.1**	**0.2**
Barley	**USDA, 2003**	**57.0**	**0.7**	**0.1**
Oats	**USDA, 2005**	**25.0**	**1.0**	**0.03**
Wheat	**USDA,2006**	**58.0**	**0.4**	**0.01**
Soybeans	**USDA, 2006**	**3.0**	**1.0**	**0.03**
Other protein sources	**Estimate**	**50.0**	**1.5**	**0.1**
[Add other feedstuff(s) here]				
NOTES:				

1. "Acres per Cow" - values from last column, Step 3a

2. "Nitrogen Fertilizer" – Calculated value (acres per cow multiplied by nitrogen pounds per acre). Average nitrogen pounds applied per acre data are from USDA, National Agricultural Statistics Service surveys, when available.

3. "Herbicides" – Calculated value (acres per cow multiplied by average pounds of herbicide active ingredients applied per acre). Average herbicide application rates per acre are from USDA, National Agricultural Statistics Service surveys of agricultural chemicalal usage (multiple years), when available.

4. "Insecticides" – Calculated value (acres per cow multiplied by average pounds of insecticide active ingredients applied per acre). Average insecticide application rates per acre are from USDA, National Agricultural Statistics Service surveys of agricultural chemical usage (multiple years), when available. Corn insecticide use includes insecticide seed treatments (0.07 pounds per acre), insecticides appplied at planting and during the season (0.13 pounds per acre). The endotoxins produced by Bt corn are not inlcuded in the estimate.

Step 5. Synthetic Animal Drugs and Hormones "Doses Delivered"

Dairy farm animal health care and management surveys are conducted periodically by the USDA's Animal and Plant Health Inspection Service, as part of the National Animal Health Monitoring System (NAHMS). Information on the incidence of various diseases and frequency of treatments in the NAHMS 2002 and 2007 dairy sector surveys, along with surveys published in the dairy science literature, were used to compile the input variable values in the Step 5 table covering animal drug use on conventional dairy farms. Users can substitute data relevant to an individual farm or set of farms, if known.

In the case of antibiotics in heifer rations and coccidiostats, these drugs are fed at low doses continuously during various life stages of a dairy animal. In the Step 5 table, this pattern of drug administration is reported as a single treatment, even though the animals are given the drug on a daily basis.

In the 2007 survey, NAHMS reported that 17.2% of lactating dairy cattle were administered the recombinant bovine Growth Hormone (rbGH). It is assumed that the average treated cow receives 15 injections of rbGH, one every 14 days over 210 days. (The rbGH Posilac drug label allows for 18 injections per 305 day lactation). Accordingly, the average milk cow equivalent would be treated 2.6 (17.2% multiplied by 15). The frequency of rbGH use has fallen in recent years as a result of the decision by most milk processors to prohibit it's use.

According to a survey by Caraviello et al. (2006), 87% of 103 large conventional dairies used hormone injections as part of an effort to synchronize estrus and increase success in a timed artificial insemination (TAI) based breeding program. We assume that the same percentage of cows on conventional farms are treated. Dr. Paul Fricke, an extension dairy reproduction specialist at the University of Wisconsin-Madison, describes the common synchronization protocols used on conventional dairy farms in a paper entitled "Ovsynch, Pre-Synch, the Kitchen-Synch: What's Up with Synchronization Protocols?" The most common protocols entail three to five injections per cycle; we assume an average of four in the estimate or reproductive aid doses delivered in Step 5.

A significant share of the treated cows will fail to conceive in the first TAI cycle, and will require another round of treatment. According to the Caraviello survey, the average dairy manager moved cows to the clean-up bull pen after an average of 6.6 failed TAI cycles, and culled cows after an average of 8.8 failed inseminations. A survey of high-producing herds found that on average 2.8 attempts were required per new pregnancy (Kellogg et al., 2001). In Step 5, we assume that the average cow is treated with reproductive aids through three cycles, resulting in an average of 12 injections per treated cow (4 injections per cycle, three cycles).

A number of antibiotics are used at various life stages on conventional dairy farms. The 2002 and 2007 NAHMS reports cover most of the common uses of antibiotics, but in some cases do not provide all information needed to estimate the number of animals treated or the treatments per animal. For this reason, the average number of antibiotic treatments per milking cow equivalent in the Step 5 table – 1.59 – is likely an underestimate.

An estimated 14.8 doses of synthetic drugs are administered to each conventional dairy cow equivalent, based on the information in the 2002 and 2007 dairy sector surveys and published literature on reproductive aid injections. It is virtually certain that the several drugs commonly used on conventional dairy farms are not included in the Step 5 table because of a lack of data on the frequency of use. As in the case of other tables, users of the calculator can replace the default drug doses delivered values with data specific to a single or multiple herds.

Step 5. Synthetic Animal Drugs and Hormones Administered to Milking Dairy Cows and Young Stock on Conventional Farms (see notes)						
	Percent Dry Cows Treated	**Percent Heifers or Calves Treated**	**Percent Milking Cows Treated**	**Number of Treatments per Lactation or Animal**	**Average Treatments per Animal**	**Average Treatments per Milking Cow Equivalent**
Production Enhancing Drugs						
rbGH (recombinant bovine Growth Hormone			17.2%	15	2.6	2.58
Reproductive Aids			**87%**	**12**	**10.4**	**10.4**
Antibiotics						
Medicated milk replacer		57.5%		1	0.58	0.23
Ionophores (Rumensin, Bovatec)		58.1%	40%	1	0.98	0.63
Heifer rations		17.5%		1	0.18	0.07
Intramammary at dryoff	84.6%			1	0.85	0.17
Any antimicrobials		7%		1	0.07	0.03
Mastitis antimicrobials			15%	2	0.3	0.3
Other treatments in milking cows			16.5%	1	0.17	0.17
Total Antibiotics						**1.59**
Other						
Coccidiostats in heifer feed		56.5%		1	0.57	0.226
All Drugs						**14.8**
Notes:						
1. Except as noted below, data on the percent of animals treated with various drugs are derived from the National Animal Health Monitoring System, USDA reports "Dairy 2002, Part III: Reference of Dairy Cattle Health and Health Management Practices in the United States, 2002," December 2003; and, "Dairy 2002, Part IV: Antimicrobial Use on U.S. Dairy Operations, 2002," September 2005.						
2. Number of treatments per cow with rbGH (15) is based on delivery of an injection every 14 days for 210 days. The Posilac label allows for a maximum of 18 injections per 305 day lactation.						
3. Reproductive aid injections based on an average of three cycles of treatment per milking cow, four injections per cycle. Average injections per cycle based on the Ovsynch, Co-Synch, and Heat-Synch programs, as described in (Fricke)						
4. Number of treatments per animal for "Antibiotics" and "Other" drugs is set at 1, except for mastitis antimicrobials, which is set at 2. These values likely underestimate the average number of treatments with some drugs, but no reliable source of data is available to establish the average number of treatments.						
5. Percent of cows given rbGH is from the USDA NAHMS report "Dairy 2007, Part I," page 79.						
6. Percent of calves being given medicated milk replacer is from the USDA HAHMS report "Dairy 2007, Part I," page 50.						
7. Percent of heifers given coccidiostats and ionophores is from the NAHMS report "Dairy 2007, Part I," page 55.						

Step 6. Estimating the Feed Needed to Support One Milking Cow on an Organic Dairy Farm

The number of milking cow feed equivalents needed on an organic dairy farm to sustain one milking cow can be estimated using the approach previously applied to cows on conventional dairies. The Step 6 table presents the basic information on the number of cows on an organic dairy, as well as the number of milking cow feed equivalents.

Based on the input parameters and default assumptions in the Step 6 table, an estimated 1.58 milking cow equivalents are required to sustain a single milking cow on organic dairy farms.

The lower portion of the table sets forth the default production levels and length of lactation – 60 pounds per day over a 305 day lactation, for total milk production per cow of 18,300.

As the case with other input variables, users of the calculator can change these values to reflect actual data on a specific farm, or set of farms.

Step 6. Estimating the Milking Cow Feed Equivalents Needed to Support One Milking Cow on an Organic Dairy Farm, and Cow Milk Production Levels

	Animal Units Based on Milking Cow Equivalents	Default Percent of Milking Cow Feed Intake	Estimated Milking Cow Feed Equivalents	Notes and Basis for Default Values
Average milking cow	1	100%	1	
Dry cows	0.2	50%`	0.1	Default values: 0.2 dry cow for each milking cow; dry cows consume 50% of the feed intake of a milking cow
Heifers < 1 year	0.4	30%	0.12	Default values: 0.4 heifers < 1 year for each milking cow; heifers <1 year consume 30% of the feed intake of milking cows
Heifers > 1 year	0.5	63%	0.32	Default values: 0.5 heifers > 1 year per milking cow; heifers > 1 year consume 63% of the feed intake of milking cows
Bulls	0.05	80%	0.04	Default values: 0.05 bulls per milking cow; bulls consume 80% of the feed intake of milking cows. Estimate of bulls required per cow will vary depending on whether natural breeding or artificial insemination is used.
Milking cow feed equivalents to sustain one milking cow			**1.58**	[Sum of animal equivalent numbers]
Production Level				
Pounds of milk per cow per day (default = 60)	60			[Use farm or herd specific value, if known]
Average days in lactation (default = 305)	305			[Use farm or herd specific value, if known]
Production per cow per year (pounds)	18,300			[Pounds milk per day * average days of lactation]
Note: Replace default value(s) when more accurate or farm-specific data is available				

Step 7. Total Dry Matter Intake Needs per Average Organic Milking Cow Equivalent

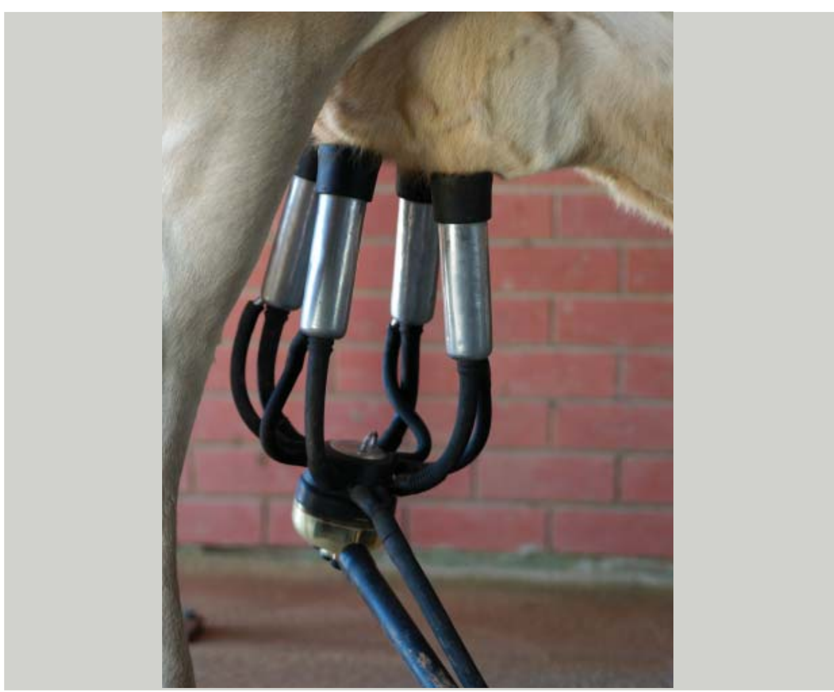
The same dairy cow nutrition model was used to estimate the pounds of Dry Matter Intake (DMI) required to produce a pound of milk on organic farms. Similar assumptions were used in terms of size of cows (1,395 pounds), days in milk (240), lactation (the third), temperatures, and humidity. As discussed previously, there were three differences incorporated in the model projections of the pounds of DMI per pound of milk on the conventional versus organic dairies:

- Organic cows were assumed to walk an extra mile per day in the course of accessing pasture and returning to the milking barn;
- The feed ration was much more dependent on pasture and forages on the organic farm, while corn was the dominant source of DMI on the conventional farm; and
- Conventional cow rations included Megalac, Rumensin, and animal proteins used to increase feed efficiency.

The Step 7 table estimates the total Dry Matter Intake needed to sustain a milking cow on an organic dairy producing 60 pounds of milk daily. A total of 0.7 pounds of dry matter are required to produce one pound of milk. Each milking cow on an organic farm requires 42 pounds of DMI per day, or 66.4 pounds of DMI per milking cow equivalent. In contrast on the average conventional farm, in the Step 2 table, the model projects the need for 0.6 pounds of DMI per pound of milk. The higher level of milk production on the conventional farm results in the need for more DMI per milking cow equivalent, despite the need for about the same DMI per pound of milk produced on the conventional farm.

Step 7. Total Dry Matter Intake Needs per Average Organic Milking Cow Equivalent

	Parameter Value	Units	Notes and Default Values
Dry Matter Intake (DMI) required for pound of milk		Pounds	[Replace default value if other value is applicable]
* Default value 0.7	0.7		
Dry matter needed per day per milking cow	42.0	Pounds	[DMI per pound * pounds milk per day]
Dry matter needed for herd per milking cow	66.4	Pounds	[DMI per pound * milking cow equivalents in herd]



Step 8. Composition of Feeds on Organic Dairy Farms and Estimates of the Acres of Organic Crops Needed to Supply Feed

The composition of feed on a typical organic dairy farm is presented in the Step 8a table, on page 24, and is based on seven feeds instead of 12. In the case of organic farms, the National Organic Program rule requires that dairy animals be given access to pasture when possible, given local climatic conditions. While the NOP pasture rule has not been finalized, the industry supports a policy calling for pasture to meet at least 30% of DMI needs for a minimum of 120 days. On many organic dairy farms, particularly those in the west and southern regions of the country, most farmers are able to increase the percentage of DMI from pasture well above the 30% benchmark and for more than 120 days.

In the Step 8a table, we assume that pasture provides, on average throughout the year, 30% of DMI, and that pasture plus other sources of forages provides 59% of DMI, compared to 45% on a typical conventional dairy farm (including corn silage).

Across all crops, a total of 6.35 acres are projected as necessary to sustain a milking dairy cow equivalent on an organic farm. The amount of land producing forages – 3.6 acres – accounts for the largest share of acres (about 56%). Another 1.8 acres is required to produce the grains in rations supporting a cow equivalent on organic dairies, and 0.97 acres of cropland are needed to produce protein supplements.

The yields included as input variables and default assumptions in the Step 8b table are the same as in the Step 3b table. Users of the calculator can insert their own values for both the composition of feeds and crop yields if farm-specific data are available.

Step 9. Impacts of the Conversion of Conventional Dairy Cows to Organic Management

The magnitude of certain avoided impacts as a result of organic dairy production can now be estimated, based upon the parameter values, default assumptions, and calculations in Steps 1 through 8. The Step 9 table reports the estimated differences between a single conventional and organic milking cow equivalent for a year. It encompasses differences in milk production level, the composition of feed rations, acres required to satisfy DMI needs by major types of feed (forages, grain, protein supplements), and avoided impacts in terms of pounds of nitrogen fertilizer, herbicides, and insecticides and animal drugs that would not applied if a cow was managed organically.

Cows under conventional management are less dependent on forages, and instead rely more heavily on grains. About 3.6 acres of forages are required on a typical organic dairy to support a milking cow, whereas only about 1.6 is needed on conventional farms (and this 1.6 acres includes 0.5 acres of corn silage). This difference reflects, in part, the much greater reliance on pasture and hay on organic farms, compared to conventional farms, which rely on corn for 60% of DMI.

On conventional farms, one-quarter of total DMI is projected to be met with corn silage, requiring just 0.51 acres because of the relatively high yield per acre of corn silage. On organic farms, the 30% of DMI provided by pasture requires on average 2.5 acres. Pasture requires about 4.4 times the land as corn silage per unit of DMI produced. On the other hand, corn production on a conventional farm is more input intensive, requiring a significant share of the nitrogen fertilizer, herbicides, and insecticides required to sustain a dairy animal. Plus, land suitable for growing corn is also typically more fertile and higher quality than pasture land.

Step 8a. Composition of Feeds in Milking Cow Rations on Organic Diary Farms as a Percent of Dry Matter Intake and Estimates of Acres of Organic Crops Needed to Supply Feed for One Organic Milking Cow Equivalent (see notes)									
	Percent of Daily DMI	**DMI per Cow Equivalent per Day**	**DMI to Pounds of Raw Feed Conversion**	**Adjustment Factor to Account for Storage and Feeding Losses**	**Pounds Feed Required per Day**	**Average Yield per Acre**	**Acres Required to Produce Feed per Day**	**Milking Days per Lactation**	**Acres Required per Milking Cow Equivalent per Lactation**
Forage Feeds									
Pasture	30%	19.91	79.63	1.25	99.54	12,000	0.0008	305	2.53
Dry hay (alfalfa)	13%	8.63	9.59	1.1	10.54	6,700	0.0016	305	0.48
Hay silage	6%	3.98	13.27	1.15	15.26	12,600	0.0012	305	0.37
Corn silage	10%	6.64	20.11	1.17	23.53	35,000	0.0007	305	0.21
[Add more forage feed(s) here]									
Total Forages	**59%**	**39.15**	**122.60**		**148.87**		**0.012**		**3.58**
Grain									
Corn (all forms)	20%	13.27	15.08	1.08	16.29	8,456	0.002	305	0.59
Small Grains (all forms)	12%	7.96	9.05	1.08	9.77	2,478	0.004	305	1.20
[Add other protein feed(s) here									
Total Grains	**32%**	**21.24**	**24.13**		**26.06**		**0.006**		**1.79**
Protein Supplements									
Soybeans	6%	3.98	4.42	1.1	4.87	2,472	0.002	305	0.6
Other protein sources	3%	1.99	2.21	1.1	2.43	2,000	0.001	305	0.37
[Add more here]									
Total Protein Supplements	**9%**	**5.97**	**6.64**		**7.30**		**0.003**		**0.97**
Sum of Percents by Type of Feed (value should equal 100%)	100%								
Total Acres Required							**0.0301**		**6.35**

Notes: Small grain weight per bushel equals weighted average of winter wheat (50%; 60 pounds), oats (25%; 32 pounds), and barley (25%; 48 pounds). Other protein assumes 50 pounds per average bushel.

Sources: 1. “Percent of Daily DMI” - Established by user, reflecting the average daily ration of a specific herd, or average daily rations across a set of herds. Default value based on typical organic industry average rations.

2. “DMI per Cow Equivalent per Day” - Calculated value based on “Percent of Daily DMI” for a given feedstuff, multiplied by the total DMI required per day to sustain a milking cow equivalent.

3. “DMI to Pounds of Raw Feed Conversion” - Conversion of the pounds of DMI required per day of a given feedstuff, to actual pounds of the feedstuff taking into account the percent of DMI in a pound of feedstuff. Data on “Percent Dry Matter” per pound of feedstuff is from “Nutrient Requirements of Dairy Cattle,” National Research Council, 1988 edition.

4. “Adjustment to Account for Storage and Feeding Loses” – Established by user reflecting conditions on a farm or across a set of herds. Default values are from “Planning the Yearly Forage and Commodity Needs for a Dairy Herd,” ASC-160, Cooperative Extension Service, University of Kentucky.

5. “Pounds Feed Required per Day” – Calculated value (pounds raw feed needed, multiplied by storage and feeding loss adjustment factor).

6. “Average Yield per Acre” – When known, user should insert farm specific, or average regional crop yields. Default values are national average yields from the USDA’s National Agricultural Statistics Service publications.

7. “Acres Required to Produce Feed per Day” – Calculated value (pounds feed required per day divided by yield per acre).

8. “Milking Days per Lactation” – User should insert farm specific or average herd value, when known. Default value based on typical lactation.

9. “Acres Required per Milking Cow Equivalent per Lactation” – Calculated value (acres required to produce feed per day, multiplied by milking days per lactation).

Step 8b. Yield Assumptions and DMI Conversion					
Crop	**Percent Dry Matter**	**Yield per Acre**	**Units**	**Pounds per Acre**	**Notes**
Dry alfalfa hay	90%	3.35	Tons	6,700	[Replace with farm or herd specific yield]
Hay silage of baleage	30%	6.3	Tons	12,600	Replace with farm or herd specific yield]
Pasture	25%	6	Ton	12,000	Replace with farm or herd specific yield]
Corn silage	33%	17.5	Tons	35,000	Replace with farm or herd specific yield]
Corn	88%	151	Bushels	8,456	Replace with farm or herd specific yield]
Small grains	88%	41	Bushels	2,478	Replace with farm or herd specific yield]
Soybeans	90%	41	Bushels	2,472	Replace with farm or herd specific yield]
Other protein	90%	40	Bushels	2,000	Replace with farm or herd specific yield]
[Add more crops here]					

Step 9. Impacts of the Conversion of One Conventional Diary Cow Equivalent to Organic Management				
	Management System		**Difference Conventional to Organic**	
	Conventional	**Organic**	**Magnitude**	**Percent**
Production Level (pounds milk per year)	**21,350**	**18,300**	**3,050**	**16.7%**
Percent of DMI in Ration				
Total forage feeds	45%	59%	-14%	
Total grain	45%	32%	13%	
Total protein supplements	10%	9%	1%	
Acres Required to Support One Cow Equivalent				
Total forage feeds	1.63	3.58	(1.95)	-54.5%
Total grain	2.62	1.79	0.83	46.2
Total protein supplements	1.01	0.97	0.04	4.3%
All Crops and Feeds	**5.30**	**6.35**	**(1.08)**	**-17.1%**
Avoided Impacts per Cow Equivalent				
Synthetic Nitrogen applied (pounds N)	337.8	0	337.8	100%
Herbicides applied (pounds A.I.)	6.0	0	6.0	100%
Instecticides applied (pounds A.I.)	0.6	0	0.6	100%
Insecticides plus herbicides	6.5		6.5	100%
Animal Synthetic Drug Treatments Avoided				
rbGH (recombinant Bovine Growth Hormone)	2.60	0	2.60	100%
Reproductive aids	10.40	0	10.40	100%
Antibiotics	1.59	0	1.59	100%
Coccidiostats (parasite control)	0.23	0	0.23	100%
All Synthetic Drugs	**14.80**	**0**	**14.80**	**100%**

The "Avoided Impacts" Calculator

The Organic Center is making available an easy to use, Excel-based calculator that encompasses the above nine Steps and tables described above (access the calculator at http://www.organic-center.org/science.environment.php?action=view&report_id=139). In addition, the calculator has a Step 10 table where a user can estimate the impacts avoided, or changes in acreage required to sustain a cow, based on different herd sizes. An example involving a herd of 100 animals appears below.

Users of the calculator can modify the tables in a number of ways, or replace input variable and default assumptions with actual data reflecting a specific farm. Some modification in the structure and data in the calculator will be required, however, if a user chooses to add additional feeds into the calculator.

The results produced by the calculator are particularly sensitive to changes in milk production levels, the pounds of DMI required per pound of milk, the composition of feeds, and yield levels. In general, the higher the milk production level, the more acres required to support a cow, but the fewer acres required per hundred weight of milk.

Individuals using the calculator are invited to provide comments to the Organic Center on ways to improve utility or ease of use. We also welcome suggestions on ways to improve the accuracy of the underlying estimates.

Step 10. Avoided Impacts per Milking Cow Equivalent Associated with a Dairy Herd of Known Size Converted from Conventional to Organic Production (Example below - 100 Milking Cows)				
	Number of Milking Cows	Acres	Pounds	Treatments
Herd Size (insert number of milking cows)	100			
Organic Acres Required to Support the Herd				
Total forage feeds		358		
Total grain		179		
Total protein supplements		97		
All Crops and Feeds		635		
Avoided Impacts per Herd				
Synthetic Nitrogen applied (pounds N)			33,780	
Herbicides applied (pounds A.I.)			595	
Instecticides applied (pounds A.I.)			59	
Insecticides plus herbicides			654	
Animal Synthetic Drug Treatments Avoided				
rbGH (recombinant bovine Growth Hormone)				258
Reproductive aids				1,040
Antibiotics				159
Coccidiostats (parasite control)				23
All Synthetic Drugs				1,480

References

Amaral-Phillips, D.M. and J. McAllister, *"Planning the Yearly Forage and Commodity Needs for a Dairy Herd,"* Cooperative Extension Service, Univ. of Kentucky, ASC-160; http://www.uky.edu/Ag/AnimalSciences/dairy/extension/nut00106.pdf

Caraviello, D.Z. et al., "Survey of Management Practices on Reproductive Performance of Dairy Cattle on Large US Commercial Farms," *J. Dairy Science*, Vol 89: 4723-4735 (2006).

Chalupa, W. et al., *"Dairy nutrition models: their forms and applications,"* http://www.docstoc.com/docs/4530729/W-Chalupa-et-al-Dairy-nutrition-models-their-forms (2004).

Eastridge, M.L. et al., "Nutrient Requirements for Dairy Cattle of the National Research Council Versus Some Commonly Used Ration Software," *J. Dairy Science,* Vol 81: 3059-3062 (1998)

Economic Research Service, USDA. "2005 Dairy Agricultural Resource Management Survey," tables generated for The Organic Center by Purdue University.

El-Zarkouny, S.Z. et al., "Pregnancy in dairy cows after synchronized ovulation regimens with or without presynchronization and progesterone," *J. Dairy Science*, Vol 87: 1024-1037 (2004).

Fricke, P.M. *"Ovsynch, Pre-synch, the Kitchen-Synch: What's Up with Synchronization Protocols,"* Dept. of Dairy Science, University of Wisconsin-Madison, http://www.wisc.edu/dysci/uwex/brochures/brochures/fricke.pdf

Hoard's Dairyman, "What we've learned from grazing," 57th Annual Hoard's Dairyman Round Table, (2007).

Kellogg, D.W. et al., "Survey of Management Practices Used for the Highest Producing DHI Herds in the United States," *J. Dairy Science,* Vol 84 (E. Suppl.)" E120-127 (2001).

Olynk, N.J. and C.A. Wolf, "Economic Analysis of Reproductive Management Strategies on US Commercial Dairy Farms," *J. Dairy Science*, Vol 91:4082-4091 (2008).

Santos, J.E.P. et al., "Effect of bST and reproductive management on reproductive performance of Holstein dairy cows," *J. Dairy Science,* Vol 87: 868-881 (2004)

Windig, J.J. et al., "Influence of herd environment on health and fertility and their relationship with milk production," *J. Dairy Science,* Vol 88: 335-347 (2005).