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Livestock-feed consumption relationships as indicators of feed demand

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Livestock-feed consumption relationships

as indicators of feed demand

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CHAPTER 1. INTRODUCTION

In the United States, livestock sales represent approximately half of the cash receipts received by farmers (USDA 1982). Livestock feeding creates a demand for feedstuffs including grains and their by-products, protein meals, hay, other crop roughages, and pasture. Over 40 percent of the 400 million cropland acres are devoted to production of livestock feed (USDA 1982). Additionally, over 660 million acres of permanent pasture and rangeland are used for the production of roughage feed for livestock (USDA 1982).

Many analysts in the grain and livestock industries, feed manufacturing industry, transportation industry, and government agencies need reliable, accurate feed usage estimates for price and supply forecasting or public policy evaluation. Currently, no public agency collects feed consumption data for the major livestock and poultry species on a regular basis. Because this void exists, a method of estimating feed consumption based on information that is regularly collected, i.e., livestock inventory numbers, is necessary to accurately inform public agency and private firm analysts and market participants.

Review of Previous Research

Previous studies of aggregate feed utilization have primarily focused on supply and demand relationships in the entire livestock-feed sector of U.S. agriculture. Researchers use data reported by the Economic Research Service, United States Department of Agriculture for estimates of feed demand. Analysts at the Economic Research Service (ERS) derive these estimates using the "Marketing Year Supply and Disappearance Balance Sheet" for each feedstuff. This balance sheet, illustrated below, reports supply, disappearance, and ending stocks and the components of each category.

The accounting indentity shown in Equation 1 is used to calculate feed utilization and residual.

$$(1) \quad \text{Feed \& Residual} = \text{Supply} - \text{Ending Stocks} - \text{Food \& Alcohol Usage} - \text{Seed} - \text{Exports}$$

The balance sheet identity would be correct if all components were known exactly. Thus, feed consumption could be calculated accurately and there would be no residual. However, all of the elements, except feed and residual, are estimated (farmer survey, yield checks) or measured and reported (processors, exporters, elevator surveys) and are thus subject to some error. Obvious sources of error include statistical sampling error which surrounds each number. Another is rounding errors that arise each time the information is processed (i.e., farm, county, state, and national levels). While these two problems are typically small and may cancel out one another, they may also snowball into a large error.

Another source of error is inconsistent reporting which may arise unless officials specify the exact information they request. A primary example is moisture content of grain. Harvested corn is typically reported as number two, yellow, 15.5 percent moisture. However, corn in long-term storage must be drier than 13.5 percent moisture to prevent

Table 1.1. Corn: Marketing year supply and disappearance, specified period, 1984[a]

Year and periods beginning October 1	Supply: Beginning stocks	Supply: Production	Supply: Imports	Supply: Total	Disappearance, Domestic use: Food	Disappearance, Domestic use: Alcohol beverage	Disappearance, Domestic use: Seed
	Million bushels						
1983/84							
Oct-Dec	3,119.9	4,174.7	0.3	7,294.9	200.3	19.3	--
Jan-Mar	4,912.9	--	0.8	4,913.7	160.0	22.4	1.1
Apr-May	3,251.2	--	0.7	3,251.9	155.0	16.7	15.5
June-Sept	2,145.1	--	0.7	2,145.8	353.6	26.6	2.3
Mkt year	3,119.9	4,174.5	2.5	7,297.1	868.9	85.0	18.9

[a]Feed Outlook and Situation Yearbook, USDA Economic Research

FdS-298.

				Ending Stocks		
Feed & residual	Total	Exports	Total disappearance	Gov't owned	Privately owned	Total
1,633.5	1,853.1	528.9	2,382.0	1,229.7	3,683.2	4,912.9
969.1	1,152.6	509.9	1,662.5	1,198.2	2,053.0	3,251.2
579.9	767.1	339.7	1,106.8	818.6	1,326.5	2,145.1
553.4	935.9	486.7	1,422.6	334.0	389.2	723.2
3,735.9	4,708.1	1,865.2	6,573.9	334.0	389.2	723.2

excessive spoilage. Unless this difference is accounted for in stocks or processors and exporters' reports, errors will exist. In addition to moisture loss, shrink will also occur during handling from dust and broken kernels and during storage from mold or insect damage. These two factors each can account for one percent loss. Grain in long-term storage, such as the three year government loan, suffers a greater loss in storage. Unless analysts take these factors into consideration this disappearance will be included in the feed and residual figure along with the statistical and rounding errors. Because this inconsistency in reporting exists, the residual element can fluctuate widely from year to year.

Another approach used by ERS analysts to estimate feed utilization is the grain consuming animal unit (GCAU). The aggregate GCAU is popular with most economists because it is a convenient proxy for feed demand. The GCAU was developed by the ERS as a common denominator for feed consumption by all livestock and poultry. This index is based on the amount of concentrates consumed by the average dairy cow in the United States (Allen, Hodges, and Devers, 1974). The average dairy cow's consumption is estimated from the minimum feed requirements published by the National Academy of Science, Council of Animal Nutrition plus a waste factor. This waste factor is assumed by ERS analysts to be five percent for all concentrates and 25 percent for all forages from harvest to ingestion. Feed consumption by other animals is estimated by the same method and then reported relative to the cow's feed consumption. As an example, for the 1969-1971 period the average dairy cow was estimated to have consumed

4,293 pounds of concentrate. Broilers were estimated to have consumed 9.2 pounds of concentrates. Therefore, it would require 466.63 broilers to equal one GCAU.

While this method attempts to account for total feed demand by all livestock and poultry, it also has problems. One obvious problem with the GCAU approach is that the index must be continuously revised to account for changes in feed practices, not only for dairy cows, but for all livestock. The trend in recent years has been toward increased concentrate feeding to dairy cows and less concentrate to most other species. For example, a broiler now requires approximately eight pounds of feed to reach slaughter weight compared to over nine pounds in 1970; feedlot cattle are currently fed a shorter period of time and consume less concentrates than before; and laying hens are also more efficient and require less feed than 15 years ago. The result is that the number of GCAUs can change each year without changing inventory numbers.

Another problem that arises is that national average GCAUs are reported in corn equivalents and do not specifically account for other feedstuffs consumed by livestock. In particular, when the change in GCAUs comes from a class of livestock that consumes a diet different from a dairy cow, estimation errors can occur. If the number of broilers increased, the demand for oilseed meal and corn would increase by more than that shown by the change in GCAUs because broiler diets contain relatively more of these two feeds than does a dairy diet. Also, the current system does little to account for regional differences in GCAUs or demand for individual grains. In the Southeast region most of the

GCAUs are comprised of poultry. In the Southern Plains region, most of the GCAUs are feedlot cattle. The nutrient requirements and, therefore, the diets of poultry and fed cattle differ greatly. Thus, a national average GCAU would represent the same number of pounds of concentrates in both regions, but the composition of feed grains, other processed feeds, and high protein feeds would be very different between the two.

The assumption that producers feed their animals according to the minimum requirements established by the National Academy of Sciences is another point of concern with the current method. While most producers attempt to fulfill the animals nutrient requirements, few follow the guidelines closely. Many producers exceed the stated minimum requirements in an effort to maximize the performance of their animals. Also, the estimate of five percent waste for concentrates and 25 percent waste for forages from harvest to ingestion may be a reasonable assumption, but it may not be reasonable to assume that waste is the same across all regions. Likewise, it is not reasonable to assume that layers in a controlled environment with a mechanized feed system waste the same amount of feed as feedlot cattle fed in outside lots with feed delivered by trucks.

In recent years analysts at the Economic Research Service have gone one step further to reconcile differences that exist between concentrates available for feed and concentrates estimated to be consumed by livestock. As discussed earlier, the balance sheet calculates a feed and residual figure based on estimates of supply and other disappearances. Feed estimated to be used by GCAUs is based on fulfilling the animals minimum nutrient requirement plus an additional waste factor. When these two numbers do not coincide ERS analysts typically assume that the balance sheet figure is correct. After adjusting for an estimated fixed amount of résidual, the remainder is divided by the number of GCAUs to arrive at feed consumption per unit. This amount is then multiplied by the number of GCAUs in each class of livestock and poultry to allocate. This approach is used for each type of feed. For example, if 6.6 million metric tons of barley is calculated to be available for feed after subtracting the residual, and there are 80 million GCAUs, then each GCAU is assumed to consume 181.5 pounds of barley (6.6/80 x 2200). This procedures, by construction, insures that the balance sheet identity is satisfied (supply equals disappearance).

Though no written procedure was found, individuals that prepare feed consumption estimates at the ERS indicate that a similar method is used to account for feed use at the regional level. A state balance sheet is used to calculate feed and residual for each feed grain. This amount is compared to state livestock inventories and is allocated among the livestock classes as it seems appropriate by the analysts after accounting for the animals nutrient requirement and producer feeding practices. These state estimates are totaled to get a regional estimate and then summed across all regions to arrive at a national estimate. While the state by state approach attempts to recognize demand for different feed grains and different feed requirements of livestock classes, it is still constrained by the national balance sheet. Feed consumption estimates summed across all regions must equal the feed and residual estimate for the entire nation for each feedgrain.

Because of problems arising from estimation and reporting errors and the combined feed and residual column, the balance sheet approach does not accurately reflect feed use by livestock and poultry. The GCAU method attempts to estimate derived demand for feedstuffs, but fails to delineate demand for individual feedstuffs, regional differences, or the impact of changing livestock inventories. A possible solution to the feed demand estimation problem would be to estimate feed consumption by livestock and include it in the balance sheet identity, and have a separate residual figure reflecting the measurement differences and sampling errors discussed earlier.

In this study, a method of estimating livestock and poultry feed consumption is developed which reflects current livestock production and nutrition technology and management practices in the major feed-using industries. In addition to the consumption estimates, the specific type of grain and processed feeds used by each species will also be estimated. Regional and seasonal variation, where it occurs, is also considered.

Objectives

The objectives of this research are:

1. Develop a method to determine feed ingredient consumption for all major feed consuming classes of livestock and poultry, and its relationship to United States Department of Agriculture reports of livestock and poultry populations.

2. Determine the composition of the feed--grains, high protein meals, roughages, pasture, etc.--consumed by each species or class of livestock and poultry by geographic area (see Figure 1.1).

3. Identify factors that cause adjustments in consumption rates of feed ingredients, and where possible, quantify likely responses in total feed intake or composition to environmental or economic stimuli.

4. Compare these estimates of individual species' feed consumption and aggregate grain fed to animals to previous USDA estimates, and consider possible reasons for any difference found.

Methodology

To determine feedstuff disappearance for the 1984-1985 period, which includes not only consumption by the animal, but also waste from storage to ingestion and other factors affecting feed use, several sources were consulted. These include livestock and poultry enterprise records, university and USDA cost of production summaries, extension management budgets and specialists, and knowledgeable industry personnel, as well as published data. These sources were also used to determine the composition of diets consumed by livestock. In the case of commercially prepared feeds, leading feed manufacturers in each region helped to identify the typical ingredients and proportions in formula feeds.

Parameters and rations are estimated separately for each region and for each major class of farm animals using information that best represented the typical feeding practices of producers. Using several sources of information from a region seasonal variation in feed

Figure 1.1 USDA geographic regions.

consumption and ration composition can be more accurately monitored. Once the regional and seasonal parameters and diets are determined, a weighted average estimate of feed consumption and ration composition by a particular group of animals for the entire nation can be calculated. This national average estimate for a class of livestock or poultry is derived by weighting the regional estimates by the proportion of the United States total produced in each region.

The results for each of the major classes or species of livestock and poultry will be discussed in the following chapters. First, the estimates of seasonal feed intake rates for each major livestock group reported in the USDA reports of livestock and poultry inventories will be considered, along with the primary sources and rationale for those estimates. Secondly, the typical combination of feedstuffs is estimated; for some species, this varies significantly by region and season of the year. Next, we consider factors (e.g., unusual price relationships, cyclical production patterns, etc.) that might cause feed consumption rates or composition to change significantly from typical patterns. Finally, our estimates are compared to previous USDA estimates of feed consumption and the Supply and Usage reports for the 1977-1984 crop years. Where differences arise, the possible reasons for the discrepancies will be discussed.

CHAPTER 2. ESTIMATING DAIRY FEED CONSUMPTION RATES

The primary function of the dairy industry in the United States is milk production. The most influential factor determining milk production is the amount and type of feed consumed by the dairy cow. Feed is also the most important cost in milk production, representing over 40 percent of the production expense (Jurgens 1982, p. 315). After considering some general aspects of dairy nutrition, average dairy feed intake rates and diet composition in ten geographical regions of the nation (Figure 1.1) are estimated.

Dairy cattle diets should be formulated to supply the cow's requirements of energy, protein, vitamins, and minerals. These requirements depend on the cow's body weight, stage of lactation, and level of milk production. However, factors, such as waste, subclinical disease, and other inefficiencies also affect feed use. To accurately reflect on-farm use, these estimates are based on actual dairy farm feed use data. Sources include: USDA Statistical Reporting Service (SRS) and Economic Research Service (ERS), Dairy Herd Improvement Association (DHIA), other farm record-keeping firms, extension dairy specialists, feed industry personnel, and others.

Daily Feed Intake

Nearly all dairy farms in the United States operate on a continuous basis, feeding cows in all stages of the lactation and dry period, and raising their own replacement heifers. The USDA Cattle and Calves report lists cow and heifer numbers separately; feed intake estimates for each class will be discussed individually. Because dairy farms have cows in all stages of production, an average daily intake per cow will be used to predict feed intake. Factors such as cow size, milk production level, and feed ingredient quality greatly affect daily feed intake rates. However, according to work compiled by the National Research Council (NRC) daily dry matter intake for mature dairy cows ranges from two to four percent of body weight. Within this range, cows normally consume approximately three percent of their body weight of daily dry matter intake (NRC, 1978, pp. 54-55). Depending on the availability of feedstuffs, the type of feed consumed by cows varies greatly between regions.

Feedstuffs

A dairy diet consists of basically two types of feedstuffs: forages (dry forages, succulent forages, and pasture) and concentrates. By definition, dry forages are grasses, legumes, or grass-legume mixtures fed to animals in the form of sun-cured hay. Succulent forages include silage, soilage (green chop), and various wet by-products. Succulent feedstuffs are stored in oxygen restricted structures or fed fresh. Pasture is a standing crop of grass and/or legume that is grazed by the cow. Concentrates include grains (corn, sorghum, oats, barley, and wheat), fats, animal by-products, grain by-products, millfeeds, molasses, oilseed meals, vitamins, and minerals, which supply the diet with the majority of the cow's required nutrients. Dairy diets are typically based on available forages with any supplemental nutrients being provided by a concentrate mixture.

Forages

Forages comprise approximately two-thirds of the mature cow's daily dry matter intake. Various combinations of dry forages and/or succulent forages are fed at a level equal to 1.5-2.0 percent of the cow's body weight as daily dry matter intake (Jurgens, 1982, p. 315). In some regions pasture is an important part of a cow's forage intake. However, the trend in most regions is to use pasture mainly for dry cows and replacement heifers. The amount of forage consumed depends on several factors: cow size, level of milk production, fiber content of feeds and seasonal availability of forage. Another important factor is the dry matter content of the forage. For example, a 1,300 pound cow requires 26 dry matter pounds of forage daily (1300 x .02). She could consume 29 pounds of alfalfa hay (dry matter=.90) or 68 pounds of corn silage (dry matter=.38) or any combination of the two that would yield 26 pounds of dry matter. This illustrates that the amount of forage consumed on an "as fed" basis depends on the type of forage available. The feed calculation procedure is explained in the appendix of a USDA technical report (Lawrence, Hayenga, Jurgens, 1986).

Smaller dairies, for the most part, produce all of the forages they require. This forage typically includes alfalfa hay and, in most regions, corn silage. More specialized larger dairies generally purchase most of their needed forage. Commercially produced alfalfa hay is the predominant forage purchased by these larger dairies. Because of transportation cost and specialized storage requirements, little succulent forage is purchased.

Concentrates

Concentrates are commonly one-third of daily consumption on a dry matter basis of dairy cows. Because most concentrates, unlike forages, have a consistent dry matter (88-90 percent), they are commonly reported as on an "as fed" basis. Concentrates supply much of the energy and protein for lactation, and are therefore highly correlated with milk production (Jurgens, 1982, p. 315). This relationship will be referred to as the milk to concentrate ratio (pounds of milk produced divided by pounds of concentrate consumed), which, according to dairy extension specialist and feed industry personnel, can be used to accurately estimate concentrate consumption by dairy cows. Because the USDA Statistical Reporting Service (SRS) reports milk production levels and dairy herd inventories, the milk to concentrate ratio can be used to estimate the amount of concentrates fed to cows. Due to differences in forage quality and management practices, the milk to concentrate ratio does vary between regions. However, the ratio is fairly consistent on most farms within a region. When using this ratio, other factors which could affect milk production should not be overlooked. Factors such as weather, technological advancements, and selling less productive cows (e.g., the Dairy Reduction Program) can affect the efficiency of production and milk to concentrate ratio.

The milk to concentrate ratio in all regions except the Pacific is based on USDA Statistical Reporting Service information. The SRS publication Milk Production reports each quarter the pounds of concentrate mixtures fed to milk cows per day (USDA, 1984). The amount of milk produced daily per cow for corresponding months, as reported in Milk Production, was calculated. The most recent three year regional average for daily milk production was divided by the three year regional average for daily concentrates fed to arrive at the milk to concentrate ratio. This procedure was performed individually for each quarter to determine whether any significant seasonal variation occurred. By using three years of data (1982-1984), short term variations caused by weather extremes or other unusual conditions were reduced. The procedure for the Pacific region is based on data reported by the California Bureau of Milk Stabilization and USDA Cost of Production survey.

To determine the amount and type of feed ingredients used in the concentrate ration, various sources of information were employed. The SRS survey of dairy producers for the years 1978-1981 was used for a preliminary estimate of ration composition (USDA, 1978-1981). By using a regional average (weighted by the number of cows in each state) from a four year period the effect of a short term change in feeding practices would be reduced.

A telephone survey of leading dairy feed manufacturers in each region was used to determine the feed ingredients in commercially prepared feed used by dairy producers. In some regions, commercial feed constitutes as much as 80 percent of all concentrates fed to dairy cows.

The results of the feed company survey were combined with results of the SRS survey of dairy farmers with each weighted relative to the amount of commercially prepared feed purchased. Feed companies often reported the amount of an ingredient in a ration as a range or approximation, and their total percentages seldom equaled 100. An average weighted by the approximate volume of dairy feed produced by each company surveyed was calculated for each region. When combined with the SRS feed ingredient survey, this composite average of commercially prepared feed was not consistent with crude protein percentages suggested by dairy industry personnel for the region, so slight adjustments were made in the relative amount of the ingredients to reconcile the difference. These adjustments based on NRC reported nutrient content for the feedstuffs seldom altered the original results more than one or two percent in meeting the suggested crude protein levels in the ration.

The composition of a concentrate ration may change seasonally and from year to year as price relationships of feed ingredients change. This is especially true in regions which feed a high percentage of commercially produced feed. Feed manufacturers often use "least cost formulations" when preparing a ration which allows them to use the most economical combination of ingredients to meet predetermined specifications. In these diets, a small price movement in one feedstuff may cause the amount of every ingredient in the ration to change. In regions where less commercially prepared feed is used, most of the feed is grown on the farm. In these areas, less substitution occurs except with very large price changes. Table 2.1 indicates the typical substitution rates

Table 2.1. Dairy concentrate changes at different relative prices

Alternative feedstuff compared to typical grain	Price ratio where substitution begins	Lake states[a]	Northeast[a]	Pacific[a]	Cornbelt[a]
Wheat to Corn	1.05 - .95	0	0	-2.0	0
	below .95	0	0	-1.0	0
Milo to Corn	.85 - .75	0	0	-3.0	0
	below .75	0	0	-3.0	-.1
Barley to Corn	.90 - .85	-.3	-1.0	-2.0	-.2
	below .85	-.6	-2.0	-2.0	-.4
Wheat to Barley	1.05 - .95	0	0	-2.0	0
	below .95	0	0	-2.0	0
Wheat to Milo	1.25 - 1.15	0	0	-2.0	0
	below 1.15	0	0	-1.0	0

[a]Percentage change of alternative feedstuff in diet per one percent change in the price ratio. As an example, if the milo to corn price ratio falls by 5 percent the percent milo in the diet will increase by 15 percent in the Mountain region. (.85 falls to .80, milo increases by 5 x 3.0 = 15 percent).

Appalachian[a]	Mountain[a]	Northern plains[a]	Southern plains[a]	Southeast[a]	Delta States[a]
-2.0	-2.0	-1.5	-2.0	-2.0	-2.0
-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-2.0	-3.0	-2.0	-3.0	-3.0	-3.0
-1.0	-3.0	-2.0	-3.0	-3.0	-3.0
-1.5	-4.0	-2.0	-2.0	-2.0	-2.0
-1.5	-4.0	-2.0	-2.0	-2.0	-2.0
-.5	-2.0	-1.0	-1.0	-2.0	-1.0
-.5	-2.0	-1.0	-1.0	-2.0	-1.0
-.5	-2.0	-1.0	-2.0	-2.0	-1.0
-.5	-1.0	-1.0	-1.0	-2.0	-1.0

among concentrates by region which may occur when prices move outside the ranges occurring in 1984-1985.

Replacement Heifers

Replacement heifers range in age from newborn to 24-28 months, with an average weight of approximately 500 pounds.[1] Replacement heifers commonly account for 40-50 percent of the animals in a dairy herd. Diets for heifers are typically balanced to meet requirements of crude protein and energy for maintenance and gain. These diets consist of the same type of feed ingredients as mature cow diets, but in differing amounts. Annual feed consumption for heifers typically is only 30 percent of mature cow consumption rates.

According to data from the National Research Council, extension budgets and feed company publications, the average heifer in a replacement herd will consume 12-14 pounds of dry matter daily (NRC, 1978, pp. 26-27). Of this amount, 80-85% is forage and 15-20% is a concentrate mixture. The amount and composition of the diet consumed may change during an expansion or contraction in replacement numbers due to a change in average weight and age of the heifers. However, there is little cyclic activity in dairy replacement numbers (an exception might arise during a government Dairy Reduction Program).

The following procedure can be used to estimate feed consumed by heifers in each region. Each heifer will consume approximately 10.75

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[1]Kent Nelson, Nelson Farm Consultants, Decorah, Iowa.

pounds (dry matter) of forage daily (13 X .825). Enter this figure in the forage consumption chart, and use the same procedure outlined earlier for dairy cows. To estimate concentrate consumption, multiply 2.5 (13 X .175/.90) pounds (as fed) consumed by the heifers by the percent of each feedstuff in the ration shown in the Composition of Concentrate Ration chart. This is the amount of each feedstuff consumed daily by each heifer. Multiply this amount by the number of heifers in a region and the number of days in the period to get the amount of each feedstuff consumed by heifers.

Dairy Calves

Dairy calves are taken from the cow shortly after birth. The cow is returned to the milking herd and the calf is raised in a separate area. The calf requires milk or milk substitute for the first four to six weeks of life. Producers may feed the calf marketable whole milk, however this is often more expensive than the alternatives. Nonmarketable milk such as colostrum (the nutrient rich milk produced the first three days following parturition), milk produced 72 hours following drug medication, or milk produced while a cow has mastitis is also fed to calves. Another choice of many dairymen is powdered milk replacer which is mixed with warm water to form a milk substitute.

In addition to the liquid diet, calves receive a high quality concentrate mixture. Intake averages slightly over one pound per day for the first six weeks. This feed generally contains 16 to 20 percent crude protein, low fiber and molasses to increase palatability. By the sixth week the calves are eating approximately three pounds of concentrate and three pounds of good quality alfalfa hay.

From the age of twelve weeks until they weigh 500 pounds at about tweleve months, the calves consume approximately five pounds daily of a concentrate mixture and eight dry matter pounds of forage. Most of the forage, especially in the younger animals, is dry hay. Low dry matter forages such as silage, haylage or pasture are usually avoided until the calf is six months old because it cannot consume enough to meet its nutrient requirements.

The ration composition for cattle in this reporting category is very similar to that of the mature cow. Often a producer will feed calves the same concentrate mixture fed to lactating cows. The forages are also similar, except that small calves will receive more dry hay than mature animals[1]. These estimates assume that calves will consume half of their forage as hay, and half as the same forage combination consumed by the cows in each region. As an example, in the Pacific region a calf's forage intake would consist of 86.5 percent hay, 6.1 percent corn silage, 3.25 percent haylage, 2.85 percent pasture and green chop, and 1.3 percent other silage. In addition, this estimate assumes that half of the calves receive liquid milk with the remaining calves receiving milk replacer.

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[1]Dr. Fred Foreman, Department of Animal Science, Iowa State University, Ames, Iowa.

Regional Summary

The four leading dairy regions account for over three-fourths of the nation's milk production. Dairies in the Lake States, Northeast, and Cornbelt regions, first, second, and fourth respectively, have mostly smaller herds, typically less than 100 cows per farm. The Pacific region, third in milk production, has dairies that generally are larger, averaging over 500 cows per farm in California. The other six regions have dairies that range in size from very small to very large.

The milk to concentrate ratio differs between regions. This ratio ranges from 2.43 pounds of milk per pound of concentrate in the Lake States and Northeast regions to 1.35 in the Southeast region. The major difference in this ratio is not the level of milk production, but rather, the amount of concentrates fed. Concentrate feeding depends heavily on the quality of forage consumed by cows. In the more efficient regions alfalfa hay and corn silage provide a good nutritional base for milk production, and thus less concentrates are needed for the cow to reach maximum milk production. In the Southeast and other regions, such as the Pacific, many producers feed a high-fiber concentrate ration to replace some of the purchased forages. Concentrate rations containing cotton seed hulls, bakery products, or other high fiber feedstuffs are often fed at higher levels than most concentrates because they are also substituting for part of the required forage. This feed can also be handled by mechanized feeding systems thus reducing labor requirements. Table 2.2 lists the milk to concentrate ratio and daily dry matter forage consumption estimated for each region and the U.S. weighted average.

Table 2.2. Milk to concentrate ratios and daily dry matter forage consumption of dairy cows by region

Region	Milk:Concentrate ratio	Daily dry matter forage intake (lbs)
Northeast	2.43	22.7
Appalachian	2.12	22.6
Southeast	1.35	19.7
Lake States	2.43	23.6
Cornbelt	2.03	22.2
Delta States	1.61	21.5
Northern Plains	2.09	22.4
Southern Plains	1.73	21.2
Mountain States	2.32	25.8
Pacific	1.84	20.5
U.S. Average	2.17	22.5

Most concentrates fed by small dairies are produced on the farm. This is especially true in the Lake States, Cornbelt, Northern Plains and other major grain producing areas where dairy enterprises are part of a diversified farming operation. The concentrate diet is primarily corn in the upper Midwest, while barley is more common in the West and Northwest where is it produced. Rations consisting of home-grown grains are typically supplemented with a commercially manufactured protein, vitamin and mineral supplement.

In the Northeast, Appalachian, and Mountain regions a sizable portion of the grain fed to dairy cows is produced on the farm. The remainder of the concentrate diet is provided by purchased grain or grain by-products such as wheat midds, corn gluten feed, brewers and distillers dried grains and other processed feeds. In the remaining regions and particularly the Pacific and Southeast regions, the majority of the concentrate diet is a commercially prepared ration. This feed consists primarily of grains transported into the area and grain by-products. For example, dairy concentrate rations in California contain a high amount of hominy, bakery by-products, grain screenings, wheat midds, and other processed feeds.

No type of forage fed to dairy cows determines the necessary protein content of the concentrate ration. In regions where most of the forage is alfalfa hay less protein is supplied by concentrates compared with high levels of corn silage. In most regions, protein in the concentrate diet is supplied by oilseed meal. However, where grain proteins such as distiller's and brewer's dried grains are used less oilseed meal is required. In the Pacific region and others where a large amount of the concentrate diet is commercially manufactured, nonprotein nitrogen (urea) will often replace part of the oilseed meal in the diet.

The U.S. weighted average diet, shown in Table 2.3 is 58.2 percent forage and 41.8 percent concentrates. The predominant forage is alfalfa hay which is fed in every region and typically makes up 40 to 100 percent of the forage diet in most regions. Corn silage is the second most common forage. Corn silage is not only popular in the major corn producing areas, but also in regions where very little corn grain is produced. In states such as Alabama, Georgia, Arizona, Idaho, Washington, and others, corn is often grown specifically for silage. The major concentrates include corn, barley, oats, oilseed meal, and other processed feeds. Corn is fed at some level in all regions. The Lake States, Northeast and Cornbelt regions rely heavily on corn and thus make it the predominant grain. Barley is fed extensively in the Pacific and Northern

Mountain regions and thus makes up a portion of the U.S. diet. Oats are used in the Lake States, Northeast and Cornbelt region. Oilseed meal is the major protein source in nearly all regions and thus makes up a large part of the national diet. Other processed feeds are common in commercially prepared diets and, in particular, diets fed by very large dairies.

Table 2.3. U.S. average dairy concentrate ration and dry matter forage diet

Feedstuff	Percent of total dry matter diet	
Concentrates	41.8	Percent of concentrates
Corn		50.3
Wheat		0.7
Milo		0.2
Barley		7.6
Oats		7.0
Oilseed meal		14.1
Animal protein		0
Grain protein		3.4
Other processed feed		13.0
Vitamins and minerals		2.4
Forages	58.2	Percent of forages
Alfalfa hay		67.1
Corn silage		25.2
Pasture and other silage		6.1
Other forage		1.6

CHAPTER 3. ESTIMATING SWINE FEED CONSUMPTION RATES

The major emphasis of the swine industry in the United States is red meat production, with annual sales (farm level) of 8.8 billion dollars (Van Arsdall and Nelson, 1984, p. 3). Hogs typically consume 33 percent of the nation's corn crop, and 25 percent of all concentrates used by livestock and poultry. Feed represents the largest cost of pork production, accounting for approximately 60 percent of total expenses (Wilken, 1983). Hogs are single stomached animals, and therefore, can only efficiently use concentrate feeds, but not forages. These concentrates are typically 80 percent high energy grain and 20 percent high protein supplements and miscellaneous micro-ingredients.

In most cases hog production is located near surplus feed production areas. The ten largest volume hog producing states which produce over 80 percent of the nation's hogs, except for North Carolina, are located in the North Central part of the country (USDA, 1983, pp. 17-18). The top two hog states, Iowa and Illinois, produce over 36 percent of all hogs in the United States. Because of the regional concentration of production and similar farm structures, feeding practices differ little between hog producers. In addition, over 50 percent of the hogs are raised in partial or full confinement, reducing much of the environmental variation between regions. According to Van Arsdall and Nelson, 40 percent of the North Central region's hogs and 50 percent of the hogs in the Southeast are produced on medium sized farms (producing 1,000-5,000 per year). In the other forty states, producing 20 percent of the hogs, less than 2 percent of the operations produce over 40 percent of the hogs. The bulk of this production is also on farms in or near the 1000-5000 head per year size bracket.

Feed Intake

The feed intake estimates for growing and finishing hogs are based on research data compiled at Iowa State University (Iowa State University, 1982). Figure 3.1 indicates the relationship between the pounds of daily air-dry feed intake and live weight of the hog from birth to market. This graph represents data from over 10,000 observations compiled over several years at the Iowa State University swine nutrition research farm. The feed to gain ratio depicted in this graph is 3.5:1 for hogs growing from 30 to 240 pounds. However, this is slightly more efficient than most growing and finishing hogs. In comparison to the survey by Van Arsdall and Nelson and the 1983 USDA Cost of Production summary, this graph represents hogs that were approximately 23 percent more efficient (4.3 versus 3.5); thus the utilization rate results were adjusted upward by 23 percent. The average daily feed intake amounts for each weight class of hogs reported in the USDA (1983) Hogs and Pigs Report were determined for the periods one, two and three months past the report. Using Figure 3.2, the relationship of body weight and average daily gain, and the mid-range average weight for each weight category in the Hogs and Pigs Report the growth and feed intake of each group of hogs is calculated for each 30 day period. From this value, an average daily feed intake amount for the month is derived. As the hogs grow the amount

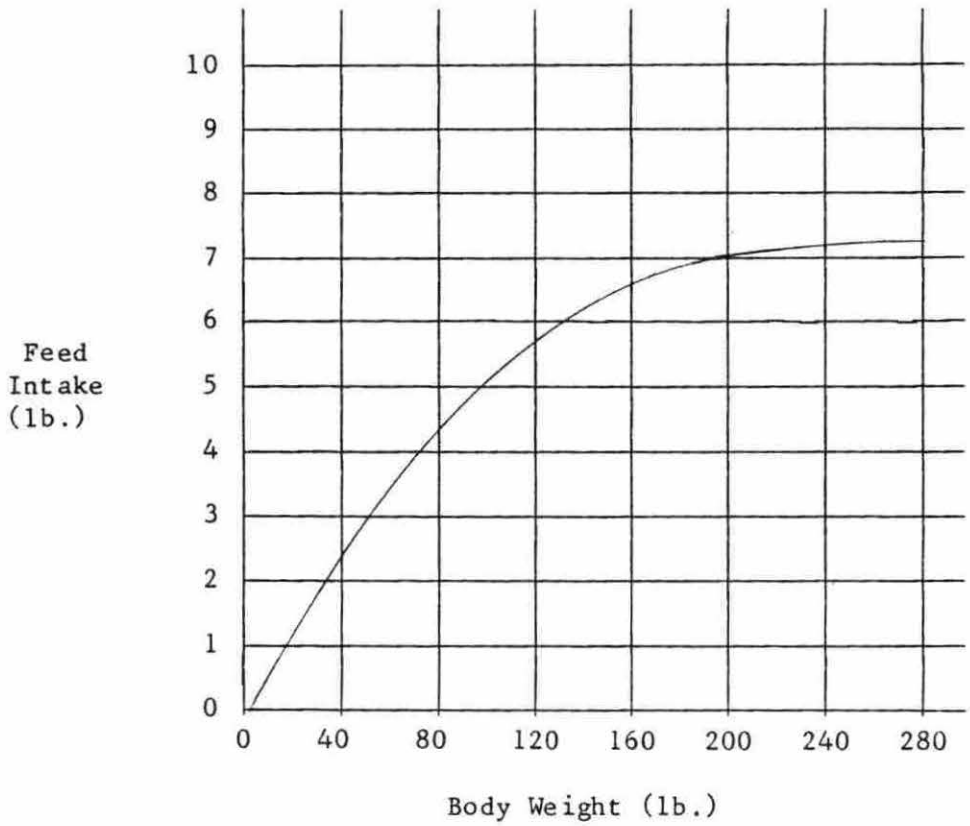

Figure 3.1. Relationship of feed intake to body weight in growing and finishing swine (Iowa State University, 1982)

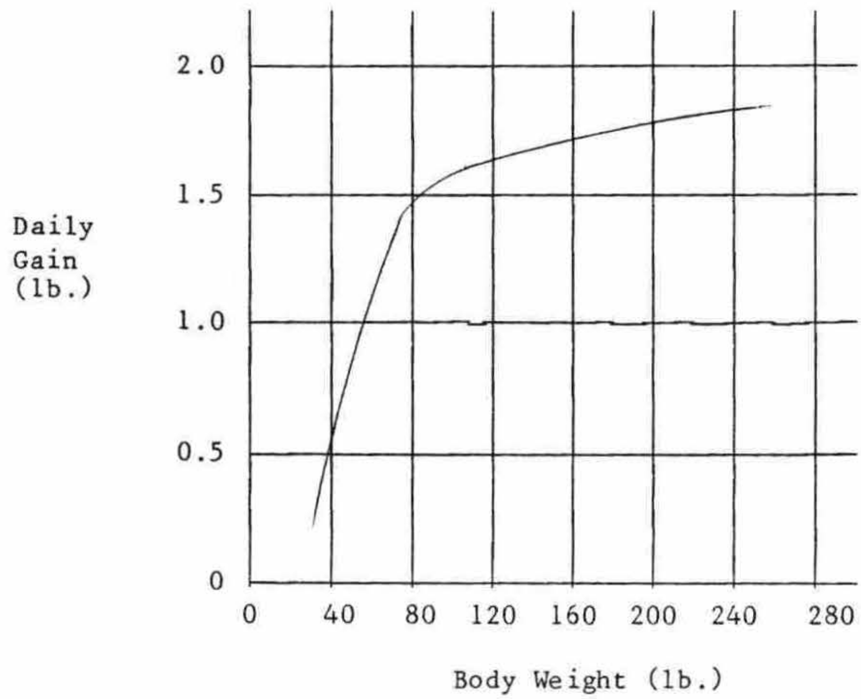

Figure 3.2. Relationship of body weight and average daily gain in growing and finishing swine (Iowa State University, 1982)

of feed consumed increases until the hogs reach slaughter weight during the month. Figure 3.3 illustrates the flow of hogs during the quarter.

The number of hogs used in each month is determined by the Hogs and Pigs Report, commercial slaughter data, gilt retention estimates, and a death loss coefficient. The starting point is the quarterly Hogs and Pigs Report. This publication indicates the number of hogs in each of four weight classes and the number of hogs in the breeding herd on a given day. The commercial slaughter data and the number of gilts kept for breeding purposes are used to adjust the starting numbers from one month to the next. The death loss coefficient accounts for the reduction in hog numbers that occur from death. For hogs under 60 pounds, this coefficient is 3.5 percent for the first 30 days and 1.0 percent thereafter; for all other market hogs death loss is .025 percent per month (Stevermer, 1984).

The number of hogs slaughtered in commercial plants is reported monthly by the Crop Reporting Board. In addition, information is available on the percent of hog kill comprised of barrows and gilts, sows, boars and stags. The number of gilts and boars retained for breeding purposes is calculated by the change in the estimated size of the breeding herd adjusted for sow, boar and stag slaughter from one quarter to the next. To put these on a monthly basis, the quarterly change in the total number of gilts kept for breeding purposes is divided by three (assuming that an equal number of gilts is saved each month).

In the first month of the report, the number of gilts saved per month is subtracted from the number of hogs in the 180 pounds and over

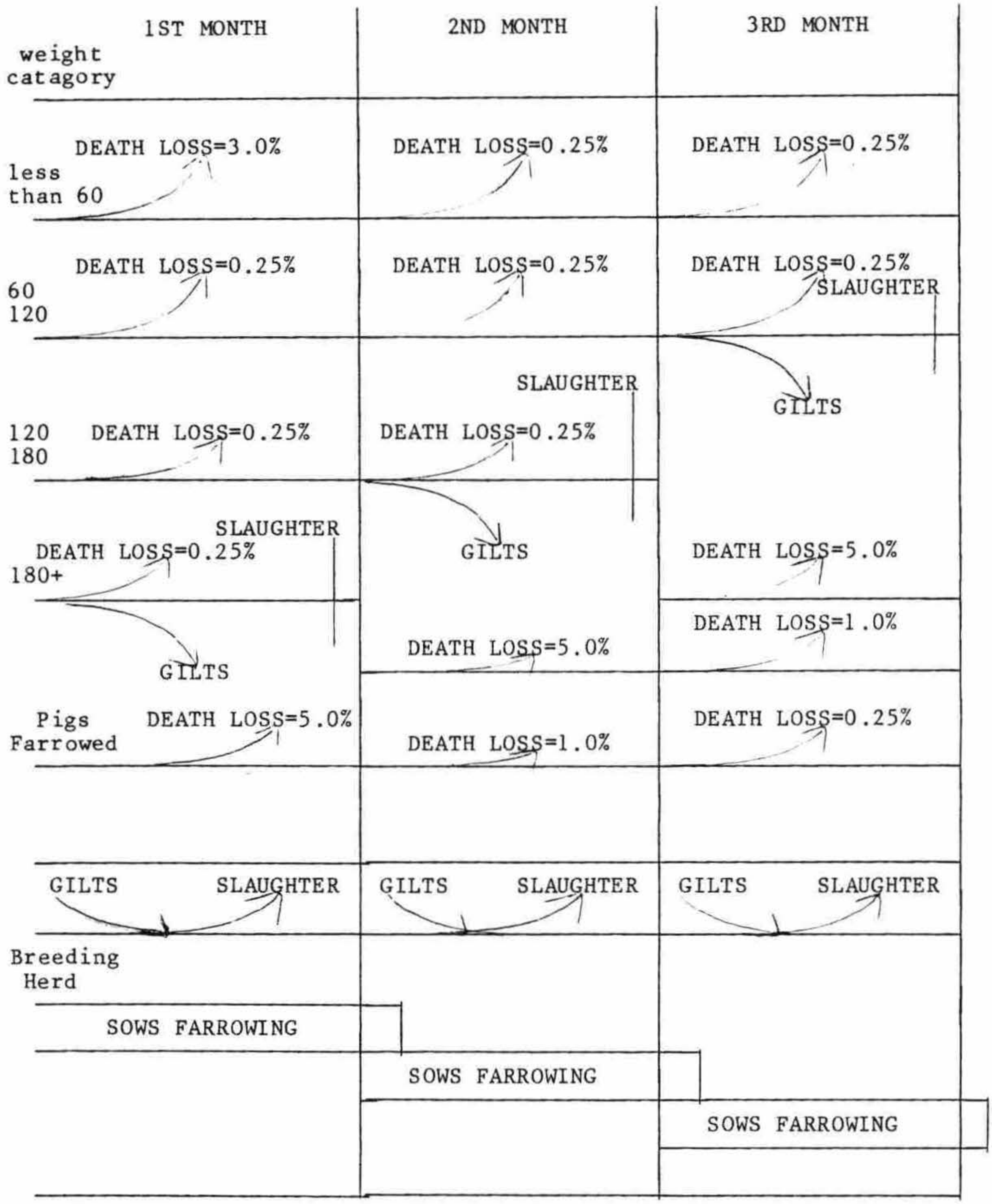

Figure 3.3. Quarterly hog flowchart

category. The remainder of the 180 and over category minus .025 percent death loss is assumed to be available for slaughter during the first month. Hogs not slaughtered are added to the 120-179 pound category. The 120-179 category, less the 1.0 percent death loss plus the remaining 180 and over hogs, are advanced into the next month. The process is repeated; replacement gilts are subtracted, monthly barrow and gilt slaughter is subtracted, and the additional hogs are added to the next lighter weight class. The 60-120 pound category is reduced by 1.0 percent estimated death loss in both the first month and second month with the remainder advanced to the third month. During the third month replacement gilts, death loss and slaughter numbers are subtracted from the remaining hogs in the 60-120 pound bracket plus any carry over from the previous months. The 0-60 pound class is reduced by the death loss estimates described earlier during each month. Any additional hogs needed to meet the slaughter number is taken from the next lighter weight class. When the next quarterly Hogs and Pigs Report becomes available, the process begins over again (USDA, 1983).

Feed intake estimates for the breeding herd are also based on Iowa State University data, published in the extension publication "Life Cycle Swine Nutrition." The extension data were adjusted to reflect the 4.34 feed efficiency reported in the 1983 Cost of Production summary. According to Iowa State data, the breeding herd consumes approximately 20 percent of the total feed used by hogs in a farrow-to-finish operation. After subtracting the amount used during lactation and adjusting for seasonal fluctuations, a base amount of 5.5 pounds per day was used for nonlactating animals in the breeding herd. This includes boars, replacement gilts, gestating sows and gilts, and sows between weaning and rebreeding. Lactating sows and gilts consume 13 pounds of feed per head per day during the lactation period, usually 35 days. For the cooler months, October through April, the amount of daily feed intake for the nonlactating animals is increased by an adjustment factor between 10 percent and 30 percent depending on the region and is shown in Table 3.1 discussed in the following sections.

The number of animals in the breeding herd is determined using the Hogs and Pigs Report and commercial slaughter data. In addition, the following assumptions are made: gilt replacement is equal in each month

Table 3.1. Seasonal feed intake coefficients for growing and finishing hogs and the breeding herd

Months	Feed consumption coefficient: Growing & finishing	Feed consumption coefficient: Breeding herd
January	1.10	1.30
February	1.00	1.30
March	1.05	1.20
April	1.00	1.00
May	1.00	1.00
June	0.90	1.00
July	0.90	1.00
August	0.90	1.00
September	1.00	1.00
October	1.00	1.00
November	1.05	1.20
December	1.10	1.30

of the quarter, and the number of sows farrowing in each month of the quarter is proportional to hogs slaughtered in each month of the quarter six months later. The estimated monthly farrowing pattern within each quarter, based on slaughter numbers six months later is shown in Table 3.2. The number of gilts and boars added to the breeding herd each quarter equal the change in breeding herd numbers minus slaughter of sows, boars and stags and death loss in breeding herd. The number of sows farrowing each quarter is reported by the USDA in the Hogs and Pigs Report.

Table 3.2. Percent of quarterly farrowings, by month

Quarter	Month and Percent of Quarterly Farrowings		
First	December[a] 33.67	January 31.5	February 34.83
Second	March 31.33	April 35.00	May 33.67
Third	June 35.17	July 33.83	August 31.00
Fourth	September 34.50	October 33.33	November 32.17

[a]December of previous year.

The USDA Hogs and Pigs Report indicates the number of pigs farrowed each quarter. The pigs farrowed will be proportional to the sows farrowed each month. For the first month, the pigs will range in age from 1-30 days and pig feed consumption will average 0.9 pounds per day. During the second month, there will be two groups of pigs, those consuming 0.9 pounds daily that were born in the second month and those that were born in the first month. The older pigs are now consuming 1.25 pounds per day. The third month has three groups of pigs. Pigs consuming 0.9 pounds, pigs consuming 1.25 pounds and pigs consuming 3.9 pounds of feed daily. A detailed example for calculating feed consumption by hogs is included in the appendix of a USDA technical report (Lawrence, Hayenga, Jurgens, 1986).

Ration Composition

Since hogs are simple stomached animals, the type of feedstuffs they can efficiently use is somewhat limited. The major feed source for hogs is concentrates which are approximately 80 percent grain and 20 percent high protein supplement, vitamins, minerals and other ingredients. While the breeding herd can utilize some forage, usually pasture, it commonly constitutes less that 2 percent of total feed intake of that small part of the total swine population (Minnesota Vocational Agriculture, 1981-1983). Therefore, concentrates are the major consideration of this study. While nutritionists consider the "composition" of a ration to be its nutrient make up, for this discussion "composition" will refer to the mix of feed ingredients in the ration.

According to USDA classification, concentrates can be broken into three classes, high energy grains, high protein supplements, and other ingredients (Liverey et al., 1980). High energy grains typically make up approximately 80 percent of a hog ration. This class consists mainly of corn, milo (sorghum grain), wheat, and to a lesser extent barley, rye and oats. These grains contain less than 20 percent crude protein and more than 2,600 kcal/kg of metabolizable energy (ME). High protein supplements constitute approximately 15 percent of a hog ration. This class includes oilseed meals and animal and grain by-products. These supplements contain more than 20 percent crude protein and are used to meet the amino acid requirement. The class known as "other ingredients" comprises 5 percent of the total ration. It contains vitamins, minerals, growth promotants, medication, molasses, or dehydrated alfalfa meal. Often these ingredients are included with the high protein feedstuff as part of a "least cost" formulated, commercially prepared supplement.

Corn is by far the major grain in swine diets, comprising over 90 percent of the grain consumed by hogs. However, other grains, (milo, wheat, and barley), are nutritionally similar to corn and can be used in place of corn in swine rations. The major factors affecting substitution of these grains for corn is their availability and price relative to corn, along with their palatibility and feeding qualities.

Adjustment Factors

Feed intake estimates for hogs may need to be adjusted to account for temperature deviations from the seasonal mean. Feed consumption is negatively correlated to temperature especially outside of the animal's thermoneutral zone (NRC, 1981). A review of literature by Curtis suggests that hogs increase feed consumption 35 grams per head per day or each degree Celsius below their lower critical temperature. Hogs will decrease feed consumption by 40 grams for each degree Celsius above their upper critical temperature (Curtis, 1983). While the upper and lower critical temperatures vary with the size of the animal, type of flooring, and type of housing, in most regions, temperature changes during April, May, September, and October will have no significant effect on feed intake because they are within the animal's thermoneutral zone. From November through March, one degree Fahrenheit deviation from the seasonal mean will cause feed consumption to change inversely by 0.044 pounds. From June through August, feed consumption will change inversely by 0.049 pounds for each one degree Fahrenheit deviation from the seasonal mean. As an example, if temperatures during January, February, and March for an entire region can be documented to be four degrees higher than average, then the estimated feed intake during that period will decrease by 0.196 pounds per day per hog. Most of the seasonal variations in feed intake are summarized based on traditional weather patterns in Table 3.01. The coefficients discussed above can be used to adjust feed intake if weather patterns and temperatures differ from the traditional mean.

Regional Summary

Most hog operations are part of a diversified farming operation with the bulk of the grain that is fed to hogs grown on the farm (Van Arsdall and Nelson, 1984, p. 34). In most hog producing areas such as the upper Midwest, corn is the common high energy grain. In the less humid hog producing regions such as Nebraska and Kansas, milo is grown because it is more drought resistant than corn. In these areas, milo is the major grain in swine diets. Likewise in the cooler Northern states, barley is grown because it has a shorter growing season than corn. In North and South Dakota, parts of Minnesota and Wisconsin and much of the Western United States barley is an important feedstuff.

Hog production in the Southeast and Appalachian regions is generally part of a diversified farming operation as well. On these farms, at least a portion of the feed grain fed to hogs is produced on the farm. However, approximately half of all grain fed in these two regions is purchased. In addition to the fact that less grain is produced in this area compared to the upper Midwest, a greater portion of the area's hog production is in very large, specialized operations which purchase nearly all of their needed feed. Corn is the most common grain in these two regions. Locally grown barley, wheat, and milo are also frequently used in hog diets. Because a large portion of the grain is purchased, substitution between grains is more common.

The remaining five regions produce less than seven percent of the nation's hogs. In general, hog diets in these regions consist of locally grown grains. For example, the corn producing area of Pennsylvania dominates Northeast hog production. In the Northwest states, barley is fed, in the Southwest milo and wheat are the common grains.

Another high energy grain that is grown in less humid regions (Northern Plains, Southern Plains, and Mountain) is wheat, but traditionally it is too expensive to use in a livestock diet. However, there are times when the price of wheat relative to the price of other grains (i.e., corn and milo) make it a feasible feeding alternative

(Table 3.3). For example, between wheat harvest in July and corn harvest in October the wheat to corn price ratio often nears 1.0-1.05 times the price of a bushel of corn; then it becomes economical to substitute wheat for corn in the diet. A case of prolonged price inversion occurred following the government's Payment in Kind (PIK) program of 1983 when wheat prices were equal to or below the price of corn for an extended period of time in some areas.

Substitution of grains depends on its availability in the region, and the feeds relative feed value compared to the alternative. Physical characteristics of some grains may limit the amount that can be included in hog diets or may require special processing equipment. Any substitution between feedstuffs will depend on local prices and the individual producers' constraints. Estimates of substitution between grains by regions is shown in Table 3.3.

High protein supplements are used to meet the hog's requirement for amino acids. Very little regional differences exist between the type of protein sources used. These feeds are typically produced from plant or animal origins. Producers preparing hog ration on the farm have two options to provide protein in the ration, a commercially manufactured protein supplement or soybean meal plus a vitamin and mineral premix.

The commercially prepared protein supplement contains a protein source along with the necessary vitamins and minerals. These commercial mixtures are usually 25-45 percent crude protein and are mixed with grain by the farmer to produce a nutritionally balanced swine diet. Most feed companies use "least cost" linear program to prepare a high protein

Table 3.3. Hog ration composition changes at different relative prices

Alternative compared to standard	Maximum percent of alternative diet	Price ratio where substitution begins	Cornbelt[a]	Lake States[a]	Appalachian[a]
Wheat to Corn	50	1.05 - 1.00	-.1	-.1	-1.9
		1.00 - .85	-.25	-.25	-1.0
Milo to Corn	100	.95 - .85	-.1	0	-1.2
		.85 - .75	-.25	0	-.10
Barley to Corn	15	.80 - .75	0	0	-.5
		.75 - .65	0	-.7	-.5
Wheat to Milo	50	1.10 - 1.05	0	0	-1.5
		1.05 - .95	0	0	-2.0

[a]Percentage change of alternative feedstuff per one percent change in the relative price.

Southeast[a]	North Plains[a]	Mountain[a]	South Plains[a]	Pacific[a]	Delta States[a]	Northeast[a]
-1.0	-2.0	-1.0	-2.0	-1.0	-2.0	-.1
-1.0	-1.0	-1.0	1.0	-1.0	-1.0	-.25
-1.2	-.6	-.5	-1.5	-.5	-1.0	0
-1.0	-.5	-.2	-1.2	-.2	-1.0	0
-.5	-.4	-.4	-.4	-.4	-.4	-.5
-.5	-.8	-.8	-.4	-.8	-.4	-.5
-1.5	-.7	-.5	-1.5	-.5	-1.0	0
-2.0	-2.0	-1.0	-2.0	-1.0	-2.0	0

supplement. This allows manufacturers to use the most economical combination of feedstuffs to obtain specific, predetermined nutrient levels. The feedstuffs used may be from various sources. According to a feed industry sources, the protein sources in a commercial supplement are typically 60-65 percent soybean meal, 25 percent animal by-products, and 15 percent other plant by-products (i.e., cottonseed meal, peanut meal, linseed meal). Synthetic amino acids are beginning to be used and promise to become more popular in the future. As technology advances it will become cheaper to produce some amino acids artificially compared to supplying them from a plant or animal source. As this occurs, protein supplements will become more concentrated requiring less in a hog feed formulation.

With the soybean meal plus premix option, a producer buys the soybean meal directly. Soybean meal contains 44-48 percent crude protein and works well with corn to produce a ration that meets the hogs requirements for amino acids and energy. In addition to the soybean meal, a commercially prepared vitamin and mineral premix (usually less than 100 pounds per ton of final ration) is used to balance the diet for the essential micro nutrients.

The 1980 USDA survey of hog farms shows that approximately half of the producers used a commercially prepared supplement. Soybean meal plus premix users accounted for over 35 percent of all farms. Complete rations (grain, protein supplement, vitamins and minerals commercially manufactured and delivered to the farm) were used by the remaining ten percent of the producers (Van Arsdall and Nelson, 1984, p. 35). Table

3.4 shows the weighted average hog diet for the entire United States. The regional diets are weighted by the percent of the production contributed by each region.

Table 3.4. U.S. average hog ration composition

Feedstuff	Percent of Diet
Corn	72.3
Wheat	1.2
Milo	5.0
Barley	1.2
Oats	1.1
Oilseed meal	12.5
Animal protein	2.0
Grain protein	0.2
Other processed feeds[a]	1.5
Vitamins and minerals	3.0

[a]Includes wheat midds, molasses, fat, alfalfa meal, grain screenings and other by-products.

CHAPTER 4. ESTIMATING BEEF CATTLE BREEDING HERD FEED CONSUMPTION RATES

The goal of the beef cow producer is to produce the most pounds of calves at weaning time at the least possible cost. Nutrition is an important factor in achieving this goal. Unlike the steer, hog, or broiler, the beef cow is not expected to make rapid weight gains or convert feed to muscle with great efficiency. Instead the cow maintains her mature size and weight, conceives and develops a calf, and nurses that calf until weaning at approximately seven months of age. Because of this reduced nutrient demand, the cow is able to utilize lower quality feedstuffs than growing animals. These feedstuffs are generally forages which include pasture, grass or grass legume hay, or crop residues.

The beef cow's production cycle is one year in length. Most cows are bred in mid-summer. Following a 280-285 day gestation, they calve early the next spring. This allows 80-85 days for the cow to recover from calving and rebreed by mid-summer.

For most of the yearly cycle, the cow's nutrient requirements are low. However, their nutrient requirements are at the highest level during the first 60-90 days post partum (time of peak lactation and rebreeding) (NRC, 1984, pp. 84-85). Because of this seasonal change in the cow's feed needs, most producers plan the cow's production cycle around available forages. By calving in early spring, the cow's highest nutrient demand coincides with the pasture's most nutritious and rapid growth phase which reduces the need for supplemental feed. Calves are normally weaned in the fall reducing the cow's requirements to relatively low maintenance plus gestation level. Again, this coincides with the available forages such as lower quality crop residues, mature pastures, or stored feed.

Factors that affect the cow's actual nutrient requirement include physiological state (lactating or dry), body size, milk production level, and weather (NRC, 1984, pp. 30-32). The amount of a feedstuff needed to meet the cow's requirements depends upon the feed's nutrient content, digestability and dry matter content. This amount must then be compared to the available forages to determine if any additional feed is needed by the cow. Storage loss, wastage at feeding, and weather stress also affect the amount of feed utilized by the cow herd.

Maturity, pregnancy, and lactation all affect the amount of feed required by beef cows and heifers. Yearling bred heifers typically account for 20 percent of the cow herd. These animals have higher nutrient requirements than an older cow because they have not reached their mature body size. Ideally, a heifer should be at 85 percent of her adult size at first calving. To accomplish this, the heifer must gain 0.5-1.5 pound(s) per day from weaning until calving. Protein is especially important for heifers, which require 33 percent more pounds daily than a mature cow. Therefore, heifers need better quality forages or supplemental grain and protein if low quality forages are fed. Also, during lactation the heifer's nutrient requirements are higher than those of a mature cow.

According to studies at the United States Meat Animal Research Center (USMARC) at Clay Center, Nebraska, cow size and milk production level have a significant affect on a cow's nutrient requirement. This is particularly true of energy throughout the year, and of protein during lactation. A large size, high milk producing cow requires 28 percent more metabolizable energy (ME) daily than a medium size, average milk producing cow (NRC, 1984, pp. 84-85). During lactation the crude protein requirement of the large size, high milk producing cow is approximately 50 percent higher than that of a medium size, average production cow.

Cow size and milk production varies greatly with all types of cows found in each region. However, in recent years the trend in the cattle industry has been toward larger size cows. Since the invasion of the "exotic" breeds of cattle from Europe in the 1970s the size and milking ability of commercial beef cows in the U.S. has steadily increased. In general, cows today require more feed than they did 15 years ago.

Another factor affecting feed use is storage and feeding loss. This has become an increasingly important factor since the early 1970s when large hay packages became popular. Large hay packages, either stacks or bales, normally weigh 800-6,000 pounds with 1,000-1,500 pounds being most common. Because of their weight they are mechanically handled, saving labor and time during hay harvest and feeding. However, these large bales often suffer nutrient loss from weathering because most are stored outside. In addition, unless precautions are taken, feeding loss wastage will increase the amount fed to cows to assure their requirements are met. Storage and feeding loss depends on several factors. Amount of rainfall, length of storage time, type of bale or stack, feeding conditions, and quality of forage all have an affect on losses. Studies at various universities indicate total losses in large packages range from 3.5 percent for hay stored inside and fed in racks to 65.2 percent for hay stored outside and fed on the ground (Verma and Nelson, 1981). According to extension specialists in most regions, feeding losses alone equal 5 to 25 percent of the dry matter fed to the cow. This study will assume a dry matter feeding loss for forage of 15 percent over the NRC requirements for all stages of the breeding herd during the winter feeding period.

Another facet of large hay packages that may offset the storage and feeding loss is the larger volume of low quality forages which are harvested. Forages such as mature grasses, corn stalks, and other crop residues that have a nutrient content too low to warrant a high cost harvesting system are now harvested, stored and fed in large packages. This allows a beef cow producer to utilize low quality, low cost forages for the nonlactating beef cows.

Weather also contributes to feed demands for beef cows. Drought or heavy snow cover will directly influence feed availability. However, extreme temperatures also affect feed requirements of cattle. Table 4.1 shows the relationship between temperature and feed intake by cattle.

Other factors which change the effective temperature for the animal include haircoat, wind velocity, amount of shelter, and precipitation (NRC, 1981). Cold climates cause an increased demand for nutrients in December, January, and February. The most crucial nutrient during cold

Table 4.1. Summary of voluntary food intake of beef cattle in different thermal environments[a]

Thermal Environment	Intakes relative to values tabulated in *Nutrient Requirements of Beef Cattle*
> 35°C	Marked depression in intake, especially with high humidity and/or solar radiation and where there is little night cooling. Cattle on full feed--10 to 35 percent depression. Cattle near maintenance--5 to 20 percent depression. Intakes depressed less when shade or cooling available and with low fiber diets.
25 to 35°C	Intakes depressed 3 to 10 percent.
15 to 25°C	Preferred values as tabulated in *Nutrient Requirements of Beef Cattle*.
5 to 15°C	Intakes stimulated 2 to 5 percent.
-5 to 5°C	Intakes stimulated 3 to 8 percent. Sudden cold snap or storm may result in digestive disturbances in young stock.
< -25°C	Intakes stimulated 8 to 25 percent. Intakes during extreme cold (< -25°C) or during blizzards and storms may be temporarily depressed. Intake of high roughage feeds may be limited by bulk.

[a]National Research Council, 1981.

weather is energy. In extremely cold weather, some producers may feed cows a small amount of grain (corn, milo, barley, or others) or an additional amount of range cubes or other supplements which have a higher energy density than forage to insure the animal's requirements are met. This is particularly true for replacement heifers which are still growing and have a higher energy demand than mature cows.

Feed Intake

Daily feed intake (dry matter basis) for the average beef cow (850-1,050 pounds) is approximately 1.75 percent of her body weight or 17.5 dry matter pounds. This amount will vary from 15 pounds between weaning and the last trimester of gestation to 23 pounds during peak lactation (NRC, 1984, pp. 84-85). The estimate of daily dry matter intake is based on NRC requirements for the average cow during each month. This takes into account the percent of cows in a region in each segment of the reproductive cycle (lactating; nonlactating, mid gestation; and non-lactating, late gestation). When wastage is included the average dry matter amount consumed is 20.1 pounds.

Ration Composition

For most of the year, cows are on pasture and their feed intake is not monitored. In some regions, cows graze all year around using crop residue or mature pasture for winter feed. In other parts of the country some, if not all, of the cows winter feed needs must be supplied by the producer. The winter feeding period varies between region but usually is

90 to 180 days long. The most common winter forage for beef cows is hay. However, in some regions, crop residues, silages, and winter pasture are used. Table 4.2 shows the average beef cow diet.

Table 4.2. U.S. average beef cow dry matter ration composition

Feedstuff	Percent of diet
Pasture	67.8
Alfalfa hay	6.2
Other hay	20.3
Corn silage	2.7
Supplement	2.9

Besides forages beef cows also require supplemental vitamins and minerals. Calcium, phosphorus, sodium chloride, trace minerals, and vitamin A are considered the most important. These are usually offered free-choice to the animals as a vitamin-mineral premix, either loose in a special feeder or in a mineral block. During the winter feeding period when low-quality forages are used it is often necessary to supplement the diet with a protein source. Table 4.3 shows the typical ingredients in a beef-cow supplement. Some of the more common methods of supplying protein include: 32 to 40 percent crude protein all natural protein supplement, 35 to 45 percent crude protein nonprotein nitrogen supplement, 20 percent crude protein range cubes, liquid molasses based supplements, and others.[1] The feedstuff estimation procedure for beef cows

[1]Survey of extension and feed industry personnel.

Table 4.3. Composition of protein supplement

	Percent
Oilseed meal	15
Processed feeds	40
Grain proteins	10
Vitamins and minerals	15
Grain	20

is illustrated in the appendix of a USDA technical report (Lawrence, Hayenga, and Jurgens, 1986).

Calves, Replacement Heifers, Bulls, and Stocker Cattle

In addition to cow feed intake, feed consumed by beef calves weighing less than 500 pounds, beef replacement heifers and bulls kept for breeding purposes, and stocker cattle must also be estimated.

Beef calves weighing less than 500 pounds get most of their nutrients from the cow's milk. Most calves are born in the spring and graze the pasture with the cow as they grow older. Some producers "creep feed" their calves, providing supplemental grain only to the calves. The percentage of producers using this practice varies, but extension beef specialists estimate that it is less than 25 percent in most regions. After weaning in the fall calves are fed a diet high in forage, but some grain is added to achieve one to two pounds of average daily gain. Once the calves weigh 500 pounds they will be accounted for as stocker cattle in the Beef Feedlot section of this report, or as replacement heifers.

The ration composition for calves weighing less than 500 pounds is shown in Table 4.4. The Calf Diet Composition chart and Cow Diet

Table 4.4. U.S. average beef calf dry matter ration composition

Feedstuff	Percent of diet
Pasture	61.0
Alfalfa hay	9.0
Other hay	14.0
Corn silage	2.4
Supplement	3.4
Corn	3.9
Milo	2.4
Barley	1.0
Oats	2.9

Composition chart explained earlier are similar in content and interpretation.

Beef replacement heifers are fed basically the same diet as other calves up to 500 pounds. Heifers over 500 pounds are fed a diet to achieve an average daily gain of 0.5 to 1.5 pounds.[1] This growth rate will allow the heifers to reach desirable body size by the time they calve at approximately two years of age. However, over-feeding will cause the animals to become too fat and hamper their reproductive performance. Daily dry matter intake for these heifers is usually 14 to 16 pounds (NRC, 1984, pp. 84-85). Most of this amount is forage, although some producers may feed a concentrate mixture containing grain, vitamins, minerals, and a protein source in addition to the forage. The Heifer Diet Composition chart (Table 4.5) estimates feed intake and

[1]Extension Specialists.

Table 4.5. U.S. average beef replacement heifer and stocker cattle dry matter ration composition

Feedstuff	Percent of diet
Pasture	68.0
Alfalfa hay	8.2
Other hay	18.2
Corn silage	2.8
Supplement	1.6
Corn	0.8
Milo	0.1
Barley	0.1
Oats	0.2

ration composition by replacement heifers and is used in the same manner as the Cow Diet Composition chart explained earlier.

Stocker cattle (steers and heifers that have been weaned but are not in feedlots) are important in some regions. These cattle typically graze summer or winter pastures or winter wheat fields for the majority of their feed requirements. The goal of the producer is to achieve weight gains on these cattle as cheaply as possible. Stockers are typically started after weaning at approximately 450-500 pounds and are put into the feedlot at 650-750 pounds. Stocker diets are similar to replacement heifer diets shown in Table 4.5.

The Statistical Reporting Service reports one category of bulls, bulls weighing over 500 pounds. Within this category are beef breeding bulls, dairy breeding bulls, bulls grown as breeding replacements, and bulls in feedlots. The feed intake and ration composition for beef breeding bulls will be discussed in this chapter, dairy breeding bulls are discussed in the Dairy chapter. Bulls weighing over 500 pounds that have not reached breeding age (15 months) and bulls in feedlots being raised for slaughter are discussed in the Beef Feedlot chapter of this report.

Beef breeding bulls make up approximately five percent of the breeding herd (USDA, ERS, 1980). Once the bull has reached mature size (approximately 15 months of age) the composition of his diet is very similar to that fed to a mature cow. Naturally his daily intake is higher because his body size is considerably larger. Mature breeding bulls consume approximately 28 pounds of dry matter daily (NRC, 1984). The number of breeding bulls is determined by multiplying the bull to cow ratio by the beef cow inventory. These calculations use the regional bull to cow ratio as reported by the ERS (Gilliam, 1984).

Regional Summary

Management practices and diets for beef cows, heifers and calves differ between regions primarily due to temperature and rainfall patterns. Because pasture is the mainstay of the diet in all regions, weather greatly influences the availability of feed. In regions which receive heavy snowfall in the winter (Cornbelt, Lake States, Northeast) hay silage, and possibly some grain is fed for 120-180 days. In parts of the Northern Plains, Mountain, and Pacific regions snow is also a problem requiring hay or silage to be fed to beef herds. In the remainder of these regions and all other regions (Southern Plains, Delta States, Southeast, and Appalachian), little hay or silage is fed. In these areas, snow cover is not a factor and beef herds graze mature pastures throughout the winter.

While cattle grazing mature pastures typically do not receive additional forage, they are fed supplemental protein, energy, vitamins and minerals. This supplement is in the form of range cubes, salt mix, liquid molasses, or a grain with free-choice mineral mixture. Range cubes are a commercially prepared product consisting of grain, grain by-product, oilseed meal, and nonprotein nitrogen (NPN). These cubes are approximately 20 percent crude protein, contain the necessary vitamins and minerals, and are fed at a rate of one to four pounds per head daily. Salt mix has the same basic ingredients as range cubes, but has a high level of salt to limit daily consumption by cattle to one to three pounds per head. Liquid molasses, an energy source, is fortified with vitamins, minerals, and NPN. In grain producing areas, cattle producers often feed the beef herd up to three pounds of grain per head daily, and supplement this with a free-choice vitamin and mineral mixture either in block or loose form.

In areas which feed harvested forages during the winter, similar supplement feeding practices are used. However, most harvested forages are higher quality than pastures and require less supplemental nutrients. Typically one-half to one and a half pounds of concentrates is required.

Beef calves in most regions do not receive concentrates. Calving is typically timed to match maximum pasture production with the cows' highest nutrient requirements. However, in the Cornbelt, Lake States, Northeast, and Appalachian regions creep feeding is popular. Creep feeding refers to providing concentrates in feeders designed to allow the calf access to the feed but not the cow.

This practice is used primarily in late summer and fall when pastures fail to meet the nutritional needs of the growing calf. In other regions pastures are often too large to make creep feeding practical. In cooler climates, where snow cover is a problem, most calves are born in the spring and weaned in the fall. In warmer climates where pasture is available year around calves are born in nearly all months of the year. While occurring in all months, most calving is concentrated in December, January, and February and is avoided in the hot summer months. One exception is southern California and Arizona where most calves are born in the fall. Again, this coincides with available pasture which is greatest in late fall and winter due to seasonal rainfall patterns.

Replacement heifers generally receive a better diet than mature cows. This is especially true in the Cornbelt, Lake States, and other grain producing areas. In these regions, heifers may receive one to four pounds of supplemental grain daily during the winter feeding period. In other regions, heifers may receive extra supplement or graze better quality pastures than mature cows to ensure the heifers higher nutritional requirements are met.

Stocker cattle are common in the Southern Plains, Northern Plains, Pacific, and Mountain regions where they graze winter wheat fields or mature pasture during the winter and early spring. In the Delta States, Southeast, and Appalachian regions these cattle graze mature pastures throughout the winter. During the summer, in all regions, stocker cattle graze pastures. In nearly all regions, however, very little concentrates are fed to stockers beyond the required vitamins and minerals.

CHAPTER 5. ESTIMATING SHEEP AND LAMB FEED CONSUMPTION RATES

The sheep industry in the United States produces red meat and wool. Nutrition is an important factor in efficient sheep production. Because sheep are ruminants, and can utilize low cost forages, the feed portion of total production expense is less than that of other species. Forages are the major feedstuff for both the breeding flock, and for market lambs. In the western United States, forty percent of the market lambs are finished entirely on pasture with little or no supplemental grain (Gee and Magleby, 1976).

Because of the extensive use of forages, over 80 percent of the sheep population in the United States is located in the western four regions (Northern and Southern Plains, Mountain, and Pacific Regions) (USDA, 1985a, p. 5). These regions have vast amounts of both publicly and privately owned grazing land. A 1974 USDA survey of western sheep producers indicated that publicly owned land supplied 18 percent of the breeding flock's feed supply with the remainder coming from privately owned grazing land or supplemental feed (Gee and Magleby, 1976, p. 28). Nearly half of the remaining 20 percent of the nation's sheep are located in the Cornbelt region. These flocks as well as the others in the eastern half of the United States are primarily small flocks with all of the feed coming from privately owned land and supplemental feeding.

The sheep population can be divided into two groups, breeding flock and lambs (feeder lambs birth to weaning, market lambs weaning to slaughter). The ewes in the breeding flock maintain a mature weight, conceive and produce a lamb (or lambs if a multiple birth), and raise their offspring until weaning at approximately six to sixteen weeks of age. Except for the period six weeks prior to lambing through lactation, the nutrient requirements and feed intake level of the ewe are quite low and can often be supplied by low quality forages. During the three to four months of higher nutrient demands, better quality forages, or possibly even grain and protein supplements may be fed. However, to insure available forages to meet the ewe's requirements many producers plan the peak nutrient demand of their sheep to coincide with peak supplies of pasture and forages.

The nutrient requirements of goats are very similar to those of sheep. Goats consume the same feedstuffs at approximately the same daily rate as sheep of comparable size. Thus, mature goat inventories can be added to mature sheep numbers when calculating the feed estimates.

Market lambs typically remain on pasture following weaning until they weigh 60 to 80 pounds depending on pasture quality.[1] When dry conditions cause a shortage of grass, lambs will enter the feedlot at lighter weights. If grazing is available and gains are acceptable the lambs will remain on pasture to higher weights and possibly until slaughtered. Regardless of the starting weight, lambs are usually slaughtered at a finished weight of 105 to 115 pounds. According to extension and feed industry personnel, feedlot rations for market lambs are generally about 85 percent concentrates and 15 percent forage.

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[1] Extension and Feed Industry Personnel.

Feed Intake

Feed intake estimates for ewes in the breeding flock are based on the National Research Council recommendations for daily dry matter intake (NRC, 1975). This amount is adjusted to account for the number of lambs per ewe reported in the 1983 ERS Cost of Production budget, and the percentage of the flock in each reproductive stage (lactation, non-lactating early gestation, and nonlactating late gestation) during a period shown in the 1974 USDA survey. The amount of feed consumed by rams is included with the ewes daily feed intake based on the ewe:ram ratio. Replacement ewe lambs will be considered market lambs until they enter the breeding flock at which time their daily feed intake will be the same as the mature ewes. The amount of harvested forages consumed per animal is increased by 15 percent to account for feeding waste. In addition, severely cold weather may cause the feed requirement for the animals to increase. This increase will be reflected in the daily intake rates in some regions during the winter months.

To estimate daily dry matter feed consumption by lambs from weaning to market, the National Research Council recommendations were again used. Lambs consume feed ad libitum either on pasture or in the feedlot. Daily dry matter intake is proportional to body size and is assumed to be at the maximum during all stages of the growing phase. Feeding waste is assumed to be five percent for all harvested feedstuffs. This loss is less because most roughages are either ground or pelleted when fed with the concentrates in a finishing ration, particularly in the larger feedlots.

The Statistical Reporting Service reports sheep and lamb inventories as of January 1. Therefore, it is difficult, if not impossible, to monitor lamb movement into and out of a region or when or how many of the lambs are placed on feed. Feed intake estimates will use the following assumptions based on information from USDA publications, extension pesonnel, and professionals in the field.

1. The annual movement of lambs into and out of each region is assumed to be equal in all regions except the Cornbelt, Lake States, and Mountain States. Outflow of lambs from the Mountain States is estimated to be equal to nine percent of the region's lamb crop. These lambs result in an inflow into the Cornbelt (67 percent) and Lake States (33 percent).
2. There will be lambs on feed at all times in all regions. The average minimum lamb weight is 65 pounds.
3. The average feeder lamb weight in the western four regions, Cornbelt, and Lake States is based on ERS Cost of Production Survey of sheep producers.
4. All lambs sold as feeder lambs receive a finishing ration containing concentrates as well as roughages.
5. Lambs receive no concentrates until they are sold as feeder lambs.
6. Lambs sold to slaughter from grass receive no concentrates.
7. Lamb placements into feedlots and rate of gain performance relative to NRC standards are as follows:

	Placements	Performance
Jan-Mar	23.3%	80%
Apr -May	23.3%	100%
June-Sept	23.3%	80%
Oct -Dec	30.0%	95%

The complete procedure and an illustrative example are included in a USDA technical report (Lawrence, Hayenga, and Jurgens, 1986).

Ration Composition

Ration composition for the breeding flock (Table 5.1) is based on the 1974 USDA survey of western sheep producers for those regions (Gee and Magleby, 1976). Estimates by extension sheep specialists were used in the remaining regions and as a cross-check of the survey data. The estimated ration composition for the market lamb diet (Table 5.2) is based primarily on a telephone survey of extension sheep specialists, sheep feed manufacturers, and large sheep feedlots. Feed intake and ration composition will be discussed in more detail in each of the regional discussions. Table 5.3 shows the typical composition of sheep supplements.

Table 5.1. U.S. average stock sheep dry matter ration composition

Feedstuff	Percent of diet
Pasture	65.6
Hay	21.9
Crop residue	5.6
Concentrates	6.9

Table 5.2. U.S. average market lamb dry matter ration composition

Feedstuff	Percent of diet
Pasture	31.3
Hay	10.0
Crop residue	1.5
Corn	35.9
Wheat	2.8
Milo	5.7
Oats	2.8
Supplement	10.0

Table 5.3. Composition of sheep protein supplement

	Percent
Oilseed meal	15%
Grain protein	10%
Processed feed	40%
Vitamins and minerals	15%
Grain	20%

Seasonal Effects

Sheep are affected less by temperature extremes than other species of livestock. Traditionally sheep are shorn in the spring prior to warm weather, and by late fall have regrown a new coat of wool. The National Research Council estimates changes in dry matter feed intake to be negatively correlated to effective ambient temperature. Table 5.4 shows the percentage change in daily dry matter feed consumption at various temperatures for the breeding flock and market lambs.

Table 5.4. Effect of temperature on dry matter feed intake of sheep[a]

Temperature	Percentage change in daily dry matter intake compared to 20°C
----°C-----	------------percent change------------
-10	+12.5
0	+7.5
10	+5.0
30	-7.5

[a]NRC, 1981.

Regional Summary

Eighty percent of the nation's sheep are produced in the western four regions of the United States. Sheep producers rely on private, federal and state grazing land for most of the breeding flock feed supply. In the eastern regions very little public land is available for grazing. Pasture and rangeland provide 38 to 78 percent of the dry matter feed consumption annually. The remainder of the diet consists of crop residues (wheat stubble, cornstalks, etc.), harvested forage (hay or silage) and a small amount of concentrates. Most concentrates are grain, grain by-products, oilseed meal, and other processed feeds which provide supplemental protein, energy, vitamins, and minerals.

In the Cornbelt, Lake States, Northeast and parts of the Mountain and Northern Plains regions snow cover prevents grazing from approximately December 1 to April 15. During this period, harvested forages and a small amount of concentrates (i.e., 0.5 to 1.5 pounds) are fed to the breeding flock. In the remaining regions winter grazing of crop residue or mature pasture is available. Sheep consuming these lower quality forages are generally fed slightly more concentrates (i.e., 1 to 2 pounds). Range cubes, protein, energy, vitamin, and mineral mixture, are the most popular concentrates in the Southern Plains and Mountain regions. In the Pacific region the breeding flock is often moved to winter pasture at lower altitudes. These pastures are typically dormant alfalfa, bluegrass, or other higher quality forages. Sheep on these pastures receive very little supplemental feed.

A large portion of the market lambs are marketed directly from pasture and do not receive any concentrates. This percentage varies from nearly zero in the eastern regions to nine percent in the Southern Plains to 62 percent in the Pacific region. When lambs are fed concentrates, they generally are not placed on feed until they weigh 60 to 80 pounds. The Mountain, Northern Plains, Southern Plains and Cornbelt are the largest lamb feeding regions. Market lamb diets are typically 85 percent concentrate and 15 percent forage. Concentrates are primarily corn in the upper Midwest and central Mountain states and corn or milo in the Southern Plains and southern Mountain states.

Forages are the primary feed source for the breeding flock and also comprise a large part of the market lamb's total feed consumption. In the western region, private and public land is grazed, while in the eastern region most pasture is privately owned. Harvested forages are typically fed during the winter in regions where snow cover prevents grazing. In general, breeding flock diets contain a small amount of supplemental concentrates. Market lamb diets may vary in concentrate content from 0 to 85 percent depending on location and market conditions.

CHAPTER 6. ESTIMATING FEEDLOT CATTLE FEED CONSUMPTION RATES

The U.S. cattle industry is the major supplier of red meat for U.S. consumers. Animals enter feedlots at a starting weight ranging from 300 to 800 pounds to a market weight of 850 to 1300 pounds. The performance (daily gain and feed efficiency) of these animals is greatly affected by the type of feedstuffs consumed. After the purchase of feeder cattle, feed is the major cost facing the feedlot operator. Following a brief overview of feedlot cattle nutrition, the feed intake and ration composition for this industry in ten geographical regions will be discussed.

Feedlot cattle diets should be formulated to fulfill the animals requirements of energy, protein, vitamins, and minerals. These requirements depend on the size and maturity of the animal as well as the desired growth rate. The National Research Council's (NRC, 1984) Nutrient Requirements of Beef Cattle summarizes these requirements. This publication also estimates daily dry matter feed intake of cattle. These estimates take into account the animal's weight, frame size (an indication of genetic potential), and average daily gain as well as the diet's energy concentration. Information about these factors was collected from nutritional consultants, extension feedlot specialists, and where possible, actual feedlot consumption records in each region. Once the animal's frame size, average daily gain, and ration composition were found, daily feed consumption was determined.

Feed Intake

Cattle will consume feed until either their energy requirement is met or they are physically full (Jurgens, 1982, pp. 267-295). Therefore, daily dry matter intake depends on both the animals' size and the diet's energy content. For medium-frame steers daily dry matter feed intake ranges from approximately 10.5 pounds for a 400 pound calf to about 21.0 pounds for a 1,000 pound animal (NRC, 1984). This is 2.63 and 2.10 percent, respectively, of the animals' bodyweight as daily dry matter intake. During the steer's stay in the feedlot, his daily dry matter consumption will average 2.0 to 2.4 percent of his bodyweight. Heifers consume less feed than steers at each weight. For medium-frame heifers, daily dry matter feed intake is approximately a half pound less than steers at 400 pounds and one pound less than steers at 1,000 pounds.

In estimating total feed utilization by fed cattle, a separate average daily dry matter intake amount will be used for the under 500 pound, 500- 700 pound, and over 700 pound weight classes of cattle reported in the USDA quarterly Cattle on Feed (USDA, 1985b). Because Cattle on Feed only reports 13 states with approximately 85 percent of the rations feedlot cattle, the reported numbers have to be adjusted to a U.S. equivalent. The adjustment should be based on January cattle on feed in 13 states compared to the U.S. total. Cattle in the 500-700 pound class are assumed to have a weight equal to the midpoint of the range. Weights for cattle in the under 500 pound class are based on seasonal weights for cattle placed on feed (Trapp, 1981). Cattle in the over 700 pound classes are assumed to have the mean weight between 700 pounds and slaughter weight (adjusted for shrink). Inventories in each weight class will be changed by death loss and placements and moved to the next higher weight class (based on typical growth rates) until they reach slaughter weight or the next Cattle on Feed report is released. The total placement number reported in the quarterly Cattle on Feed is divided among the different sex and weight categories based on seasonal estimates by Trapp. Slaughter weight is based on Federally Inspected dressed weight divided by 60 percent dressing percentage. Slaughter numbers are based on percent steers or heifers slaughtered in Federally Inspected plants adjusted to commercial slaughter and feedlot marketings. The animals' growth and subsequent increase in feed consumption as the quarter progresses will be included in the estimate. In addition, seasonal and regional differences in average daily gain and feed intake will also be considered. Dry matter consumption by feedlot cattle is adjusted for feed wastage. Concentrate wastage is assumed to be approximately four percent on a dry matter basis. Roughage wastage varies between regions depending on the type of roughage being fed to cattle. On a dry matter basis, roughage waste is assumed to average 15 percent across all regions. Once the total dry matter consumption for a group of animals is determined it will be multiplied by the ration composition matrix to indicate the individual feed ingredient demand for a region during a given time period. Further details are contained in a USDA technical report (Lawrence, Hayenga, Jurgens, 1986).

Seasonal performance will differ between regions with some regions having more variation between seasons than others. Environmental stress caused by temperatures outside the thermoneutral zone (15° to 25° C), humidity, wind speed, precipitation, and lot conditions all effect feed consumption (NRC, 1981). Except for those with access to shelter or those in confinement housing, feedlot cattle are exposed to environmental elements. These protective structures are found on a portion of the farms in the Cornbelt and Lake States regions and represent a relatively small percentage of feedlot cattle. Although feedlots in most regions may offer protection from the wind, it is still a major stress to the cattle. Precipitation during the cooler months stresses the animal not only by wetting the hair coat and reducing its insulation value, but also by increasing mud in the feedlot. Mud can greatly effect the animals performance, and is considered by some to be the greatest environmental factor.

The 1981 NCR report Effects of Environment on Nutrient Requirements of Domestic Animals suggests that feed intake is negatively correlated to the effective ambient temperature (EAT). However, the extent of the temperature stress depends on other factors as well. Type of ration, duration of temperature stress, acclimatization to extreme temperatures, and fluctuation in temperatures all affect the animal's feed consumption. While this relationship would seem to indicate higher feed intake in the winter, lower feed intake in the summer, with fall and spring consumption in between, research and commercial feedlot data does not support that hypothesis. Johnson analyzed data from Colorado, Iowa, Minnesota, and Canada which showed little difference in daily dry matter intake between winter and summer (Johnson, 1984). Iowa State University research indicated that cattle fed 140 to 180 days had the lowest daily dry matter consumption when started on feed in November and the highest feed intake when started in May (Pusillo and Hoffman, 1985). Cattle fed through the winter consumed two pounds less dry matter than those fed through the summer. Three years of Texas feedlot data, representing approximately half of the feedlot cattle in that state, also shows feed consumption to be lowest in the winter, highest in the spring, with summer and fall nearly equal.[1] There are increased maintenance requirement for cattle under stressful conditions. However, this increased requirement does not guarantee that feed intake will also increase, as it is often reflected in reduced performance (feed efficiency and average daily gain). In the research reviewed by Johnson, average daily gain (ADG) was lowest in the winter and highest in the summer. The Iowa study reported fluctuations in ADG similar to feed consumption, lowest in winter and highest in summer. Feedlot records from Texas indicated the same results. These findings suggest that the animal does not increase feed intake during cold weather to offset the increased maintenance requirement, but rather experiences a reduced growth rate and feed efficiency.

Often the cause of the increased maintenance requirement is also the reason the animal does not increase feed consumption. Heavy snow or deep mud may make it difficult for the animal to get to the feed bunk, increasing stress and reducing feed intake. During extremely cold temperatures, animals may prefer to huddle or stand in a sheltered area

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[1]Texas Cattle Feeders Association monthly summaries 1982, 1983, and 1984.

rather than eat. Sudden weather changes, snow, or rain may cause cattle to "go off feed" for a short time reducing overall performance and feed consumption. During times of high temperatures, cattle may eat in the cooler parts of the day or night. Producers may increase the energy density of the ration so the same amount of net energy for maintenance and gain are consumed but in less pounds of feed daily. Also, feedlot operators may provide shade or sprinkler systems to reduce the heat stress on the animals.

Ration Composition

Cattle are ruminants and therefore, can utilize a wide variety of concentrates and roughages. The typical concentrates used in a feedlot ration are high energy grains (corn, wheat, milo, and barley), high protein supplements (oilseed meals and nonprotein nitrogen), and by-products (wheat midds, corn gluten feed, rice bran, and potato waste). Depending on the size of the cattle and the desired rate of weight gain, concentrates will comprise 40 to 90 percent of the daily feedlot diet. Roughages include dry roughages such as hay (alfalfa, clover, or grass), by-products (cotton gin trash, almond hulls and beet pulp), and wet roughages like silage (corn, milo, alfalfa and small grain). Corn silage is assumed to be 50 percent concentrate and 50 percent roughage. Milo silage is assumed to be 20 percent concentrate and 80 percent roughage. A minimum amount of roughages is required in the cattle diet to insure proper rumen function (Jurgens, 1982, pp. 267-295). Roughages comprise 10 to 60 percent of the feedlot cattle diet. In general, cattle diets contain 2 to 6 percent more roughage in the winter than summer. The sometimes adverse and dramatic fluctuations in winter weather will cause cattle to "go off feed" or make it impossible to get feed. Higher roughage content in the diet reduces the chance of serious digestive problems that can arise when cattle are off feed.

Concentrates are higher in energy than roughages and provide more weight gain per pound of dry matter intake. A typical diet for cattle weighing 400 to 700 pounds has a higher roughage content than a "finishing" diet for cattle weighing over 700 pounds. The lower energy content "growing" diet is usually 25 to 50 percent roughage. This diet allows younger cattle to develop bones and structural muscles without producing excess fat. The higher energy content "finishing" diet promotes more rapid weight gains and allows the animal to produce enough fat to grade U.S. good or better at slaughter according to USDA grading standards. The switch from a growing to a finishing ration may occur at a higher or lower weight depending on the animal's frame size, desired slaughter weight, and the producer's preference.

The type of ration consumed by cattle will vary between regions depending on available feedstuffs and management practices of the cattle feeder. The producer will prepare a ration that has the necessary protein, vitamins, minerals and the proper amount of energy to achieve the desired daily gain. Energy is the major concern of cattle feeders because protein, vitamin, and mineral requirements can easily be fulfilled with a supplement. The standard method of calculating energy requirements for feedlot cattle used today is the net energy system.

This system separates the animal's requirement into net energy for maintenance (NE_m) and net energy for gain (NE_g). Cattle of a given weight and desired rate of gain have a specific requirement for NE_m and NE_g. Feedstuffs which vary in NE_m and NE_g are then combined in the proper proportion to fulfill the requirements.

The goal of cattle feeders is to obtain the least possible cost of gain. This goal is best achieved by maximizing the animals genetic potential for gain. The animal's maintenance requirement can be compared to a fixed cost; even if the animal is not gaining it still will consume some feed. Thus, by increasing the animals average daily gain (ADG), the cost of gain per pound can be reduced as shown in Figure 6.1. For this example, consider a 700 pound medium-frame steer at six different levels of gain.

Daily gain (lb)	Dry matter intake (lb)	--Energy density of diet-- NE_m (Mcal/lb)	NE_g (Mcal/lb)
0.5	14.8	0.50	0.25
1.0	15.8	0.57	0.31
1.5	16.5	0.64	0.38
2.0	16.8	0.70	0.44
2.5	16.7	0.79	0.51
3.0	15.2	0.95	0.64

Source: Nutrient Requirements for Growing and Finishing Cattle, Table 10.

Figure 6.1. Dry matter intake and diet energy density for growing and finishing cattle (NRC, 1984)

As daily gain increases the energy density must (Mcal/lb) also increase, particularly when the animal is near his maximum dry matter intake. The cost of gain in terms of Mcal per pound of gain is much higher at 0.5 pound ADG compared to 3.0 pounds, NE_m is 14.8 versus 4.81 and NE_g is 7.4 versus 3.24. The producer has in essence lowered his "fixed cost" per pound of gain by obtaining the higher rate of gain.

Another important point is that to maximize returns the producer must feed a ration that yields the lowest dollar cost per pound of gain, not the lowest cost per pound of feed. Assuming that the 700 pound steer will be fed 0.75 pound of a commercial supplement to balance the diet for protein, vitamins, and minerals, the producer can choose between two rations. Ration 1 is corn silage at $26.00 per ton (as fed), and Ration 2 is a mixture of 90 percent corn at $2.60 per bushel and 10 percent alfalfa hay at $70.00 per ton. Excluding the cost of the supplement which is the same for both rations, the cost to feed the steer per day is 54.74 cents on ration 1 and 65.21 cents on ration 2. However, the cost per pound of gain is 3.84 cents less on ration 2 (21.04 versus 24.88) because the steer is gaining an additional 0.9 pounds per day on ration 2 compared to ration 1. When the nonfeed costs (interest, labor, etc.) are included, the difference increases substantially because of the added time required to reach market weight. The producer must combine available feedstuffs to achieve the optimal level of NE_g for the ration. The composition of this ration is dependent on the price of available feedstuffs, the relative feeding value of feedstuffs, and the feedlot's management system.

The relative feeding value of feedstuffs is important when considering substitutions in the diet. Corn is the most common grain in feedlot cattle rations. Close substitutes include wheat, milo, and barley. Least-cost formulations or cropping practices in the area determine the composition of the ration, but physical characteristics of some grains limit their potential in a diet. Corn is the standard to which other grains are compared; when it is cost effective it will be the only grain in the ration. Table 6.1 lists the substitutibility of common feed grains compared to corn in each region.

Wheat is typically too expensive to feed; however, in recent years its price relative to corn has led to increased use. Wheat has slightly less energy per unit compared to corn, but is higher in protein (NRC, 1984). Because the starch in wheat is so readily digestible, acidosis and other digestive problems can occur if its portion of the ration is too high. Traditionally 50 percent of the diet was considered to be a safe maximum level for wheat (Jurgens, 1982, p. 151). However, according to consulting nutritionists the use of additives such as sodium bicarbonate can increase the wheat portion of many feedlot diets to 75 percent or more when relative prices are favorable. While several factors enter into the relative worth of wheat compared to corn, i.e., protein requirements of cattle, price of alternate protein sources, price of cattle, and others, a common rule of thumb is that wheat can be substituted for corn when its price is 105 percent that of the corn price. The marginal value of wheat declines as more is added to the diet and drops significantly beyond the 50 percent level. Where wheat is available, it will be

Table 6.1. Feedlot ration composition changes at different relative prices

Alternative feedstuff compared to typical grain	Price ratio where substitution begins	Northern Plains[a]	Southern Plains[a]	Mountain[a]
Wheat to Corn	1.05 - .95	-2.0	-4.0	-2.5
	below .95	-1.0	-1.0	-1.0
Milo to Corn	.85 - .75	-2.0	-3.0	-1.2
	below .75	-2.0	-3.0	-1.7
Barley to Corn	.90 - .85	-1.0	-1.7	-1.8
	below .85	-1.5	-1.7	-.18
Wheat to Barley	1.05 - .95	-1.2	-1.2	-2.0
	below .95	-2.0	-2.0	-2.0
Wheat to Milo	1.25 - 1.15	-2.0	-2.0	-1.5
	below 1.15	-1.0	-1.0	-1.0

[a]Percentage change of alternative feedstuff in diet per one percent change in the price ratio. As an example, if the wheat to corn price ratio falls by 5 percent the percent wheat in the diet will increase by 10 percent in the Northern Plains region. (1.05 falls to 1.00, wheat increases by 5 x 2.0 = 10 percent).

Cornbelt[a]	Pacific[a]	Lake States[a]	Northeast Appalachian[a]	Southeast Delta[a]
0	-4.0	0	0	-4.0
-.3	-1.0	-.3	-.5	-1.0
0	-3.0	0	0	-3.0
-.2	-3.0	0	-.5	-3.0
-.2	-2.0	-.2	-.2	-1.7
-.4	-2.0	-.4	-.4	-1.7
0	-2.0	0	-2.0	-1.2
0	-2.0	0	-2.0	-1.0
0	-2.0	0	-2.0	-2.0
0	-1.0	0	-1.0	-1.0

substituted for corn in feedlot diets if the local wheat to corn price ratio is less than 105 percent. However, for a region as a whole the maximum level of wheat is assumed to be 50 percent of the total diet.

Milo has always been used in cattle rations, but as a second choice to corn. Nutritionally, milo appears comparable to corn. However, physical characteristics limit milo's effective feeding value for cattle to 85-95 percent of corn (Jurgens, 1982, p. 150). The seed coat on milo is extremely hard and requires that the kernel be properly processed (ground, rolled, flaked, etc.) before cattle can fully utilize it. As with wheat, several factors determine when milo will be included in a diet. The rule of thumb for milo is that pound for pound it is worth 85-95 percent the price of corn. However, if a feedlot does not have the proper processing equipment to handle milo it is nearly useless. Because not all lots can process this grain, milo will not make up over approximately 60 percent of the grain portion of the ration in any region.

Barley is also used in feedlot rations. As with other grains, relative prices locally dictates its portion of a ration. Relative to corn, barley has a feeding value of approximately 90 percent in a feedlot cattle diet (Jurgens, 1982, p. 151). When the barley to corn price ratio falls below 90 percent barley will be used in the ration up to a 100 percent of the grain portion.

Roughages in feedlot diets depend greatly on what is available locally. Because of their high bulk and sometimes high moisture content (silage), roughages can be not economically transported very far. Thus, roughages in feedlot diets differ between geographical areas and will be discussed in the regional summary. Alfalfa hay is a common roughage in feedlot rations. It does not require specialized storage like silage, and it is easily marketed and transported. Corn silage does require special storage facilities, must be grown in the immediate vicinity, and must be held in inventory, tying up capital over a long period of time. Cotton by-products are popular for many of the same reasons as alfalfa hay--lower storage cost, easy handling, and a ready market. In addition, whole cottonseed is higher in NE_g than other roughages and may be used in a ration instead of alfalfa for that reason. Because of high transportation cost of roughages, feedlots prefer to use locally grown forages when possible.

In addition to grains and roughages, feedlot diets include a vitamin, mineral and protein supplement. This supplement is typically fed at a fixed amount per head daily, i.e., .75 to 1.25 pounds per head per day. Two basic types of supplements exist. Those with nonprotein nitrogen for cattle weighing over 700 pounds and those without nonprotein nitrogen for cattle weighing less than 700 pounds (Table 6.2). Lighter cattle cannot fully utilize nonprotein nitrogen and require a supplement with all natural protein sources (oilseed meal, grain protein, and other processed feedstuffs). Heavier cattle can utilize the lower cost nonprotein nitrogen and require less of the more expensive natural sources.

Management systems can be divided into two basic groups, commercial feedlots and farmer-feeders. Commercial feedlots typically have capacity in excess of 5,000 head and often specialize in custom-feeding a large portion of their cattle. Custom-feeding refers to feeding cattle owned

Table 6.2. Protein, vitamin, and mineral supplement for beef feedlot cattle

Weight of cattle	Oilseed meal	Other processed feed	Grain protein	Nonprotein nitrogen	Vitamins and minerals
	Percent of diet				
Under 700 lbs	75	13	5	0	7
Over 700 lbs	40	38	5	9	8

by someone else for a fee. Commercial feedlots care for the cattle from a starting weight (i.e., 700 pounds) to slaughter, and charge the owner of the animal for the feed consumed and a daily yardage fee to cover nonfeed costs (labor, management, and return on investment). Many of these feedlots are able to capture economies of scale, make use of the latest technology, and hire nutritional consultants to obtain maximum efficiencies. These feedlots purchase some, if not all, of their feed ingredients and thus can use a wide variety of feedstuffs. Rations are formulated for the least cost of gain based on feed prices delivered to the feedlot.

It is difficult to predict aggregate ration composition, even assuming that feedlots use least cost formulation. Feedlots may have different physical constraints, i.e., processing equipment, transportation alternatives, or storage facilities. Also, some feedlots may choose to forward price their feedstuffs by hedging in the futures markets or forward pricing in the cash market. Thus, the effective price which the feedlot faces may not be the same as the current local price. Without full knowledge of these constraints, least cost formulation for an entire region is extremely difficult.

Farmer-feeders, as the name implies, include cattle feeding as part of a diversified farming operation. These producers are located mainly in the Cornbelt and Lake States regions. Characteristics of Farmer Cattle Feeding reports that farmer-feeders produce all of the silage, 99 percent of the hay, and 95 percent of the corn fed in their cattle feeding operation (Van Arsdall and Nelson, 1983). In addition, 83 percent of these farms have another livestock enterprise. The majority of the farmer-feeders have relatively small capacity compared to commercial feedlots, generally less than 1,000 head. Unlike the commercial feedlots, the cattle are usually owned by the farmer.

Traditionally, the farmer-feeder has fed cattle in a seasonal pattern. Cattle are normally purchased in the fall, fed to slaughter weight, and sold the next spring or summer. The farmer-feeder generally buys feeder cattle at a lighter weight (calves instead of yearlings) and feeds more roughage in the ration than do commercial feedlots (Cattle-Fax, 1984).

Because of the smaller capacity, it is often difficult for farmer-feeders to justify some practices that improve efficiency commonly used by larger feedlots. These practices include accurately weighing all feed daily for each pen, hiring a nutritional consultant, and using a detailed enterprise record keeping system. Also, these producers face a constraint because they produce their own feed supply.

Once the crops, corn, corn silage, and alfalfa hay are harvested, most farmer-feeders are locked into feeding these feedstuffs in the ration. While alternative feeds may be lower priced, producers still may choose not to switch feed ingredients. Several problems can arise when alternative feedstuffs are considered. Producers in the Cornbelt may not have the necessary experience with other feedstuffs to properly feed them. Storage space may not be available to hold another commodity without selling the farmer's crop first. A ready market may not exist for the farmer's silage or high moisture corn, leaving no alternative but to feed it to livestock. In addition, the necessary processing equipment may not be available to properly handle the alternative feedstuff.

Although farmer-feeders all use similar rations, the exact composition is difficult to estimate because of a lack of accurate information. As mentioned, small capacity cattle feeders seldom have scales to weigh feed or a record system to keep track of feed information. Those producers who do record feed data generally are above average producers, and may not be representative of typical farmer-feeders.

Because ration composition in either commercial or farmer owned feedlots is difficult to accurately predict, this study will estimate a typical ration for each region. This estimated ration will be for typical commodity price relationships. As the relative prices of feed ingredients that are close substitutes change, an adjustment factor can be used to alter the original ration in each region. These regional diets are then combined into a U.S. average diet weighted by the portion of cattle fed in each region (Table 6.3).

Table 6.3. U.S. average feedlot cattle dry matter ration composition

Feedstuff	------Percent of diet by weight of cattle----- Under 500 lbs	500-700 lbs	Over 700 lbs
Corn silage	36.3	24.1	12.8
Hay	16.0	12.5	5.3
Other roughage	1.2	1.2	1.2
Corn	22.5	35.4	51.0
Wheat	4.1	5.3	6.6
Milo	7.9	10.5	14.1
Barley	3.3	4.3	5.4
Oilseed meal	7.5	5.3	1.2
Grain protein	0.5	0.4	0.2
Other processed feed	2.0	2.6	3.3
Vitamins and minerals	0.7	0.5	0.2

Adjustment Factors

Daily dry matter feed intake estimates can be adjusted to reflect abnormal weather conditions if necessary. The seasonal intake coefficient in the estimate accounts for most of the variation in feed intake (Table 6.4). Deviations from the mean temperature for an entire region for a period of two to four months typically are very small. When these deviations can be documented for a region and period the coefficients in Table 6.5 can be used to adjust the daily dry matter feed intake. As discussed earlier, cattle consume more feed in warmer weather than in colder weather. However, a negative correlation does exist between temperature and feed intake at each intake range. A steer will eat more in summer than winter, but during summer as temperatures increase, his consumption will decline over a narrow range.

Table 6.4. Seasonal feed intake and average daily gain adjustment

Period	Feed intake	Average daily gain
January-March	.983	.845
April-May	.997	.921
June-September	1.008	1.00
October-December	1.005	.889

Table 6.5. Effect of temperature deviation from seasonal mean on daily dry matter intake[a]

Region	Percentage change in dry matter feed consumption per degree Fahrenheit deviation from seasonal mean temperature
Northern plains	.0875
Southern plains	.05
Mountain	.0875
Cornbelt	.10
Pacific	.0625
Lake states	.10
Southeast	.05
Northeast	.10
Appalachian	.0875
Delta states	.05
U.S. average	.08

[a]Inverse relationship between temperature and feed intake, an increase in temperature will cause a decrease in feed consumption.

As an example, if the average temperature for the June-September period is three degrees above normal in the Northern Plains region, daily dry matter consumption would decline by 0.2625 percent. For a 1,000 pound medium frame steer, this would be a reduction of 0.05 pounds per day for the entire period.

Adjustments in ration composition due to relative price changes of feedstuffs is also an important factor. As discussed earlier, the amount of substitution between feedstuffs differs across regions. Thus, a particular change in prices relative between wheat and corn in the Southern Plains would have a different result in the Lake States. Table 6.1 lists the estimated rate of substitution in each region at given price ratios. As an example, if originally the Southern Plains diet contained five percent wheat at a wheat to corn price ratio above 1.05 and the price ratio went to 1.00, the ration would contain 25 percent wheat.

Ration composition adjustments may occur due to changes in feeding margins. If the change in feeding margins is due to a change in fed cattle prices, no change in the ration will occur. Cattle feeders are producing beef at a minimum cost regardless of the price of the output. The only change that may occur is a change in output. In the short run, output is fixed except for slaughter weight. The estimation procedure includes an equation to account for changes in slaughter weights. If the change in feeding margins occurs because of a change in an input price, a ration change may occur. In most cases, particularly in the commercial feedlots, if a substitution does occur it is one concentrate for another and not roughage for concentrate. For example, corn may be replaced by milo or wheat. But corn will seldom be replaced by alfalfa hay because roughages reduce the net energy of the diet and therefore the performance of the cattle. If roughages do replace concentrates, it is typically less than 3 percent and fat is normally added to the diet to maintain the energy level. Substitution among roughages is also rare because of the physical constraint of transporting roughages. Once cattle are on a "finishing" diet, it is doubtful that feeders will alter the ration. Such a change would reduce the animal's performance until it is fully adjusted to the new diet, offsetting most, if not all of the savings. The primary situation where concentrate-roughage substitution would occur would be when cattle are held on the "grower" diet for a longer time before being switched to the "finishing" diet, for example, if grain is priced relatively higher than roughages.

Regional Summary

Northern Plains is the largest fed cattle producing region. Nebraska and Kansas have most of the production within the region. This region is unique because many farmer-feeders and commercial feedlots are both present. Approximately 22 percent of the cattle marketed are from lots with less than 1000 head capacity, slightly over half are marketed from lots with more than 8000 head capacity. Diets in this region reflect the structure of the industry, with the finishing diet containing less than 90 percent concentrates. Corn, corn silage, milo, alfalfa hay, and wheat, the most common feedstuffs, are locally produced.

The feedlot industry in the Mountain, Southern Plains, and Pacific regions is dominated by commercial feedlots with 96, 98, and 99 percent of the cattle, respectively, produced in lots with over 1000 head capacity. Finishing diets in these three regions are typically more than 90 percent concentrates. Corn is the most popular grain; however, milo is used extensively in the Southern Plains and southern Mountain states. In the northern Mountain states and Pacific region barley is very popular. Wheat is also used in feedlot diets where it is produced especially during the local harvest when relative prices make wheat feeding feasible.

The Cornbelt and Lake States regions fed cattle are produced primarily by farmer-feeders. While most feedlots have less than 1000 head capacity, a 1983 study by Van Arsdall and Nelson showed that 46 percent of the cattle are produced in lots with capacity between 100 and 500 head, and an additional 23 percent are produced in lots of less than 100 head. Finishing diets in these two regions are typically lower in concentrates compared to commercial feedlots in the western regions, 80 vs. 90 percent. As one would expect corn and corn silage are the primary feed ingredients. In general, very little substitution between feedstuffs occurs as nearly all of the feed is produced and stored on the farm.

The remaining four regions produce less than four percent of the nation's fed cattle. These lots vary from farmer-feeder operations in Pennsylvania to large commercial feedlots in Florida. The type of feedstuffs fed in these lots is also very diverse. In smaller feedlots corn, corn silage, and hay are popular. In larger lots, by-products such as wheat midds, corn gluten feed, and pelleted peanut hulls are used.

In general, the feedlot cattle industry can be divided into two classes, commercial feedlots and farmer-feeders. The management of each is quite different. Commercial lots use the latest technology and a variety of feedstuffs to achieve the lowest cost of gain. Farmer-feeders produce and store on the farm most of the feedstuffs they feed to their cattle. Cropping practices in the major cattle producing regions plays an important role in determining the typical feedlot diet.

CHAPTER 7. ESTIMATING POULTRY FEED CONSUMPTION RATES

The poultry industry in the United States has grown rapidly since World War II to become a major supplier of protein in the American diet. Because of advancements in genetics, housing, management and nutrition, feed efficiency and daily production (pounds of meat or eggs produced) have improved tremendously. Many of today's birds and eggs are produced by large integrated firms which control all phases of production from hatch through wholesale distribution sales through either contract or ownership.

Technology employed is quite similar among the small number of large firms, which leads to homogeneous products and similar management practices. Nearly all birds are grown in some type of housing which reduces the effect of environmental differences between regions. Therefore, feed intake and ration specifications for birds throughout the U.S. are similar. However, ration composition will differ between regions due to price and availability of feedstuffs.

Unlike hogs, feedlot cattle, and cow-calf herds, poultry producers do not have enterprise records which are publicly available. The firms which dominate poultry production have their own record systems. In addition, there has not been a recent Cost of Production survey of the poultry industry. Turkey producers do have an annual survey which involves approximately 25 percent of all turkeys marketed. This survey, which is the basis of our turkey estimates, includes information about slaughter weights and feed efficiency by sex, region, and marketing period. However, this type of data is not available for broilers and layers. The estimates of feed efficiency for broilers and daily feed intake for layers are based on an informal telephone survey of poultry feed manufacturers who specialize in these two classes of birds. This method of estimation is currently employed by the Animal Products branch of the ERS. According to Dr. Floyd Lasley, the Animal Products branch conducts an informal survey of major poultry producers annually to determine feed consumption. Annual surveys by Dr. Sell, professor of poultry Science, Iowa State University, for turkeys and the ERS for broilers and layers will be used as the basis of the feed intake estimates. Our procedure will adjust these annual estimates to account for seasonal and geographical differences which occur in the poultry industry.

Poultry diets are highly specialized concentrate mixtures of an energy source, a protein source, vitamins, and minerals. Because of the structure of the industry, one firm may prepare feed for millions of birds. These diets are prepared by trained nutritionists to provide the most profitable production. Poultry diets are computer-balanced to meet the bird's requirements for amino acids, calories, and other essential macro and micro nutrients. The requirements depend on the bird's size and rate of growth or rate of lay for hens. The National Research Council's (1977) Nutrient Requirements for Poultry lists the specific requirements for each class of birds (layers, broilers, and turkeys). Poultry nutritionists in each region were contacted to determine the proper estimate of feed intake and ration composition for their locality and how that may differ from other regions.

Even though nearly all poultry diets are least-cost formulated, estimating an average ration for an entire region using that method is not feasible. Firms face different constraints (transportation costs, feed processing equipment, and available feedstuffs) and may price feedstuffs at different times (forward contract vs. spot purchases). Also, because of the large geographical area in some regions, it is difficult to estimate one set of prices which would apply to the entire region for the production period. The following estimates are based on what regional experts suggest is typically in the rations at different times of the year. If unusual price relationships do exist, the ration composition may need to be altered. Table 7.1 lists the rate of substitution that would be expected as relative grain prices change in each region.

Because production technology is similar among regions, regional differences in feed consumption and ration composition for each class of birds will be discussed separately. The calculations necessary to determine total feedstuff demand by poultry are illustrated in a USDA technical report (Lawrence, Hayenga, Jurgens, 1986).

Layer Feed Intake and Ration Composition

The nutrient requirement for layers differs from that of broilers and turkeys. While broilers and turkeys are expected to grow rapidly and efficiently and are sold when reaching market weight, layers are required

Table 7.1. Substitution of other grains for corn in poultry diets

Substitution	Price of other grain relative to corn	Percentage change in other grain in diet per one percent change in the relative price			
		Layers	Pullets	Broilers	Turkeys
Corn to milo	1.00 - 0.95	-1.0	-1.0	0	-1.0
	0.95 or less	-2.0	-2.0	-1.0	-2.0
Corn to wheat	1.05 - 0.95	-0.8	-0.8	-0.5	-0.5
	0.95 or less	-0.5	-0.5	-0.35	-0.35
Corn to barley	0.95 - 0.90	-2.0	-2.0	0	-0.5
	0.90 or less	-1.3	-1.3	0	-0.3
Corn to oats	0.85 - 0.80	-1.0	-1.0	0	0
	0.80 or less	-0.8	-0.8	0	0

to maintain a mature size and produce eggs. According to poultry nutritionists, daily feed intake for layers is approximately 22.5 pounds of feed per 100 hens. Because nearly all layers are caged in environmentally controlled houses, there is very little seasonal variation in feed consumption.

Layer rations, regardless of the region, contain 16 to 19 percent crude protein and 1270-1320 kcal of energy per pound (NRC, 1977). Nutritionists recommend feeding a ration that is higher in protein and metabolizable energy (ME) in the summer when feed consumption is reduced. Thus, a typical summer ration in the Southeast will be 21 pounds of feed per 100 birds of of a diet containing 18 percent crude protein and 1310 kcal per pound of metabolizable energy. During the winter the same flock may consume 24 pounds of feed per 100 birds of a 16 percent diet with 1280 kcal of ME. Layer rations typically contain feed grain, oilseed meal and animal and grain protein and other processed feedstuffs.

Layer replacements

Pullets (replacement layers) consume approximately 14.75 pounds of feed per bird from hatch until they begin egg production at about 20 weeks of age.[1] This amount fluctuates depending on the season and type of growing facilities used. Pullets raised during the winter require approximately 15.5 pounds of feed while summer raised pullets require 14.0 pounds of feed. If the pullets are grown on the floor as opposed to cages, an additional one and a half pounds of feed is required per bird. According to industry nutritionists, more variation in feed consumption occurs among producers than among seasons and facilities. Because the majority of the pullets are raised under conditions similar to layers, these estimates will assume the same regional and seasonal adjustment coefficients as layers. Estimated feed intake for pullets and the adjustment coefficients are shown in Table 7.2.

Pullets typically consume three different diets at different ages prior to entering the laying flock. These diets are designed to allow the bird to grow, develop, and mature without gaining excessive weight. The diet recommended by poultry feed manufacturers for the 20 week period before the pullet begins production will average 14-18 percent crude protein and 1280-1310 kcal per pound of metabolizable energy. This diet has similar specifications to the layer diet, and in fact, pullet rations contain many of the same ingredients as the layer rations. Corn is the most common grain, but it may be replaced by milo, wheat, barley, or

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[1]Extension and Feed Industry Personnel.

Table 7.2. Feed intake and regional and seasonal adjustment coefficient for layers and broiler and turkey breeding flocks and pullets

Pounds feed per 100 birds per day	Pounds of feed per bird from hatch to egg production[a]	Period	Pacific and mountain
Layers 22.7	Layer Pullets 14.75	Jan-March	1.030
Broiler hens 34.1	Broiler Pullets 22.10	Apr-May	1.000
Turkey hens 54.5	Turkey rplcmnt 88.50	June-Sept	0.935
		Oct-Dec	1.013

[a]Assume 20 week period for layer and broiler pullets, 30 week period for turkey replacement.

Cornbelt, Lake States, Northeast and Northern Plains	Delta States and Southern Plains	Southeast and Appalachian
---------Seasonal and Regional Coefficients-------------		
1.000	1.030	1.022
1.000	1.000	0.978
0.952	0.904	0.930
1.000	1.013	1.000

other processed feeds. Soybean meal provides most of the protein in a pullet diet, but other oilseed meals and animal proteins are also included. Ration composition for pullet diets is assumed to be the same as the layer diets shown in Table 7.3.

Table 7.3. U.S. average layer and broiler and turkey breeding flock diet

Feedstuff	Percent of Diet
Corn	45.9
Wheat	4.3
Milo	11.5
Barley	2.3
Oats	2.3
Oilseed meal	13.7
Animal protein	5.0
Grain protein	1.5
Other processed feed[a]	6.4
Vitamins and minerals	7.0

[a]Includes wheat midds, fat, molasses, alfalfa meal beet and citrus pulp and other by-products.

Regional summary

Regional differences are also very small because the size of hens, type of rations, and methods of production are similar. However, the seasonal effect is larger in some regions than others. In cooler regions (Northeast, Lake States, Cornbelt, Northern Plains), buildings provide more protection from the environment than do buildings in warmer regions (Southeast, Delta States, Southern Plains, Pacific).[1] Because buildings are less protective in the warmer regions, seasonal

[1]Poultry nutritionists.

fluctuations there are greater than those in cooler regions. During the summer, daily feed intake per 100 birds will normally fall as low as 21.5 to 22.0 pounds. In the Delta States and Southeast regions, daily consumption may fall as low as 19 to 20 pounds during the hottest part of the summer. During cold weather, there also is more change in feed consumption for layers in southern regions. Most hens consume 23 to 24 pounds of feed daily per 100 layers in the winter. Table 7.2 lists the feed consumption estimates for each region.

The most common grain in layer diets is corn. Corn comprises over 60 percent of the ration in most regions. In the Southern Plains, milo replaces almost all of the corn in a diet. Layer diets in the Delta States and the southern parts of the Pacific, Northern Plains, and Mountain regions include milo most of the year, when it is priced competitively with corn. According to feed manufacturers in these areas, milo will replace corn in a layer diet when its local price per pound is 90 percent of the price of corn.

Wheat will also replace corn in a layer diet when its local price per pound is equal to the price of corn. From a nutritive standpoint, wheat is worth relatively more than corn. However, wheat may cause more physical problems with the feed handling equipment; it therefore is discounted in value. Wheat typically is priced competitively with corn only during the local wheat harvest. Layer diets in the Appalachian, Southeast, Delta States, Southern Plains, Northern Plains, Mountain, and Pacific regions will include wheat for at least 30 to 120 days during most summers.

Barley is another grain that may be used in layer diets. Because barley is lower in energy than other grains, it is seldom used in broiler or turkey diets. Barley is most commonly fed in those areas where it is produced, i.e., the northern tier of states. Rations in the Lake States and Northeast regions may include a small amount of barley. This is especially true during the summer when corn prices are seasonally high and barley is being harvested. The northern parts of the Pacific, Mountain, and Northern Plains region also include barley in layer diets.

Other processed feedstuffs may also be used in layer diets. Because the energy requirement for these diets is less than other poultry diets, wheat and rice millrun are often used in layer rations in place of grain. Nutritionists typically limit these ingredients to 15 percent of the diet. Corn gluten meal or alfalfa meal are often added to a layer diet at a rate of one to three percent. Alfalfa meal, a processed feedstuff, and corn gluten meal, a grain protein, provide essential amino acids and result in darker colored egg yolks which are desirable in some markets (Jurgens, 1982, p. 382). Fat is also used in some layer rations, not as an energy source, but to reduce dust and lubricate feed handling equipment.

Minerals and vitamins make up a larger portion of a layer diet than in other animal species because of the calcium needed for egg shell formation. Typically all supplemental vitamins and minerals except calcium are supplied by a premix which makes up less than one percent of the diet. Nutritionists recommend using limestone, the most common source of calcium, at a rate of three to seven percent of the diet.

Protein in the diet commonly is supplied by oilseed meals which comprise 10 to 15 percent of the diet. Soybean meal is used in virtually all poultry diets. In the southwestern states, cottonseed meal may replace soybean meal for up to three percent of the total diet. However, toxic substances such as gossypol and aflatoxins often found in cottonseed meal have caused producers to use less cottonseed meal now than before. Sunflower meal is used in layer rations in areas of sunflower production and processing, predominantly the North Central region of the U.S.[1] It may replace up to 50 percent of the soybean meal in these states. In the Northwest and northern Mountain states canola meal, produced in Canada, replaces a portion of the soybean meal.

According to poultry nutritionists, animal proteins such as meat and bone meal, tankage, poultry meal, and fish meal are also used as protein sources in layer diets. Most of these feedstuffs also supply the mineral phosphorus in the diet. These products are high in the required amino acids, but are typically limited to five to eight percent of the diet, e.g., seven percent meat and bone meal and two percent fish meal could be included in a diet. Depending on the price relative to other protein sources, an animal protein may range from zero to eight percent of the diet. However, total protein from animal sources is commonly limited to ten percent.

Table 7.3 shows the estimated U.S. average layer ration composition and how that varies seasonally.

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[1] Feed manufacturers.

Broilers Feed Intake and Ration Consumption

Broilers have been genetically developed for rapid, efficient growth and meat production. The average broiler will be slaughtered at six to seven weeks of age and weighing 3.5 to 4.25 pounds. According to industry and extension nutritionists, feed efficiency is approximately two pounds of feed per pound of gain. Thus, broilers consume between seven and eight and a half pounds of feed over their lifetime. Nearly 40 percent of this feed is consumed in the first month after hatching.

Broilers are produced in buildings designed to moderate environmental stress. However, during the summer feed efficiency is adversely affected in most major broiler states. Most industry personnel agree that feed efficiency fluctuates approximately 2.5 percent depending on the seasons. This equates to a summer feed conversion of 2.05 and a spring feed conversion of 1.95, and fall and winter somewhere near the average of 2.0 pounds of feed per pound of gain. Pounds of feed consumed per bird are found by multiplying the pounds of live weight at slaughter by the feed efficiency estimates to determine total feed intake.

Broilers typically consume three different rations over their lifetime (Jurgens, 1982, p. 383). For the first three weeks, the birds consume a starter ration containing 24 percent crude protein and 1475 kcal per pound of ME. This diet comprises approximately 20 percent of the broiler's total feed. From three to six weeks of age, the diet contains 22.5 percent crude protein and 1530 kcal of ME per pound. This grower diet constitutes 50 to 55 percent of total broiler feed. The last ration fed to birds after they are six weeks old has 19.5 percent crude protein and 1535 kcal of ME per pound. This final diet represents approximately 25 percent of broiler feed and is referred to as a withdrawal feed because it contains no medications that may leave a residue in the carcass following slaughter.

Grain makes up over 60 percent of the broiler diet. Corn is the major grain in these diets. Wheat may replace corn up to a maximum of 15 percent of the total diet when the local wheat price is less than 95 percent of the price of corn. According to nutritionists, wheat is discounted relative to corn because many producers are not experienced at feeding wheat and because in some markets carcass coloring is important. Wheat does not give the desired skin color. Because of the necessary price relationship, wheat typically only enters a ration during the local wheat harvest in the summer. Milo is also used in broiler diets, but it is discounted to corn as well. According to poultry nutritionists, milo must be priced 45 to 50 cents per hundred pounds cheaper than corn before it is feasible to include milo in the ration. Barley is not used in broiler diets because it is lower in metabolizable energy and higher in fiber than other grains. Wheat midds and millrun are also too low in energy to be efficiently used in broiler diets.

Oilseed meals constitute most of the protein in broiler diets. A survey of broiler nutritionists and Extension Poultry Specialists indicates that soybean meal is by far the major oilseed meal for broilers. Animal proteins, meat and bone meal, poultry meal, and fish meal may be used in place of soybean meal. However, nutritionists limit each of these products to 4 to 6 percent of the diets. Corn gluten meal, a grain protein, is also used in the diet at a rate of 2 to 5 percent. Corn gluten meal contributes to the amino acid composition of the diet and gives the carcass coloring desired in some markets.

Other processed feeds are also used in broiler diets. Alfalfa meal is often used at a rate of 1 to 2 percent of the total diet. Fat is typically added to broiler diets to increase the energy density. Broiler rations in the South and Southeast contain 2 to 4 percent added fat. Rations in the West often have 6 to 8 percent added fat. Vitamins and minerals comprise approximately 2 percent of the total ration.

Broiler breeding flock

The broiler breeding flock, according to nutritionists, consume the same type of ration as layers (Table 7.3). However, these birds require more feed. Broiler hens require 1.66 times more feed per dozen eggs than layers or approximately 34.1 pounds of feed per 100 birds daily. During the summer, this amount will decrease to nearly 30 pounds per 100 birds per day, and may increase to over 35 pounds in cool weather (Table 7.2). Broiler pullets consume 1.5 times more feed than their layer counter parts. These pullets consume approximately 22.1 pounds of feed from hatch until they enter production at 20 weeks of age.

Regional summary

Regional differences in feed efficiency are also less pronounced because of similar management practices throughout the U.S. In addition, over 55 percent of the broilers are produced in a seven state area reaching from northeast Alabama to Delaware (Census of Agriculture 1982). Another 32 percent are produced in the Delta States and Southern Plains regions. Seasonal weather patterns do not vary significantly throughout these major broiler producing areas. Feed efficiency will be slightly more depressed in the states with higher summer temperatures, i.e., Delta States, Southern Plains, and Southeast compared to the other regions, Appalachian and Northeast. The Pacific region accounts for 4.4 percent of the U.S. broiler production (USDA, 1982). According to nutritional consultants in that region, Pacific broilers are slightly more efficient than broilers in other areas. Feed conversion in this region averages approximately 1.9 pounds of feed per pound of gain. As in other regions, the summer heat increases feed requirements by 2.5 percent. The remaining four regions combined produce slightly over 2 percent of U.S. broilers. These estimates assume that broilers in these regions are produced similar to broilers in the eastern regions. Table 7.4 indicates the change in estimated feed efficiencies for broilers due to season and region.

Because of the highly integrated nature of the broiler industry, little regional differences exist in broiler diets. All firms use similar technology and least-cost formulation programs when developing a broiler ration. The major difference between regional diets will be caused by relative local grain prices. While corn is the most common grain in all regions, milo and wheat may also be fed. Milo is typically most attractive from a relative price standpoint in regions where it is produced--the Southern Plains, southern Mountain states, and California.

Table 7.4. Broiler feed efficiencies adjustments by region and time of year[a]

Period	Pacific and Mountain	Lakes States Cornbelt Northeast Northern Plains	Delta States and Southern Plains	Southeast and Appalachian
	Adjustment coefficients			
Jan-March	0.95	1.025	1.00	1.00
Apr-May	0.925	1.00	0.975	0.975
June-Sept	0.975	1.05	1.025	1.025
Oct-Dec	0.95	1.025	1.00	1.00

[a]As an example: a 4 pound bird in the Delta States Region with a feed efficiency of 2:0 would consume 8 pounds in Jan-March, 7.8 pounds in Apr-May, and 8.2 pounds in June-Sept.

However, milo is also fed in the Delta States and Southeast regions because it sometimes can be delivered at a lower cost than corn. Wheat is similar to milo. It is more popular where it is produced--the Southern Plains and southern Mountain states. However, because wheat is harvested in the summer, it is often competitively priced with corn for a few weeks during harvest. When this occurs, wheat may be fed in all regions where its local price is competitive with corn. Table 7.5 lists the U.S. average broiler diet.

Turkey Feed Intake and Ration Composition

Turkeys, like broilers, are produced for meat and have been developed for rapid efficient growth. The average tom is slaughtered when five months old and weighing 25 to 28 pounds. Hens are slaughtered at four months and weigh between 13 to 16 pounds. A survey of turkey producers shows that feed efficiency is approximately 2.95 and 2.66

Table 7.5. U.S. average broiler ration

Feedstuff	Percent of Diet
Corn	53.4
Wheat	2.4
Milo	7.4
Barley	0
Oats	0
Oilseed meal	21.8
Animal protein	6.0
Grain protein	0.8
Other processed feed[a]	5.5
Vitamins and minerals	2.0

[a]Includes wheat midds, fat, molasses, alfalfa meal, beet and citrus pulp and other by-products.

pounds of feed per pound of gain for toms and hens, respectively (Sell, 1985). Table 7.6 shows the percentage of total feed consumed each month.

Seasonal factors do have an effect on feed efficiency. The 1984 survey of turkey producers indicates toms grown through the coldest part of the year have feed efficiency reduced by 3.0 percent. Hens' feed efficiency is reduced by less than one percent due to cold weather. Birds fed through the hottest part of the year had better than average feed efficiency, in contrast to broiler data. The 1984 survey of turkey producers (on which these estimates are based) does not have seasonal

Table 7.6. Perent of total turkey ration consumed per month

	First	Second	Third	Fourth	Fifth
Toms	3.5	12.5	21.5	29.0	33.5
Hens	6.0	21.5	33.5	39.0	--

statistics by region. As is the situation in broiler and layer production, there is more seasonal variation in Appalachian, Southeast, Delta States and Southern Plains region than in the Cornbelt, Lakes States, Mountain and Pacific regions. Birds that are grown in colder regions have housing that reduces much of the temperature variation.

According to industry and extension nutritionists, turkeys receive four to six different diets during the production period. These diets range from 29 percent crude protein and 1325 kcal of ME per pound in the starter ration to 15 percent crude protein and 1575 kcal of ME per pound in the withdrawal ration. Corn is the major grain in turkey diets, comprising 50 to 60 percent of the total ration. Wheat may replace corn in the diet if its local price relative to corn is favorable. Typically, if wheat is priced at 95 percent of corn, nutritionists will use it in a ration up to a maximum of 15 percent of the diet. In general, the only time wheat is priced competitively with corn is during the local wheat harvest in the summer. Because most turkey diets are in a pellet or crumble form, wheat does not cause problems in the mechanized feed handling equipment.

Milo may also replace corn in a turkey diet. Again, depending on the local price relationship between milo and corn, milo may be the only grain in the diet. This is particularly true in the Southern Plains region and southern states of the Mountain and Pacific regions, the major milo producing areas. Barley is also used to a lesser extent in turkey rations. Because it is higher in fiber than other grains, barley is typically limited to less than 10 percent of the diet and is fed in conjunction with higher levels of fat.

Oilseed meal is the major protein source in turkey diets. Soybean meal comprises the majority of this category. Another important oilseed meal in the area where it is processed is sunflower meal. Feed manufacturers in in the Lake States, Cornbelt, and Northern Plains regions replace some but not all soybean meal with sunflower meal. Animal proteins also supply a portion of the protein in turkey diets. Meat and bone meal, poultry meal, and fish meal each will replace soybean meal. However, these three products are each limited to less than 7 percent of the diet with a maximum of 10 percent of the diet from animal sources.

Other processed feeds are used heavily in turkey diets. Wheat midds and millrun and corn screenings will replace some of the grain in the diet, but are usually limited to 5 percent because they are too low in energy. Alfalfa meal may be used up to 2 percent as a protein source. Fat is used extensively in turkey diets. It adds the necessary energy density to the diets to increase the growth rate and improve feed efficiency of turkeys. Starter rations often contain 2 percent added fat. The percent added fat increases to levels as high as 12 percent or more in the final diet. Vitamins and minerals comprise approximately 2 percent of the diet in turkey rations.

Turkey breeding flock

The turkey breeder flock consumes a relatively small proportion of all turkey feed. Feed manufacturers recommend a diet containing 16-18 percent crude protein and 1290-1325 kcal per pound of ME. These specifications are very similar to the layer diet. Most nutritionists agree that the turkey breeding flock consumes the same type of diet as the layers (Table 7.3). Although the ration composition is the same, turkeys consume 1.6 times more feed than broiler hens do (Table 7.2). These birds consume approximately 54.5 pounds per 100 birds daily. Replacement hens (turkey pullets) also consume more feed than layer pullets (Table 7.2). From hatch until they enter the breeding flock at 30 weeks of age, turkey pullets consume approximately 6 times more feed than layer pullets (Table 7.4). For the first half of this period the ration is the same as that for the birds grown for slaughter (Table 7.8). From weeks 16 to 30, the ration is lower in energy to prevent excessive weight gain, similar to the layer ration (Table 7.3). This ration contains less fat and more alfalfa meal, oats, or wheat midds.

Regional summary

Regionally, turkeys in the Southeast and Appalachian regions are the most efficient (Sell, 1985). Toms in these regions are 3.2 percent more efficient than the U.S. average, while hens are 3.8 percent more efficient. The Lake States and Cornbelt regions are the least efficient, requiring 2.5 and 5.3 percent more feed than average for toms and hens, respectively. Table 7.7 lists feed efficiency adjustments due to season and region for turkeys.

As with broiler rations, relative grain prices play an important role in determining turkey diets. Although, in the upper Midwest (Lake

Table 7.7. Turkey feed efficiencies adjustments by sex, region, and time of year[a]

Month of Hatch	Pacific and Mountain		Lakes States Cornbelt Northeast Northern Plains		Delta States and Southern Plains		Southeast and Appalachian	
	----Adjustment coefficients----							
	Toms	Hens	Toms	Hens	Toms	Hens	Toms	Hens
Jan-March	1.000	1.000	1.035	1.050	1.000	1.010	0.960	1.010
Apr-May	0.965	0.995	1.015	1.040	0.975	1.005	0.940	0.965
June-Sept	0.945	0.985	0.985	1.030	0.950	0.995	0.915	0.960
Oct-Dec	0.985	1.000	1.025	1.045	0.995	1.010	0.955	0.970

[a]As an example: a 25 pound tom in the Delta States Region with a feed efficiency of 2.95 pounds would consume 73.75 pounds in Jan-March, 71.9 pounds in Apr-May, and 70.1 pounds in June-Sept.

Table 7.8. U.S. average turkey ration composition

Feedstuff	Percent of Diet
Corn	56.9
Wheat	1.9
Milo	6.6
Barley	0.7
Oats	0.7
Oilseed meal	17.0
Animal protein	6.0
Grain protein	0.8
Other processed feed[a]	7.4
Vitamins and minerals	2.0

[a]Includes wheat midds, fat, molasses, alfalfa meal, beet and citrus pulp and other by-products.

States and Cornbelt) turkey production is often part of a diversified farming operation, and the diets contain home grown grain. In these regions, corn is the major ingredient. Oats and barley may also make up a small portion of the diet. In the Appalachian, Southeast and Delta States regions, corn is also the predominant grain, but diets in these regions are more sensitive to prices. Milo and/or wheat may also be fed where its price relative to corn is favorable. These regions tend to feed a higher energy diet compared to the Midwest. This extra energy is typically supplied by fat. Diets in the Southern Plains, Mountain, and Pacific regions are similar to those in the Southeastern United States. Because relatively more wheat and milo is grown in these regions, typically diets in these regions contain less corn and more of these grains.

Adjustment Factors

Most factors that influence feed intake for poultry have been discussed and are already incorporated into the estimates. These factors (season, sex of turkeys, slaughter weight of birds) are inputs for the feed estimation program. Unusual circumstances such as extreme temperature from the seasonal average or changes in feed efficiencies can be incorporated into these estimates.

The National Research Council's (1981) report Effects of Environment on Nutrient Requirements of Domestic Livestock suggests that feed intake changes 0.8 percent per degree Fahrenheit over the range of 30-95° F. The baseline temperature for poultry is 70° F. More feed is required at lower temperatures and less feed at higher temperatures. However, this temperature refers to the microenvironment of the bird which, for most birds, is some type of building. Layers are typically housed in an environmentally controlled building in which the temperature deviations are kept to a minimum. Broilers and most turkeys are grown in a semi-environmentally controlled building. These buildings typically have walls covered by screens which allow for natural airflow, but that can be covered by curtains during cool weather. This housing prevents wide fluctuations in temperatures inside the building. In climates that have large seasonal temperature extremes, buildings are designed to counteract these fluctuations. Regions with milder weather, i.e., the South and Southeast, often have greater changes in feed intake because the buildings do not prevent the extreme temperature changes.

The seasonal estimates of feed intake account for most of the temperature-induced changes in feed intake. If abnormal temperatures do occur in poultry producing areas and this deviation from the seasonal average temperature can be determined, then an adjustment can be made.

For each one degree Fahrenheit change from the seasonal mean temperature, total feed consumption by poultry should be changed 0.8 percent in the opposite direction. Average temperatures for a location for a month seldom vary by more than five degrees. When an entire region is considered for a two, three, or four month period, the deviation from normal is typically very small.

Changes in feed efficiency will also affect these estimates. While environment causes most changes, technology, genetics, and new growth promotants can also greatly alter efficiencies. Feed efficiency seems to have leveled off after many years of rapid change. Future changes will, for the most part, probably be slow but steady improvements.

CHAPTER 8. ESTIMATING FEED CONSUMPTION RATES OF OTHER ANIMALS

This section will outline the estimation procedure for feed consumed by animals other than the major species discussed in earlier chapters. This category includes horses and mules, pets, laboratory, zoological and fur-bearing animals, fish, and other poultry (ducks, geese, and game birds). Animals in this group consume a relatively small portion of all feed, but are still considered as competitors to livestock and poultry for feedstuffs. Except for catfish, very little inventory information exists about these animals. Because accurate data are sparse, the estimates of feed intake and ration composition for some species will be annual totals on a national basis. Also, unlike the livestock and poultry discussed in previous sections, estimates for some of these animals are derived from aggregate totals such as the Census of Manufacturers Product Production or Census of Agriculture Livestock on Farms estimates.

Pets

Pets, primarily dogs and cats, consume over nine billion pounds of pet food annually. Essentially all of this pet food is manufactured and sold to pet owners and kennel operators. Approximately 85 percent of all pet food sales is through a retail outlet. Because these products are processed, consumption data are available from the Census of Manufacturers or the Pet Food Institute (PFI).[1]

These estimates will rely on the annual PFI reports which measure retail sales of pet food, which accounts for 85 percent of all dog and cat food produced.[2] These figures break total sales into categories of dry, canned, and semi-moist types of pet food. These subdivisions coupled with the dry matter percentages shown in Table 8.1 allow the actual tonnage of feedstuffs consumed to be determined. The estimates also assume that the 15 percent of pet food not sold at retail grocery stores will have a similar composition.

Table 8.1. Percent dry matter of pet foods[a]

Type	Percent dry matter
Dry	88
Semi-moist	70
Canned	22

[a]Pet Food Institute, 1984.

Using the 1983 PFI Fact Sheet (Figure 8.1), total feedstuff demand by pets would be calculated as follows. Divide retail sales of each type by .85 to estimate total sales. Total sales multiplied by the appropriate dry matter percent will determine the dry matter pounds of pet food sold.

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[1] Pet Food Institute, 1101 Connecticut Avenue, NW, Washington, D.C. 10036.

[2] Dr. Jim Corbin, University of Illinois, Department of Animal Science.

	Retail sales (1983)	Total sales	Percent dry matter	Dry matter pounds
Dog food				
Dry	4,895.1	5,758.9	88	5,067.8
Canned	1,864.3	2,193.3	22	482.5
Semi-moist	320.8	377.4	70	264.2
Treats	255.6	300.7	88	264.6
Cat food				
Dry	913.7	1,074.9	88	945.9
Canned	1,135.3	1,335.6	22	293.8
Semi-moist	154.1	181.3	70	126.9

Figure 8.1. Pet food sales (Pet Food Institute, 1984).

The dry matter total is then multiplied by the appropriate diet composition shown in Table 8.2. Next divide each subtotal by the dry matter percent of that feedstuff to arrive at as-fed demand for each feedstuff.

Table 8.2. Pet food diet composition[a]

	Dry matter percent of diet			
	Dog food		Cat food	
	Dry and treats	Canned and semi-moist	Dry	Canned and semi-moist
Corn	34.4	5.1	25.2	3.8
Wheat	10.0	1.5	14.5	2.2
Processed feeds	16.1	2.5	11.3	1.7
Animal protein	13.5	87.0	27.0	89.0
Grain protein	16.0	2.4	14.0	2.1
Oilseed meal	10.0	1.5	8.0	1.2

[a]Dr. Jim Corbin, University of Illinois, Department of Animal Science.

For example total corn used by pets in 1983 is:

$$(5{,}067.8 + 264.6).344 + (482.5 + 264.2).051 + (945.9).252$$
$$+ (293.8 + 126.9).038 = 2{,}126.78 \text{ million pounds}$$
$$2{,}126.78 \div .88 = 2{,}416.8 \text{ million pounds.}$$

Pets consume approximately 1.1 million metric tons of corn annually.

Horses

According to statistics from the American Horse Council (AHC) there are currently 8.4 million horses in the United States. The horse population is evenly distributed throughout the U.S. (Table 8.3). The 1982 Census of Agriculture accounts for only 27 percent of those reported by the AHC suggesting that most horses are owned by nonfarm individuals. These horses are often boarded at stables near metropolitan areas or owned by people who have an acreage in the country, but are not considered farmers.

Regardless of who owns the horses or where they are boarded their feed consumption and ration composition are similar. According to the National Research Council's Nutrient Requirements of Horses (Jurgens, 1982) horses will consume between 1.5 to 3.5 percent of their body weight as feed daily (air dry basis). The composition of the diet depends on the animal's level of activity and physiological condition. A maintenance diet for a mature horse often will be entirely made up of forages. However, lactating mares or horses working intensely will require that the diet be 60-80 percent concentrates.

Table 8.3. Horse population by region[a]

Region	Number (1000's)	Percent of U.S. total
Northeast	739	8.8
Appalachian	799	9.5
Southeast	551	6.5
Lake States	589	7.0
Cornbelt	1,110	13.2
Delta States	518	6.1
Northern Plains	556	6.6
Southern Plains	1,080	12.8
Mountain	1,281	15.2
Pacific	1,185	14.1

[a]American Horse Council cited by Schoeff, October 1984.

Assuming an average weight of 900 pounds per horse and that the diet is 75 percent forage and 25 percent concentrate, the average horse will consume 13.5 pounds of forage and 4.5 pounds of concentrate per day. Nearly all forage is hay except during the warmer months when pasture is available. Approximately half of this hay is alfalfa or another legume, with the remainder being grass or a legume-grass mixture hay. Oats are the most popular grain in horse diets; however, corn, barley, and some processed feedstuffs such as wheat midds and molasses are also used (Table 8.4).

Specialty Animals

This group includes laboratory animals such as mice, rats, and guinea pigs; fur bearing animals like rabbits, mink, and fox; and other small animals which are raised commercially. Nearly all of the feed for this group is commercially manufactured as a complete ration. The Census

Table 8.4. Horse ration composition

Feedstuff	Percent DM	Percent of daily dry matter intake
Pasture	20	30
Alfalfa hay	90	11.25
Other hay	90	33.75
Corn	88	7.5
Oats	89	12.5
Barley	88	2.5
Milo	89	0.25
Wheat	88	0.25
Oilseed	90	0.75
Other Processed	90	1.25

of Manufacturers-Industry Series is the best source of information for total specialty feed prepared. Specialty feeds are listed under the Grain Mill Products class and dog, cat, and other pet food heading. The SIC numbers 2047661-2047669 (with the exception of 2047665 - birds which will be discussed later) in the Products and Product Classes table pertain to this group of animals. In 1982, 1,818,000 tons of specialty feed was produced.

The composition of this feed is difficult to determine because each type of animal in the group has different nutrient requirements. These estimates assume that the composition of specialty feeds is the same as the composition of pet food. While the diet of a fox is quite different from the diet of a quail, the average composition of all specialty feed will be fairly close to that of pet food.

Another area of specialty feed is game birds and other poultry (excluding broilers, layers, and turkey). Feed prepared for these birds is shown in the Census of Manufacturers Industry Series under Grain Mill Products. SIC numbers 2047665, 2048814, and 2048815 list feed prepared for these birds. These estimates assume that the composition of this ration is similar to that for layers shown in Table 7.3 because they have similar digestive systems.

Fish

Commercial fish production in the U.S. is dominated by catfish, trout, and salmon. These fish and other aquaculture species require a diet that is very high in crude protein. Fish have feed efficiency of 1.5 to 1.8 pounds of feed per pound of gain depending on the species; this figure is even more efficient then broilers. Catfish is the only aquaculture specie that has inventories reported by the USDA. Other fish (trout, salmon, and other less popular species) are not reported. These estimates are based on discussions with fish feed manufacturers and nutritionist Dr. Poston of the National Fisheries Center, Tunison Laboratory of Fish Nutrition.

The major catfish producing states are Mississippi, Arkansas, Alabama, and California. These fish require water temperatures of $55^{\circ}F$ or above for production. The temperature requirement limits most of the production to an April through October growing period. The typical feeding period is four to six months in length. Feed conversion for catfish is approximately 1.80 pounds of feed per pound of liveweight fish. This feed is relatively high in protein containing 28 to 32 percent crude protein. Ration composition is shown in Table 8.5.

Trout are also fresh water fish and are produced in two main areas, south central Idaho and Arkansas. According to one fish processor and feed manufacturer, 27 to 42 million pounds of trout are commercially produced each year. Trout are placed anytime throughout the year depending on market demand. These fish convert feed at a rate of 1.6:1, and have an average adult weight of 12 ounces. Therefore, approximately 1.2 pounds of feed is consumed per fish. This feed is 40 to 50 percent crude protein and is higher in animal proteins than catfish feed. Table 8.05 indicates the estimated ration composition. Salmon are fresh and salt water fish. The commercial production emphasis is on the hatching and raising of young fish until they are ready to go out to sea at a weight of 55-60 grams. With feed conversion at approximately 1:1 and their small size, only about one-quarter of a pound of feed is consumed per fish. This diet is also high in crude protein and uses a large amount of fish and animal protein (Table 8.5).

Table 8.5. Fish ration composition

	--------Percent of diet-------		
Feedstuff	Catfish	Trout	Salmon
Corn	21.0		4.0
Wheat	2.0		9.0
Milo	11.0		0
Barley	0		0.5
Oilseed meal	53.0	34.0	21.5
Animal protein	8.5	65	60.0
Other processed feed	3.5		2.0
Vitamins and minerals	1.0	1.0	3.0

CHAPTER 9. AGGREGATE FEED USE ESTIMATES AND COMPARISONS

This chapter summarizes feed consumption estimates based on the procedures discussed in earlier chapters, and compares these results to figures reported by the Economic Research Service (ERS) in the Feed Situation and Outlook (USDA, 1985c). Total concentrate consumption by individual species are compared to reported ERS estimates for the same species. Aggregate feed use of individual grains and processed feeds is compared to the feed and residual figure shown in the marketing year supply and disappearance balance sheet. Crop years 1977-1984 were analyzed holding the ration composition of each species constant at 1984 levels. These results were then compared to estimates in the USDA Feed Outlook and Situation for feed grains and processed feeds. Where differences exist between the estimates, possible explanations are suggested.

The following assumptions were made while estimating feed consumption for crop years 1977-1984. Ration composition for all species is held constant at 1984 levels, and does not reflect changes in price relationships from year to year. The placement ratio of steers to heifers and placement weight of feedlot cattle was also held constant. Feed efficiency of poultry was changed each year to reflect the improvements made between 1977 and 1984. The milk to concentrate ratio for dairy cows also changed each year using the method described in chapter 2. The beef feedlot ration within each region was unchanged, but the aggregate ration was changed each year to reflect changes in the portion of cattle produced in each region.

Comparisons between our results and the USDA Feed Outlook and Situation estimates are shown graphically by species and by feed grain. The species results based on the procedure outlined in earlier chapters are compared to species estimates made by ERS analysts and published in the Feed Outlook and Situation. These estimates are based on reported livestock and poultry inventories, production, and slaughter, and representative feeding rates for each class of animals. The ERS estimates for feed consumption by livestock and poultry appear to be a two-step process. First, estimates for each class of livestock are calculated using the National Research Council's recommended minimum requirements of nutrients plus a waste factor. These first estimates are aggregated across all species and compared to the balance sheet's feed and residual column. Where differences exist, the feed estimates are altered to match the balance sheet numbers. The aggregate grain and concentrates fed to livestock and poultry estimated by this procedure are compared to the feed and residual figures reported in the "Feed Year Supply and Disappearance" tables of the Feed Outlook and Situation.

When comparing the two estimates keep in mind how each is calculated. The feed and residual total is derived from beginning stocks, production, and imports of a grain less food, alcohol and seed production, exports, and ending stocks. Possible discrepancies may arise due to how the amounts are estimated and reported. ERS estimates of feed and residual include feed consumed plus any loss from harvest to final use on all grain and not just that which is fed to livestock. For example, harvested corn is typically reported as 15.5 percent moisture; however, it is necessary for corn to be 13.5 percent moisture or less for safe long-term storage. Thus it is possible that beginning stocks and the grain for food, alcohol, and seed production coming from storage are drier than 15.5 percent. In addition, according to Dr. Charles Hurburgh, Professor of Agricultural Engineering at Iowa State University, one percent of the grain's dry matter weight typically is lost during the handling process, i.e., transporting from storage to processing. He also estimates that an additional one percent is lost to insect damage during storage. By combining these factors it is possible for two to four percent of a crop to disappear between the harvest and exports and food, alcohol and seed production. This difference is reflected in the residual along with any statistical sampling error on the original crop production estimates, beginning stock, etc.

The estimation procedure discussed in this report relies on reported livestock and poultry inventories and production to predict feed use from processing to ingestion. In addition to a statistical sampling error that may occur in those livestock estimates, extrapolating numbers between reports can also lead to variation. While monthly milk and egg production, slaughter number and weights, and dairy cow and layer flock inventories are readily usable, quarterly reported hog inventories, fed cattle numbers and placements, and semi-annual beef breeding herd and annual sheep inventories must be manipulated to estimate average feed consumption for each time period.

Individual Species

The following individual species graphs are comparisons of the total concentrates estimated by the methods outlined in earlier chapters to total concentrates reported consumed by livestock and poultry in the USDA Feed Outlook and Situation (USDA, 1985c). Total concentrates include the four feed grains (corn, sorghum, oats, and barley), wheat and rye, oilseed meal, animal protein, grain protein, and other processed feeds.

Our estimates suggest higher and less variable concentrate consumption by dairy cattle (Figure 9.1). For the 1984 crop year, this method estimates that dairy cattle consumed 36.0 million metric tons (MMT) of concentrates compared to 33.2 MMT estimated by the ERS. Over the eight years this method was 12.5 percent higher, 34.0 vs. 30.2 MMT. By basing concentrate consumption of dairy cows on milk production and using a three year weighted average milk to concentrate ratio the estimated feed use follows milk production closely. Concentrates consumed by dairy replacement heifers and dairy calves weighing less than 500 pounds are also included in these totals. The steady increase in concentrate consumption reflects the increase in milk production and increases in heifer and calf inventories over the years. The decline in concentrate feeding reported by the USDA from 1978- 1980 crop years follows the assumption the producers will substitute forages for concentrates which increased in price over the period. While some dairy producers may have substituted forages for concentrates in times of relatively higher grain prices, i.e., 1979, it is unlikely that such practices were wide-spread, otherwise milk production per cow would not have continued to increase.

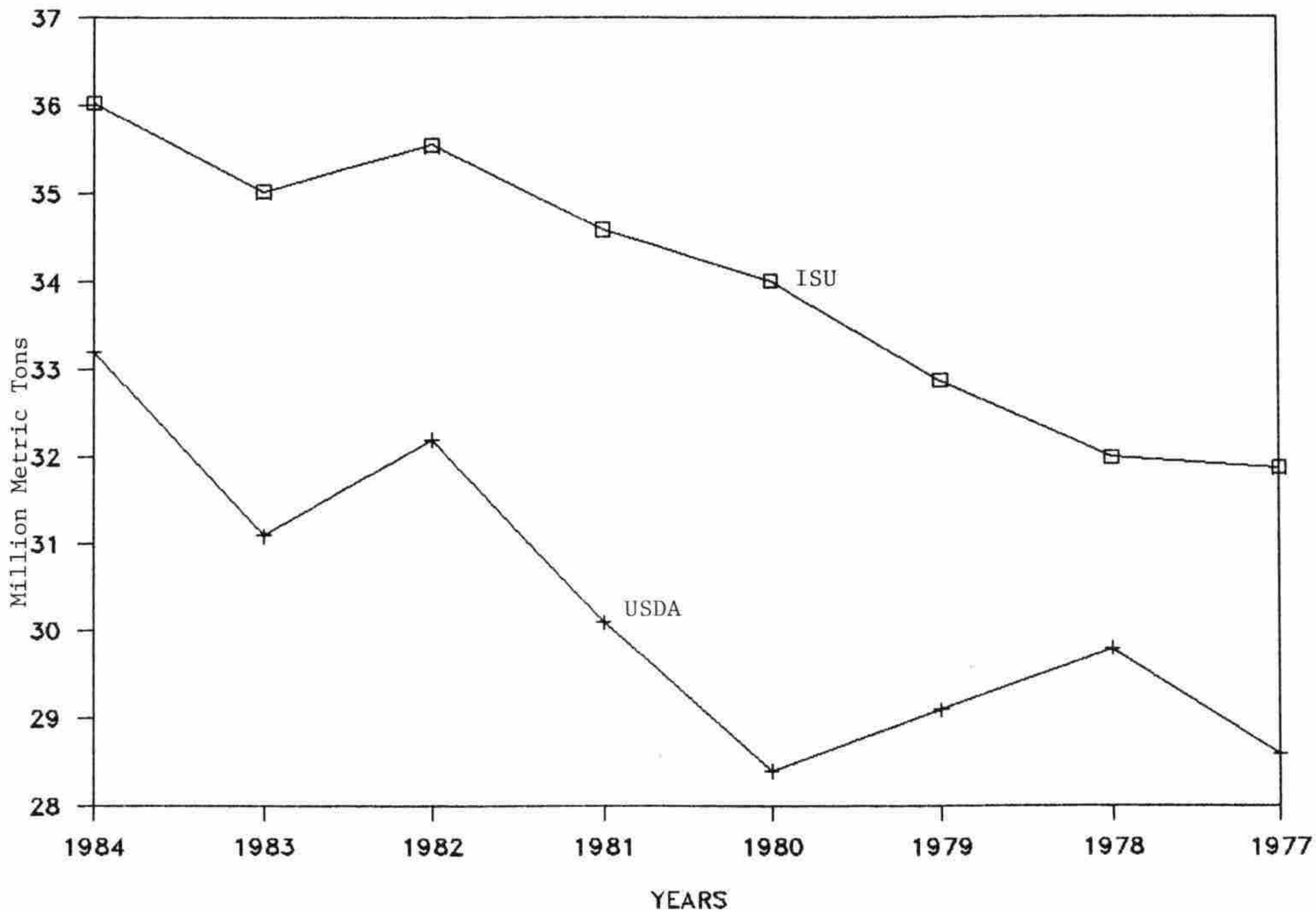

Figure 9.1. Dairy feed estimates

The efficiency of dairy cows has improved, but a large substitution of forages for concentrates would reduce production efficiency, and thus result in lower, not higher, milk produced per cow. In addition, hay prices also increased during the same period, making switching from grains to forages less attractive to dairy producers. Because of increased aggregate milk production, milk per cow, and heifer and calf inventories during the period 1977-1982, it seems unlikely that concentrate feeding would have fluctuated significantly.

In addition to the reduced concentrate feeding in 1980, ERS estimated a sharp decline in the amount of forages consumed. Such an estimate assumes a decline in total dairy feed consumption and not simply a substitution of forages for concentrates. This assumption seems unlikely as dairy cow inventories, total milk production, milk per cow, and dairy heifer replacements all increased during the same period. Such an accomplishment would require a dramatic improvement in feed efficiency as each animal would have received less feed while increasing production.

The largest discrepancy between the two dairy feed estimates is in high protein and other processed feeds. The procedure outlined in earlier chapters estimates derived demand of high protein feeds (oilseed meal and grain and animal protein) and other processed feeds (wheat midds, molasses, grain screenings, alfalfa pellets, etc.) is typically higher than the ERS estimates. One reason given by ERS analysts for the seemingly low estimate of high protein feeds is that producers replace natural proteins with nonprotein nitrogen (NPN). If this is the case, dairy concentrate rations in 1984 would have required 0.8 percent NPN to achieve a reasonable crude protein level (i.e., 15 percent). According to dairy nutritionists, one percent of the total dry matter feed intake is the maximum level of NPN without risk of ammonia toxicity. Therefore, it would appear that ERS estimates are either low in protein or high in NPN. Another possible source of discrepancy is the amount of nonconventional feed used, particularly dairy and feedlot diets. These feedstuffs include citrus pulp, almond hulls, cottonseed hulls, potato waste, bakery products, etc. While ERS does attempt to account for their use, it is difficult to account for all of these products.

While the concentrate consumption estimates outlined in Chapter 2 are higher than ERS estimates, they are consistent with increased milk production, production per cow, and cow and heifer inventories. In the period 1977-1982, and in particular, 1980, the crude protein content of dairy concentrates reported by the ERS do not reflect modern dairy production practices.

Feed consumption by hogs estimated by this method is also higher than USDA estimates (Figure 9.2). Hogs consumed 46.4 MMT of concentrates in the 1984 crop year by the outlined procedure as opposed to 50.0 MMT estimated by ERS analysts. For the eight year period this procedure estimated an average of 4.5 percent more feed consumed by hogs annually, 50.3 vs. 48.0 MMT. In general, the pattern is similar for the two estimates with the exception of 1980, 1983, and 1984. In 1980 a drought-reduced crop resulted in higher grain prices. USDA estimated a sharp decline in feed consumed by hogs. Producers responded by cutting back

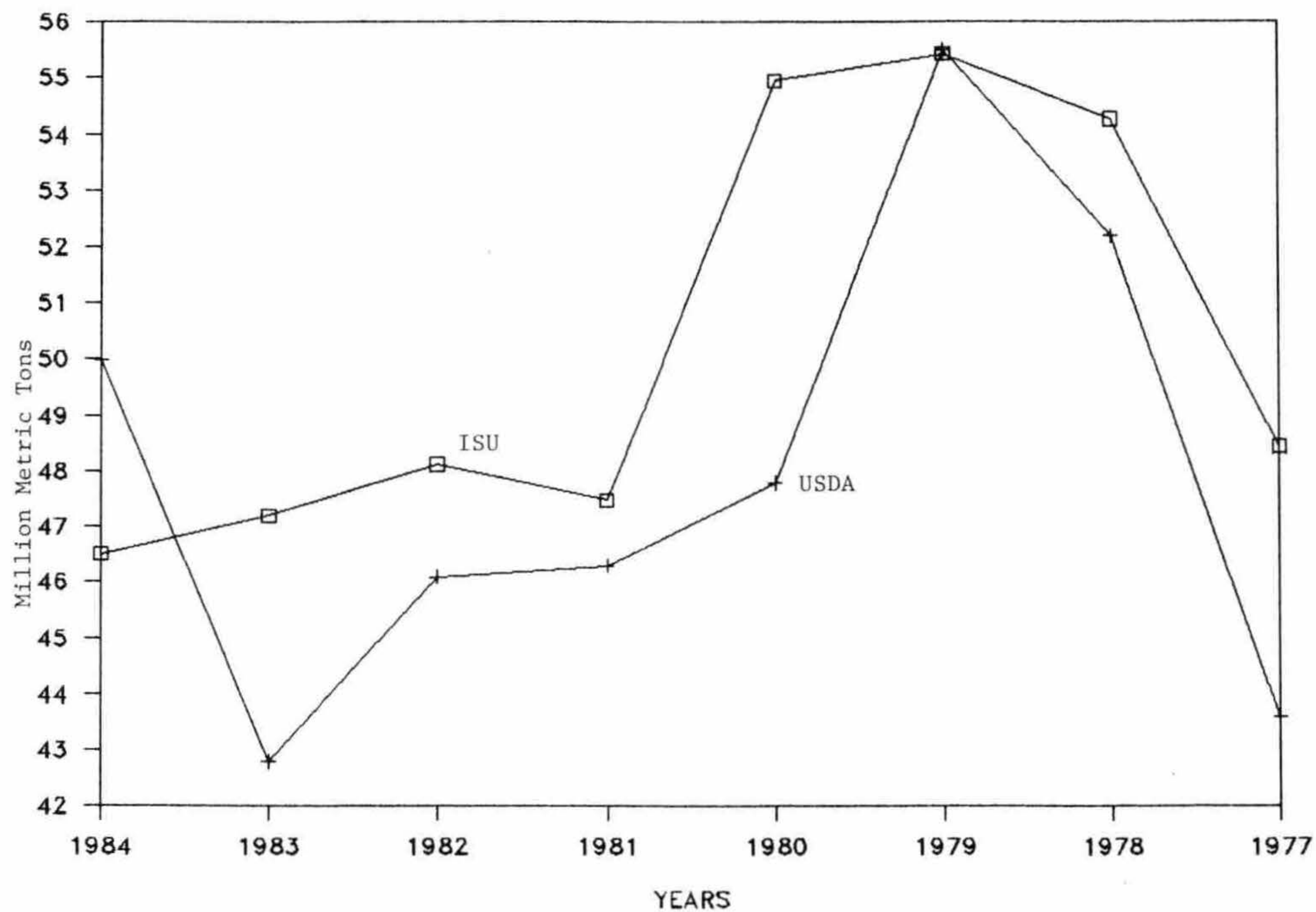

Figure 9.2. Hog feed estimates

inventories, but because of the biological lag in hog production, inventories and feed consumption were not reduced significantly until 1981. Total hog inventories declined by approximately 7.4 percent from the 1979 crop year to the 1980 crop year. 1981 inventories fell another 12 percent from the 1980 level. By USDA estimates, feed consumption by hogs fell 16 percent from 1979 to 1980 and 3.2 percent between 1980 and 1981. These changes are much greater than would be expected based on the market weights, slaughter and inventory figures during that time period. While hog production may not have been profitable in the 1980 crop year, the animals were on farms and were consuming concentrates. In 1983, a similar condition existed as corn prices increased due to a drought and the Payment in Kind (PIK) program. Again producers begin to reduce their inventories. Total hog numbers were 3.9 percent lower in the 1983 crop year compared to 1982. In the 1984 crop year herds had decreased further, down 6.8 percent from 1982. Feed consumption estimated by the USDA declined 7.1 percent from 1982 to 1983, and increased 14.4 percent between 1983 and 1984. Again USDA hog feed estimates are not consistent with hog inventories. While this method does not account for substitution between grains, the total concentrate amount should not be significantly affected because hog diets do not include forages. Because this procedure is based on USDA estimates of livestock inventories, the results do follow hog numbers closely. Of course, errors in USDA livestock inventories would lead to corresponding errors in feed use estimated by this procedure.

The beef breeding herd and stocker cattle, by this procedure, consume similar amounts to those reported by the USDA (Figure 9.3). For the 1984 crop year, these cattle consumed 11.2 MMT of concentrates compared to 9.6 MMT reported by the ERS. For the period 1977 through 1984 this method estimates 4.4 percent more concentrates consumed by these cattle, 11.4 vs. 10.9 MMT. This class of livestock includes beef cows, bulls, and replacement heifers and beef calves weighing less than 500 pounds and steers and heifers weighing over 500 pounds that are not accounted for as cattle on feed or breeding herd feed of replacements. Pasture, hay, and crop residues are the major feed sources for these cattle. Concentrates are mainly fed in the form of protein, vitamin, and mineral supplements. However, replacement heifers and especially calves will often be fed grain during the late fall, winter, and early spring.

The difference in the estimates begins between the 1981 and 1982 crop years. During that period, beef inventories increased slightly, and then began to decrease in the 1982 crop year. Also pasture and range conditions in most of the major beef cow and stocker areas were in poor condition during the 1983 and 1984 calendar years. It is therefore unlikely that producers reduced concentrate feeding to their cattle, and probably increased supplemental concentrate feeding to stretch the forage supply. This estimation procedure does not account for substitution of concentrates for forages, and thus would not capture such practices if they occurred. Because these estimates do rely on inventory reports, if the number of beef cattle increases, so will the estimated feed consumption. Beef inventories began to decline again in 1982. This procedure

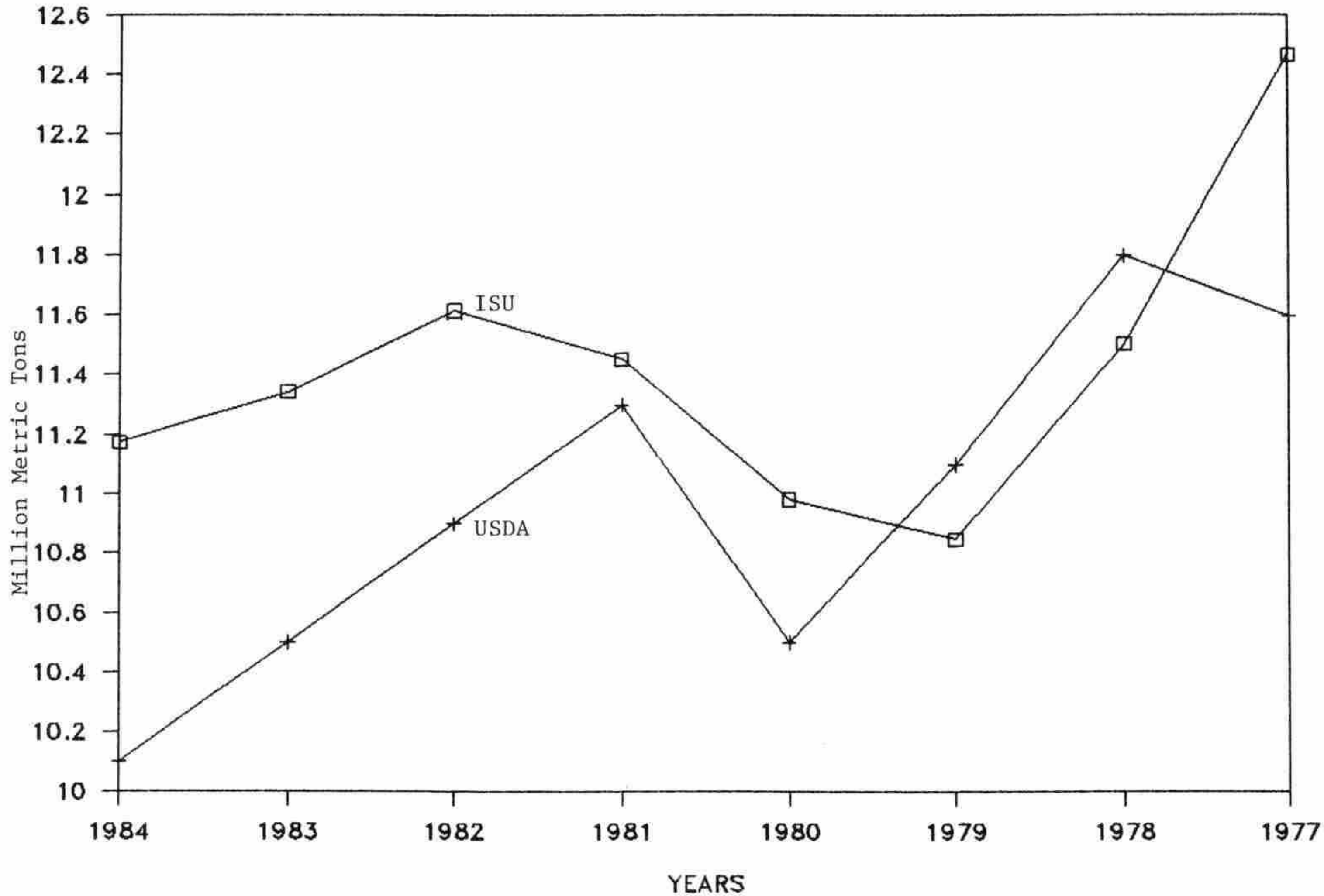

Figure 9.3. Other beef cattle feed estimates

does show a decline in concentrate feeding, but not as sharp as reported by USDA. By holding ration composition and daily dry matter intake constant over time, this estimation procedure does not reflect changes in feeding practices caused by price changes, poor pasture conditions, or reduced winter grazing (and therefore heavier concentrate feeding) caused by heavy snow cover.

Sheep and miscellaneous animals are estimated by this procedure to consume less concentrates than reported by the USDA (Figure 9.4). Feed consumption estimates for these two classes of animals are combined by ERS analysts into a category known as "other livestock and unallocated." Considering the magnitude of the fluctuations in the USDA estimate, unallocated appears to refer to concentrates and not animals. For comparison this procedure will also combine the sheep and miscellaneous categories. For the 1984 calendar year feed consumption is estimated to have been 7.9 MMT. The ERS reports 15.7 MMT of concentrates consumed by these animals in 1984. Over the eight year period this method estimates 9.6 MMT compared to 11.2 MMT estimated by the ERS or a 16.7 percent difference. In addition, the USDA estimates are more variable. Sheep and goat inventories decreased from 77-79, increased from 79-82, and have decreased again since 1982.

Because the animals included in this category have relatively stable inventories, feed consumption should also be stable. Sheep consume approximately half the concentrates used by this group. While sheep numbers are cyclical in nature, changes in inventories are not as dramatic as changes in, say, hog inventories. Also, sheep diets are

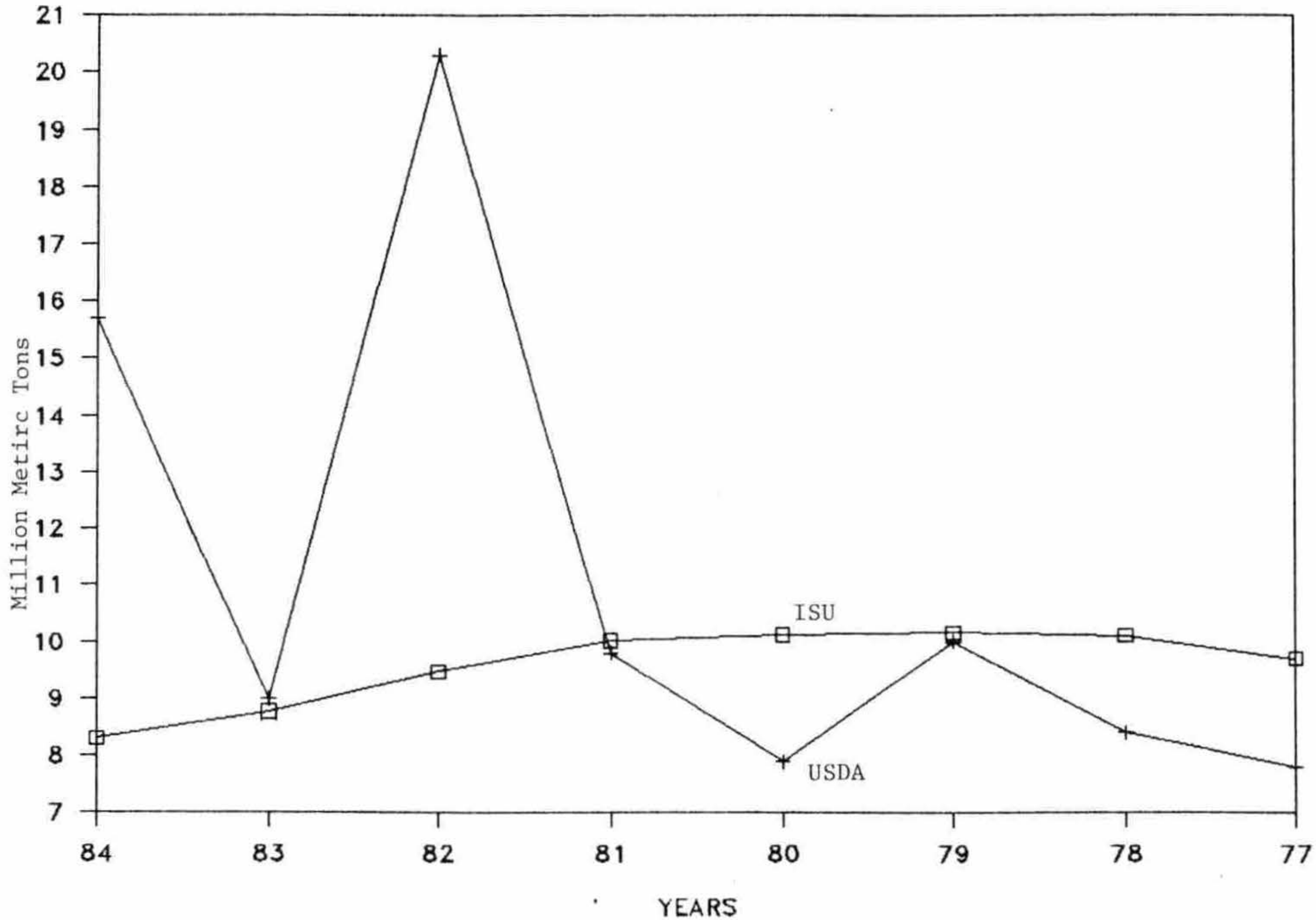

Figure 9.4. Miscellaneous & sheep feed estimates

predominately forage and a small amount of concentrates. A large shift in sheep numbers will have a relatively small impact on concentrate consumption.

Of the miscellaneous animals, horses, pets, laboratory and fur bearing animals all have very stable, and in general, slowly increasing inventories. Fish, catfish, trout, and salmon, production may fluctuate, but the relative amount of feed consumed by fish is so small it is unlikely that feed consumption by the entire category will be affected.

This estimation procedure relies on reported annual tonage of feed consumed by pets and specialty animals and reported inventories of sheep, horses, and fish. Pet food sales have increased since 1977. Specialty animal feed consumption was held constant 1977-1981 based on the 1977 Census of Manufacturers Report (U.S. Bureau of Census, 1982). The 1982 report showed slightly lower specialty feed sales compared to 1977. These later figures were used from 1982 forward. Horse and fish feed consumption was assumed constant at the 1984 level. Therefore, our results are more stable because specialty animals, horse, and fish feed consumption is held constant. Only sheep and goat inventories fluctuated. Pet food numbers increased slightly each year. The largest discrepancies between the two estimates arise in 1982 and 1984. This estimate relies on reported inventories of sheep, horses, and fish and aggregate tonnage reports for pets and specialty animals. Unless these numbers fluctuated dramatically from 1982 through 1984, these feed estimates would not have reflected the change shown by the USDA during that time. However, it would seem that the wide fluctuation in the USDA estimates are caused by unallocated feedstuffs and not by severe changes in the horse, fish, or specialty animal population.

The feedlot cattle feed use estimates (Figure 9.5) using the procedure described in earlier chapters, are lower and more stable than those reported by the USDA. Total concentrates consumed by fed cattle in the 1984 crop year was estimated to be 30.6 MMT by this procedure compared to 34.4 MMT by the ERS. For the eight year period this procedure estimated 10.5 percent less concentrates consumed by feedlot cattle, 28.7 vs. 31.7 MMT. In general the pattern is similar. The largest difference occurs in the 1978-1980 crop years. The number of cattle on feed fell approximately 10 percent between 1978 and 1979 and 5 percent between 1979 and 1980. USDA estimates of concentrates consumed by cattle on feed dropped 13.3 percent the first year and 26 percent the second. This procedure's estimate of concentrates fell 6.8 percent in 1979 and 4.9 percent in 1980. During that period grain prices were increasing, and fed cattle producers probably did a limited amount of substitution of forages for higher priced grain. Because our estimates hold rations constant, this substitution is not reflected in the results. However, during the same period, hay prices were also increasing which would tend to make substitution less practical. Also, as pointed out in chapter 6, substituting forage for, say, 10 percent of the concentrates in a ration will reduce total concentrate consumption by less than 10 percent. Therefore, it seems unlikely that cattle feeders would substitute forages for concentrates to the extent necessary to decrease concentrate consumption by 26 percent. The one variable that is unknown

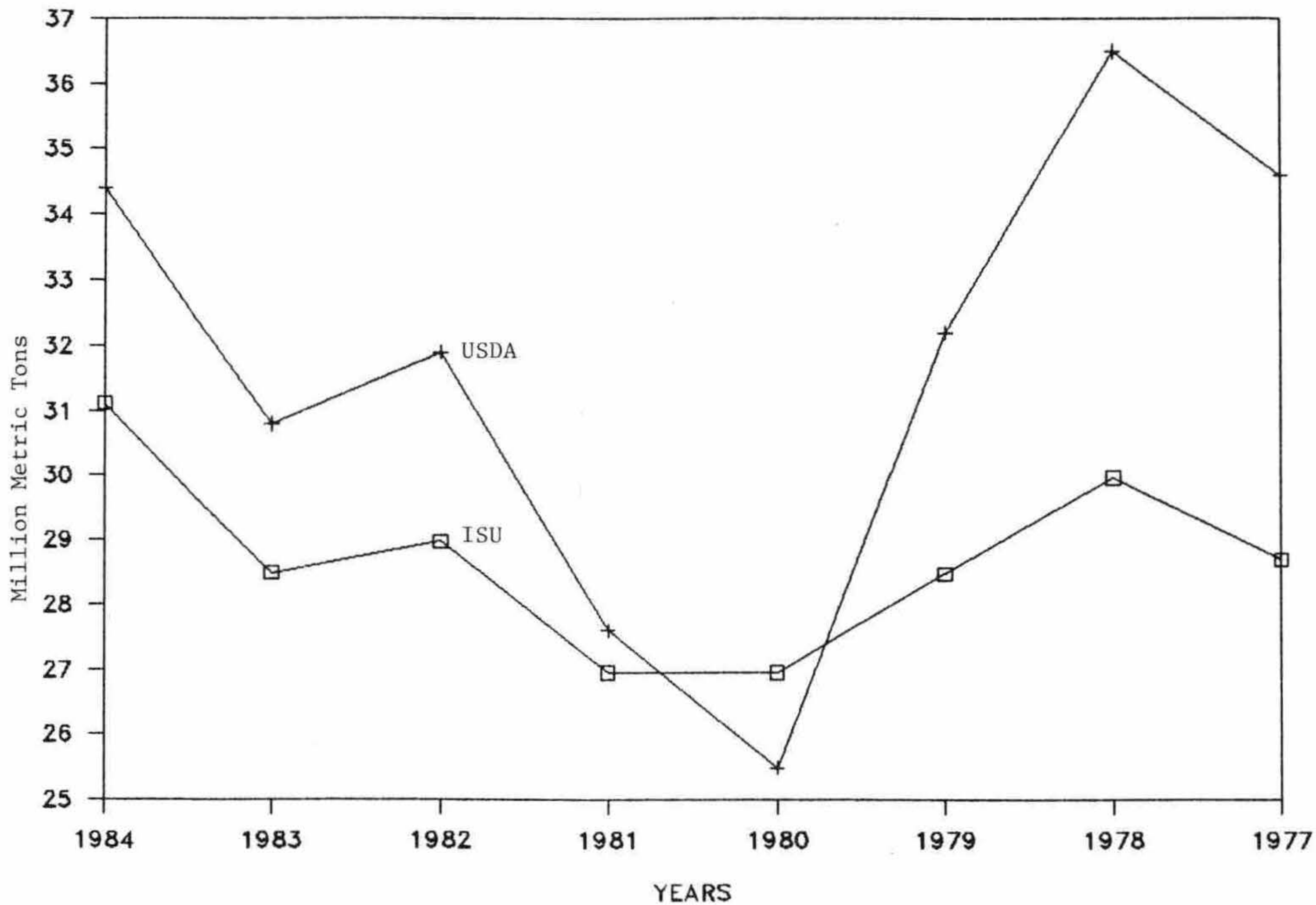

Figure 9.5. Feedlot cattle estimates

is starting weights of cattle placed on feed. While higher grain prices of 1979 and 1980 suggest feeders would prefer to have heavier placement weights, the poor pasture and range conditions of 1980 could have led to lighter placement weights. These estimates assume constant placement weights throughout and did not account for changes in feeder placement decisions. While this estimate does not reflect substitution of forage for grain, the USDA estimate assuming extensive substitution would appear to overstate the ration changes.

In addition to the higher substitution rates, ERS analysts also assumed a lower concentrate to roughage ratio than this procedure does. For the eight year period, ERS estimates that approximately 50 percent of the diet is concentrates and 50 percent roughage; for 1984 the ratio is 60:40. A diet such as that reported in 1984 would supply less than 2.6 pounds of gain per day for feedlot cattle. Such a diet and performance level is not indicative of today's feedlot industry. While USDA assumes a lower percent concentrates in the diet, their overall of concentrate is higher. This discrepancy may be explained by assuming different feed efficiencies of feedlot cattle. USDA estimates may not reflect the current level of efficiency in the cattle industry. In general, the procedure outlined in Chapter 6 more accurately reflects the management and nutritional practices used by fed cattle producers.

These estimates indicate that poultry consume considerably less concentrates than reported by the USDA (Figure 9.6). In the 1984 crop year, this procedure estimates total poultry feed consumption to be 33.1

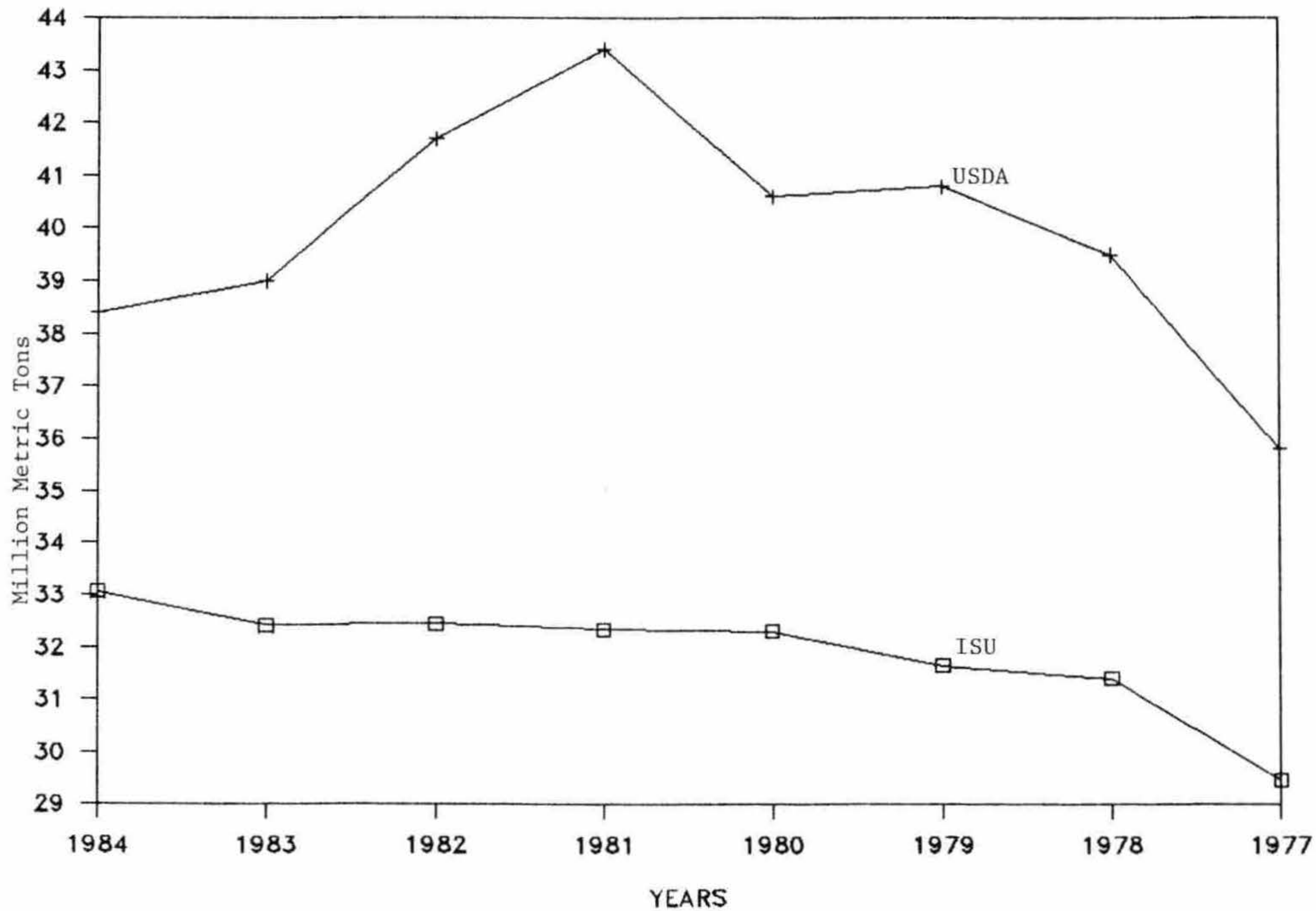

Figure 9.6. Poultry feed estimates

MMT compared to 38.4 MMT estimated by the ERS. For the eight year period this procedure averages 20 percent lower than the ERS estimates, 31.9 vs. 39.9 MMT. While this estimate of turkey and broiler feed consumption is slightly lower than that reported by the USDA, layers and the layer and broiler supply flocks feed intake is considerably lower. Feed estimates for broilers and turkeys slaughtered are based on live weight slaughtered and a feed efficiency coefficient. Layer and broiler breeding flock feed consumption is based on the number of eggs produced and a feed efficiency estimate. The supply flock feed estimates are determined as a fixed amount of feed per bird placed in the supply flock. As mentioned in the other sections, because of how these estimates are designed, feed consumption follows inventories and production closely. Egg production was relatively constant from 1978-1983 with increases between 1977 and 1978 and 1983 and 1984. The supply flock increased between 1977 to 1978, and stabilized from 1978 through 1981 crop years. Following a decline in the 1982 crop year, numbers begin to increase again. Broiler and turkey slaughter has increased steadily from 1977 to 1984 except for 1982 when turkey slaughter declined from its 1981 levels. Thus if all production and inventory statistics have increased over the period, it seems logical that feed consumption would also increase over the period unless feed efficiency changes significantly, and there are no indications that such a dramatic change occurred. The USDA estimates of the changes in total poultry feed consumption do not appear to correspond to the changes in production and inventories reported for the major poultry classes.

Aggregate Feed Use

These estimates compared to the feed and residual figures reported in the USDA Feed Outlook and Situation indicate a lower feeding rate for corn and oats (Figures 9.7 and 9.8), generally higher rates for barley (Figure 9.9) and similar feeding rates for milo (Figure 9.10). These differences are partly due to holding the ration composition constant through time, thus substitution between grains is not reflected in the results. The ration composition that is based on 1984-85 diets has a relatively high percent wheat in it due to recently favorable wheat feeding conditions. An aggregate comparison would be feed grains and wheat use combined which was 8.3 percent lower than the USDA reports for the 8-year period (Figure 9.11). The major difference in Figure 9.11 occurs in the 1982 crop year, but when livestock inventories and production levels are considered the ERS estimates seem unlikely. From 1980 to 1981 crop years, cattle slaughter and poultry and dairy production all increased slightly. Hogs, the largest user of feed grains, decreased sharply in number during the same period. Inventories of all the major grain consuming animals increased from the 1981 to 1982 crop years in number. The following year hogs, fed cattle, and dairy production decreased while poultry inventories increased. Dairy producers did reduce concentrate feeding in the 1983 crop year due to the dairy reduction program and higher grain prices. Fed cattle rations may also have included relatively less concentrates in 1983, however, higher hay prices in the major cattle feeding states would have prevented large scale substitution. Thus, moderate substitution of forages for grain by dairies

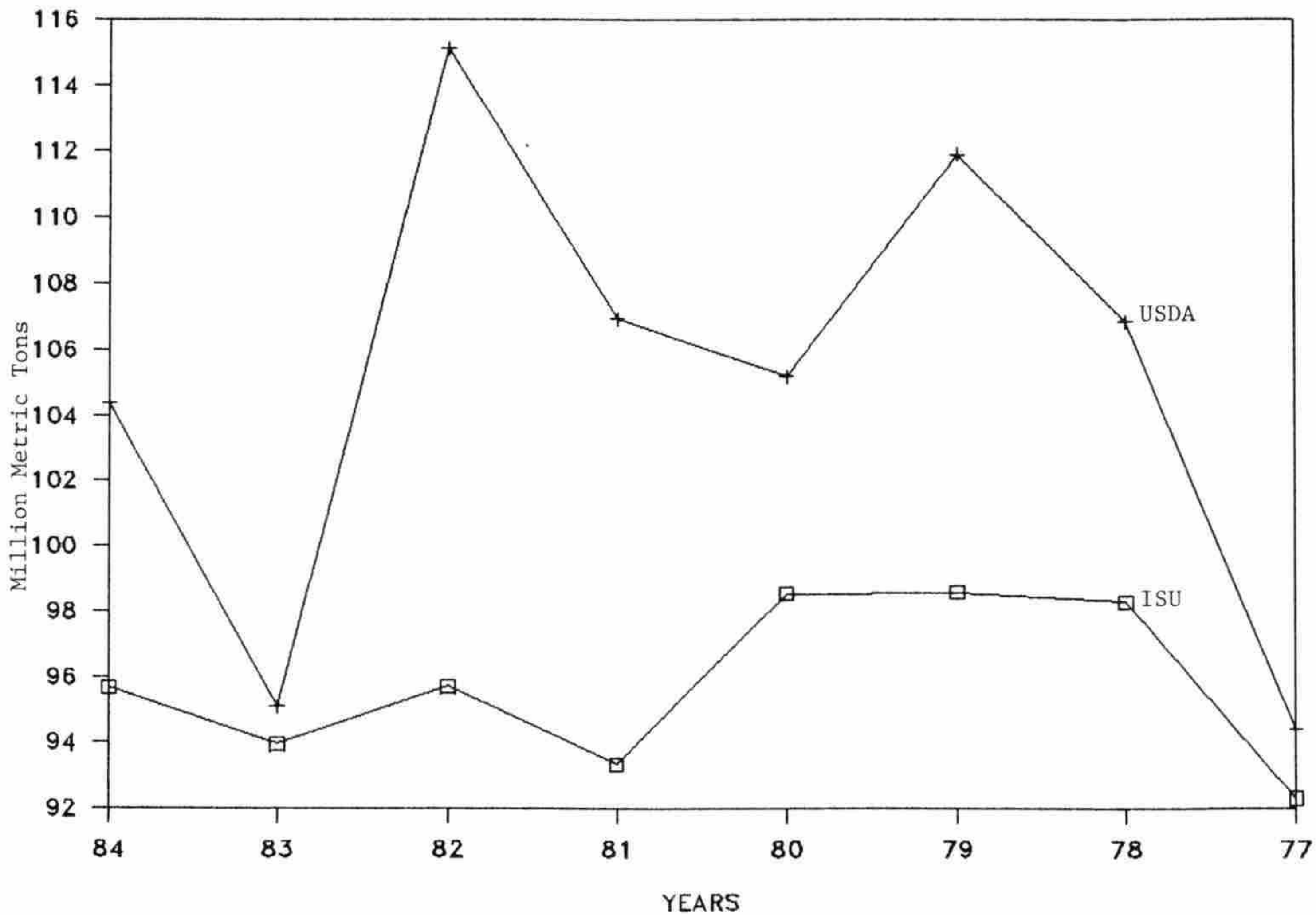

Figure 9.7. Corn

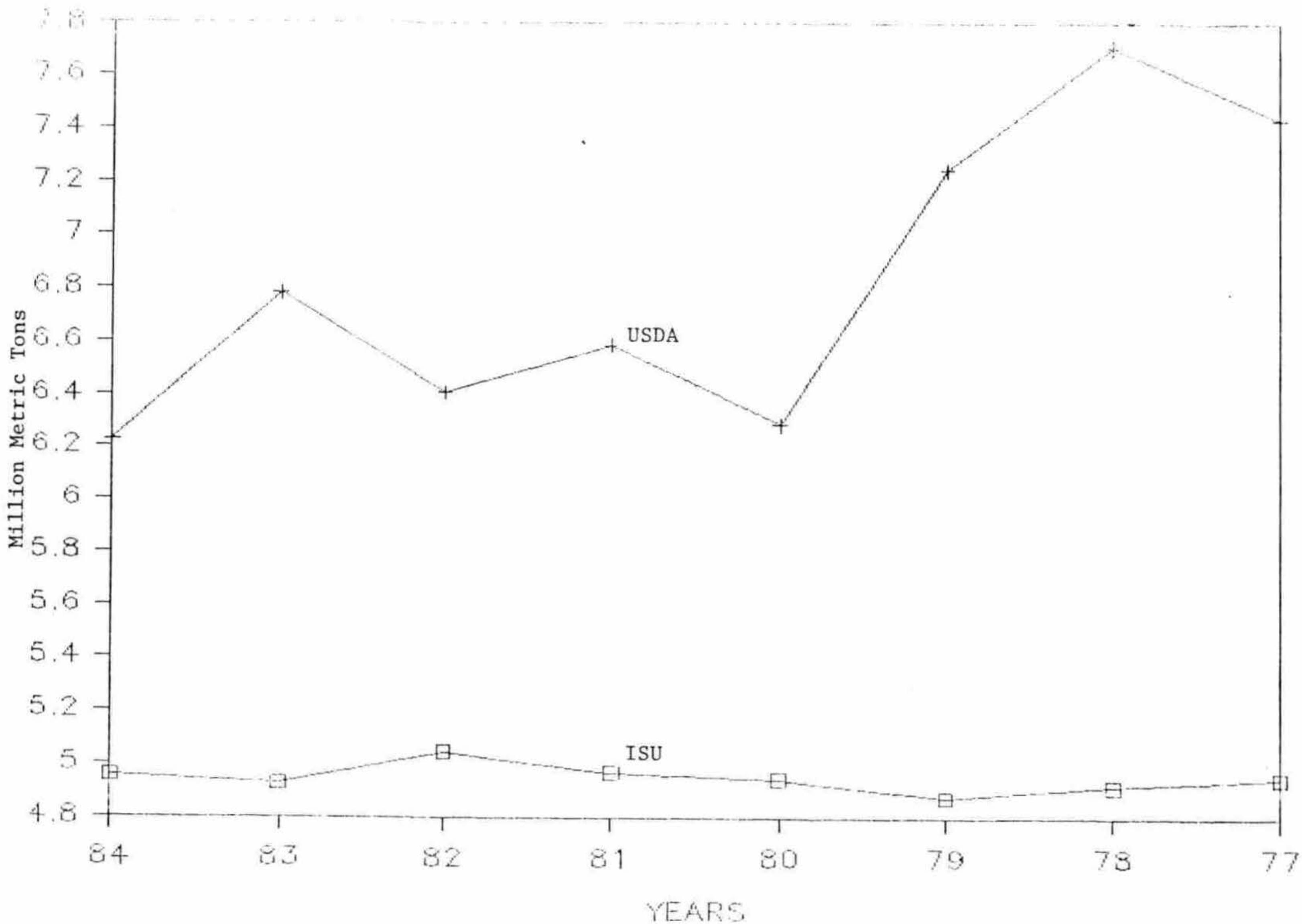

Figure 9.8. Oats

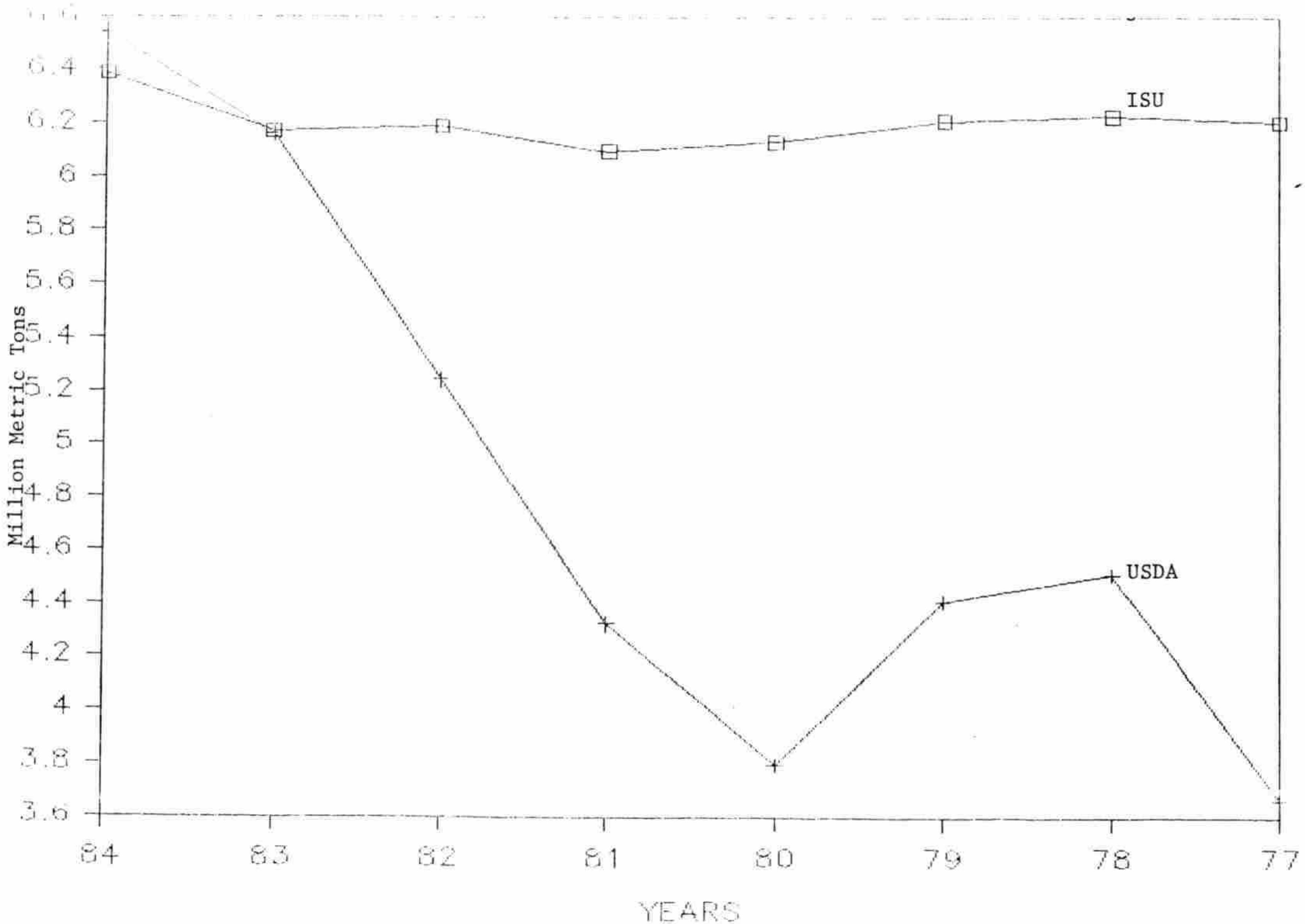

Figure 9.9. Barley

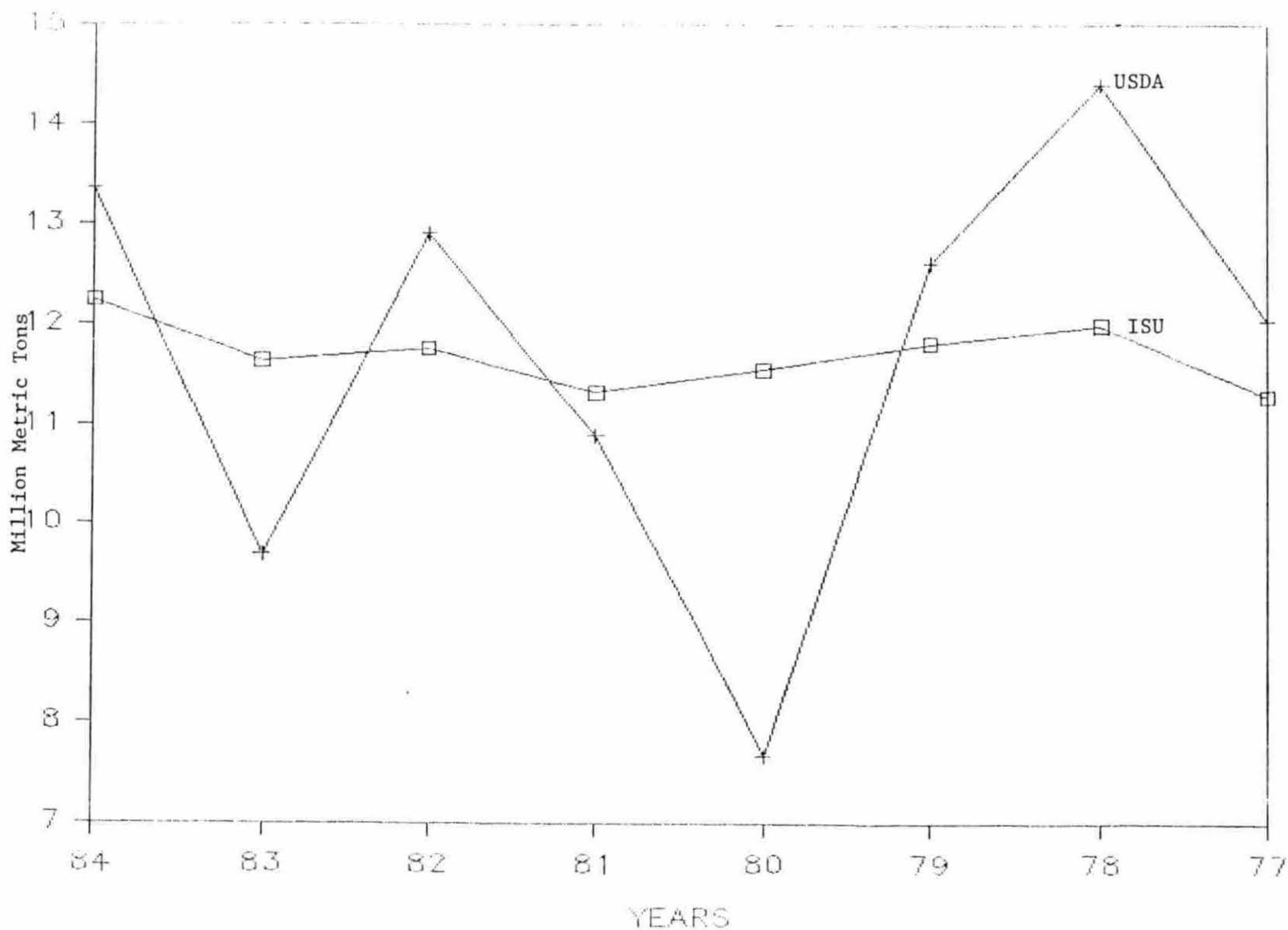

Figure 9.10. Sorghum

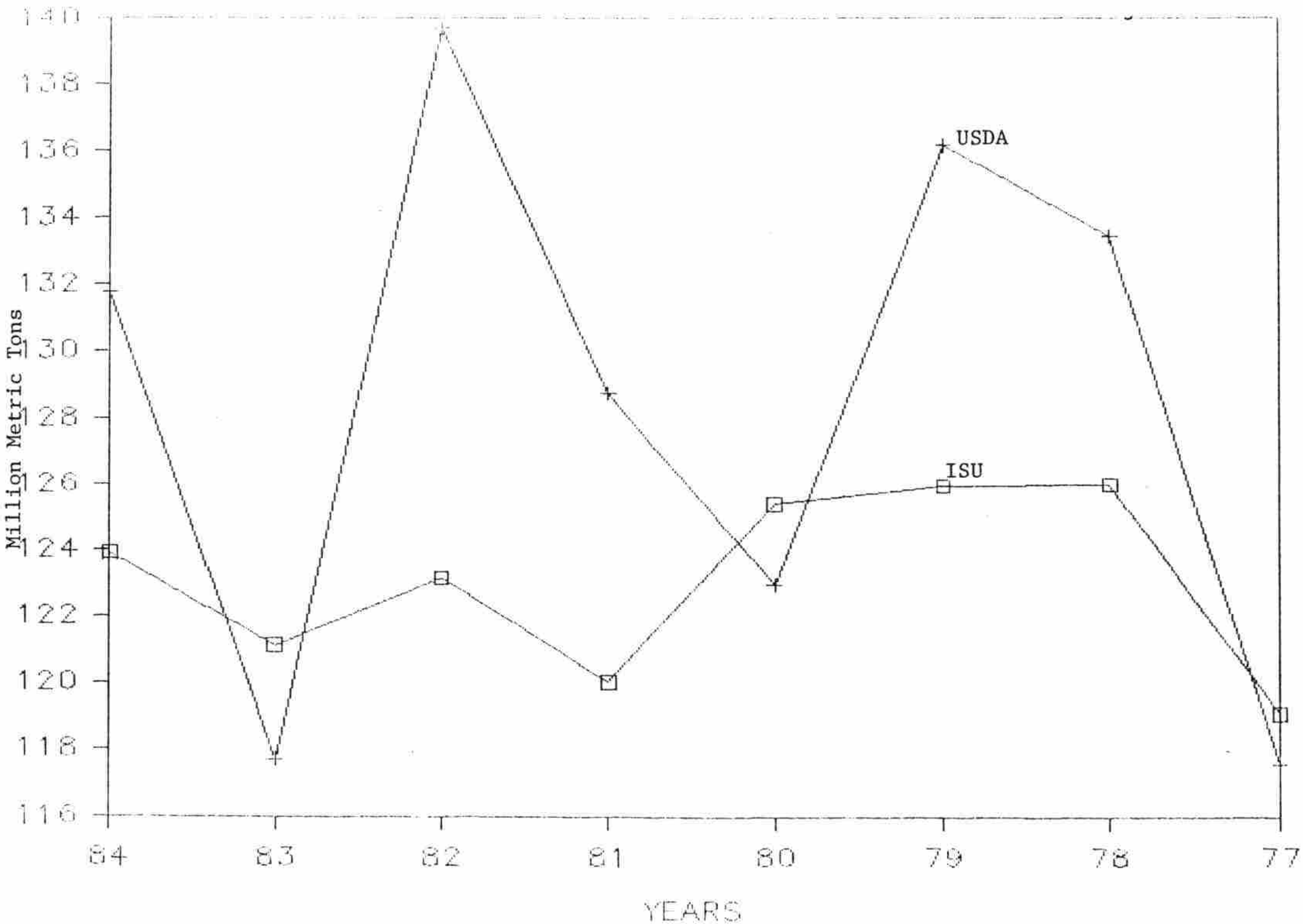

Figure 9.11. Feed grain & wheat

and feedlots, coupled with a lower number of cattle on feed and 3.9 percent fewer hogs, would cause a reduction in concentrate feeding in the 1983 crop year. However a 15 percent reduction, as suggested by the USDA, seems unlikely.

Oilseed meals, grain and animal proteins, and other processed feeds all are estimated at higher rates than reported by the USDA (Figures 9.12 to 9.15). Much of this difference is explained by the current ration composition which reflects modern livestock production practices. Hog, poultry, and dairy rations were all assumed to have higher protein content than estimated by the USDA. In addition to the higher protein content of the diet, hogs and dairy animals are estimated to consume more total concentrates than estimated by the USDA.

Those estimates of total concentrates consumed by all livestock and poultry over the eight years analyzed averaged 3.6 percent lower than USDA estimates (Figure 9.16). This is much closer than it appears, as at least two to three percent difference is expected because of the difference in what the two methods are estimating. This method estimates feed consumption by livestock and poultry and feed wastage from processing to ingestion. ERS analysts, using the balance sheet approach, calculate a feed and residual figure which includes feed consumed by animals, statistical reporting errors and loss due to storage, handling and wastage from harvest to final use on all feed grains whether they are used for feed or not. After adjusting for the two to three percent difference expected from moisture, handling, and storage loss, the eight year average for the two estimates is much closer.

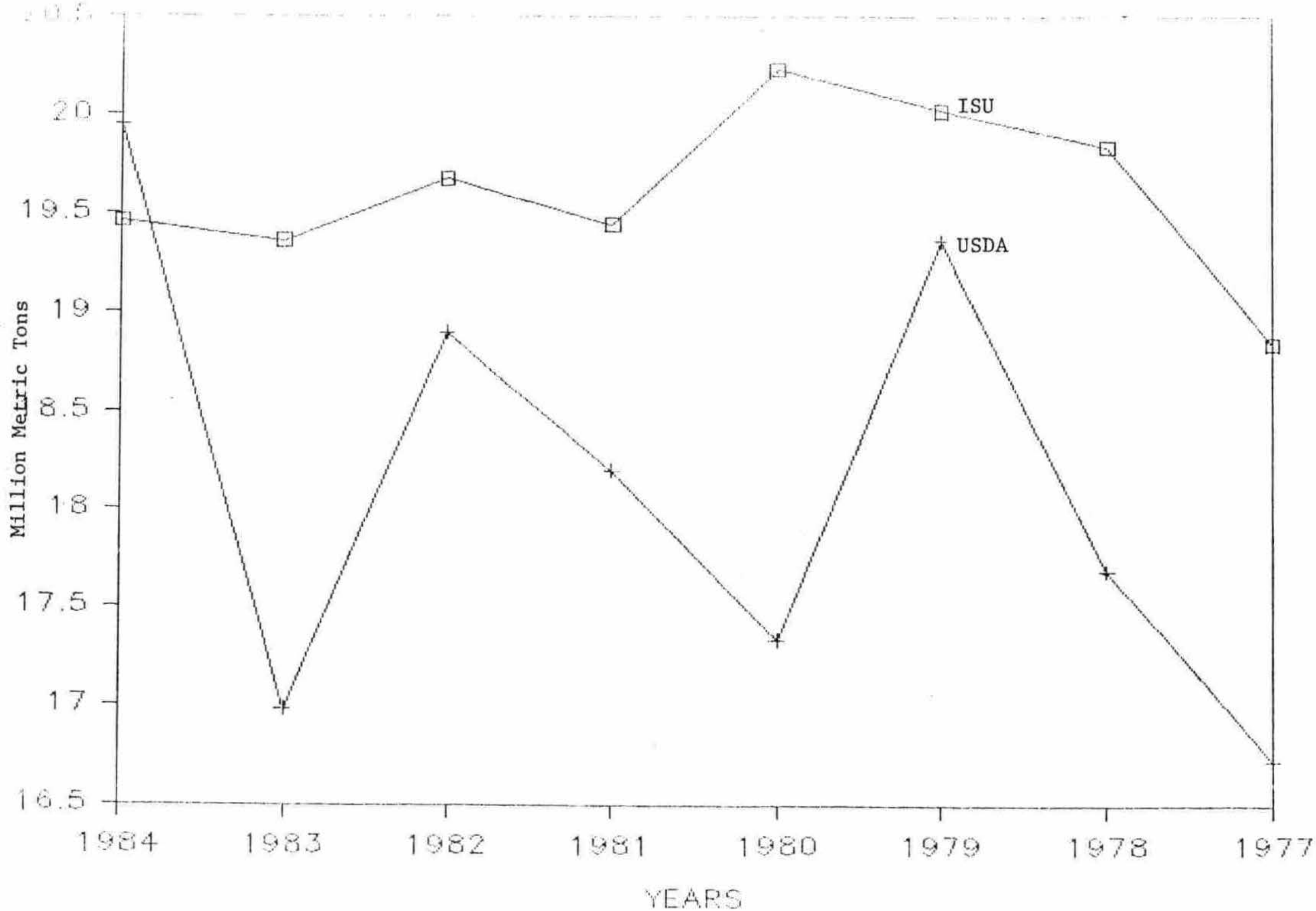

Figure 9.12. Oilseed meal

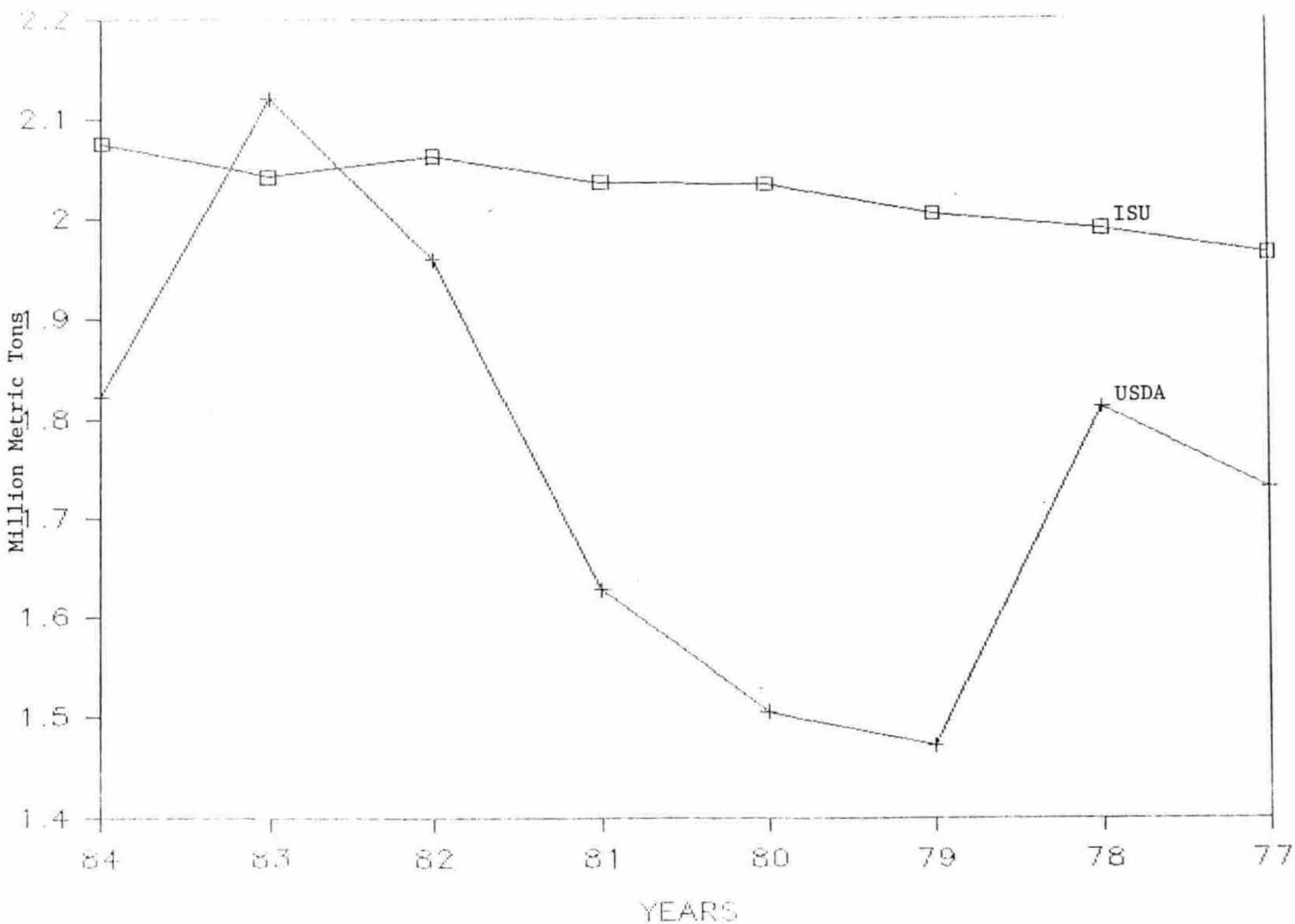

Figure 9.13. Grain protein

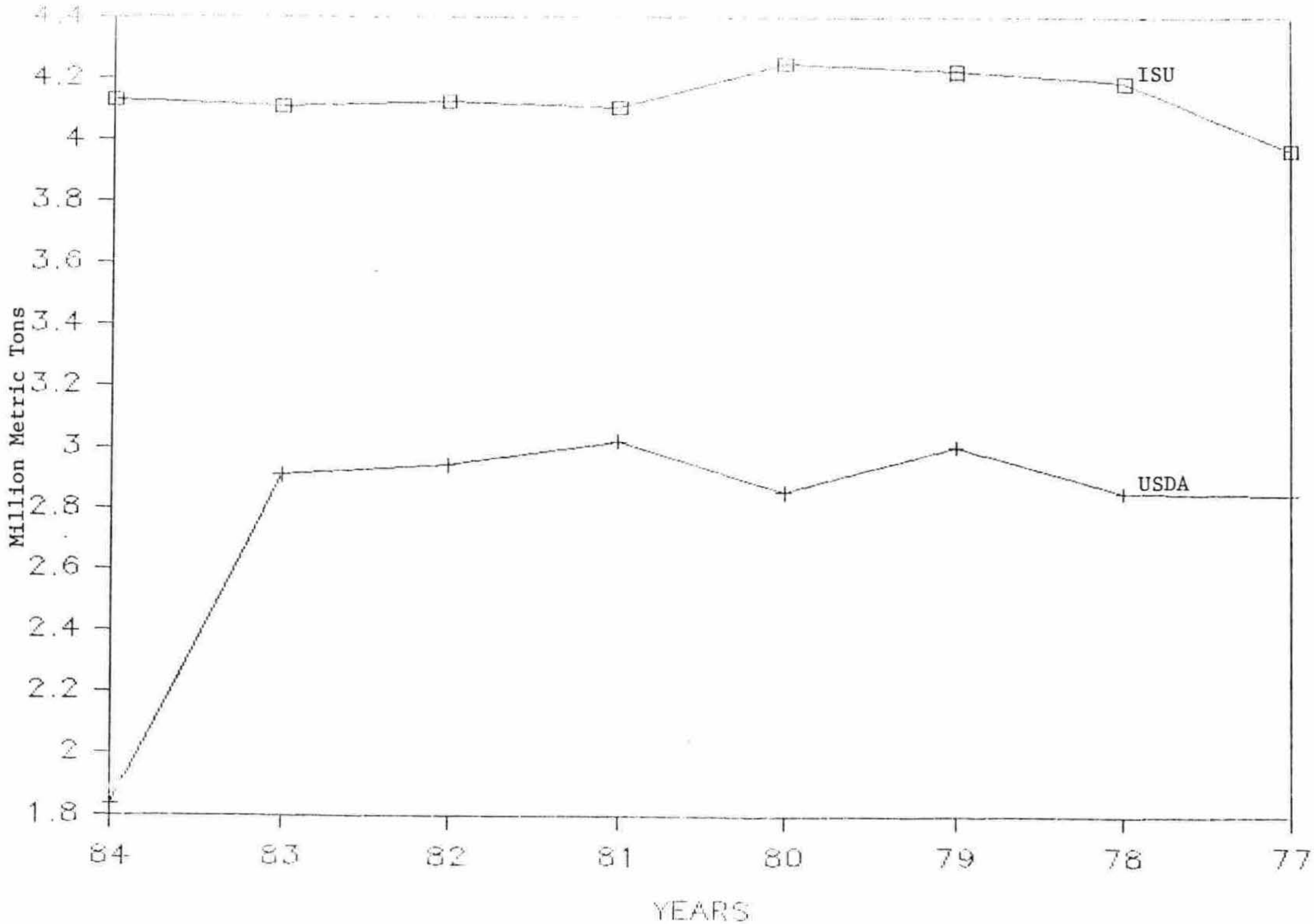

Figure 9.14. Animal protein

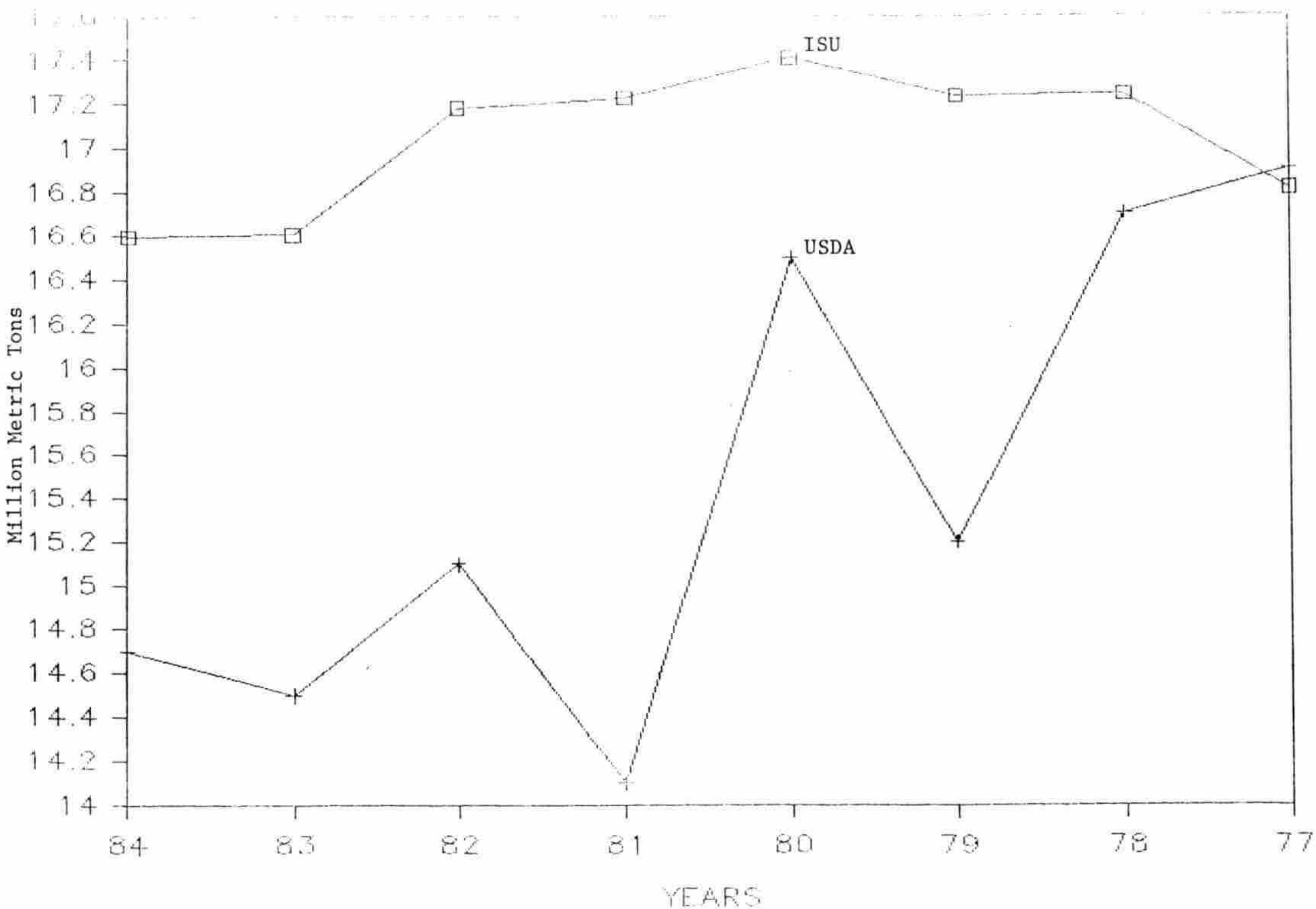

Figure 9.15. Processed feed, vitamins, and minerals

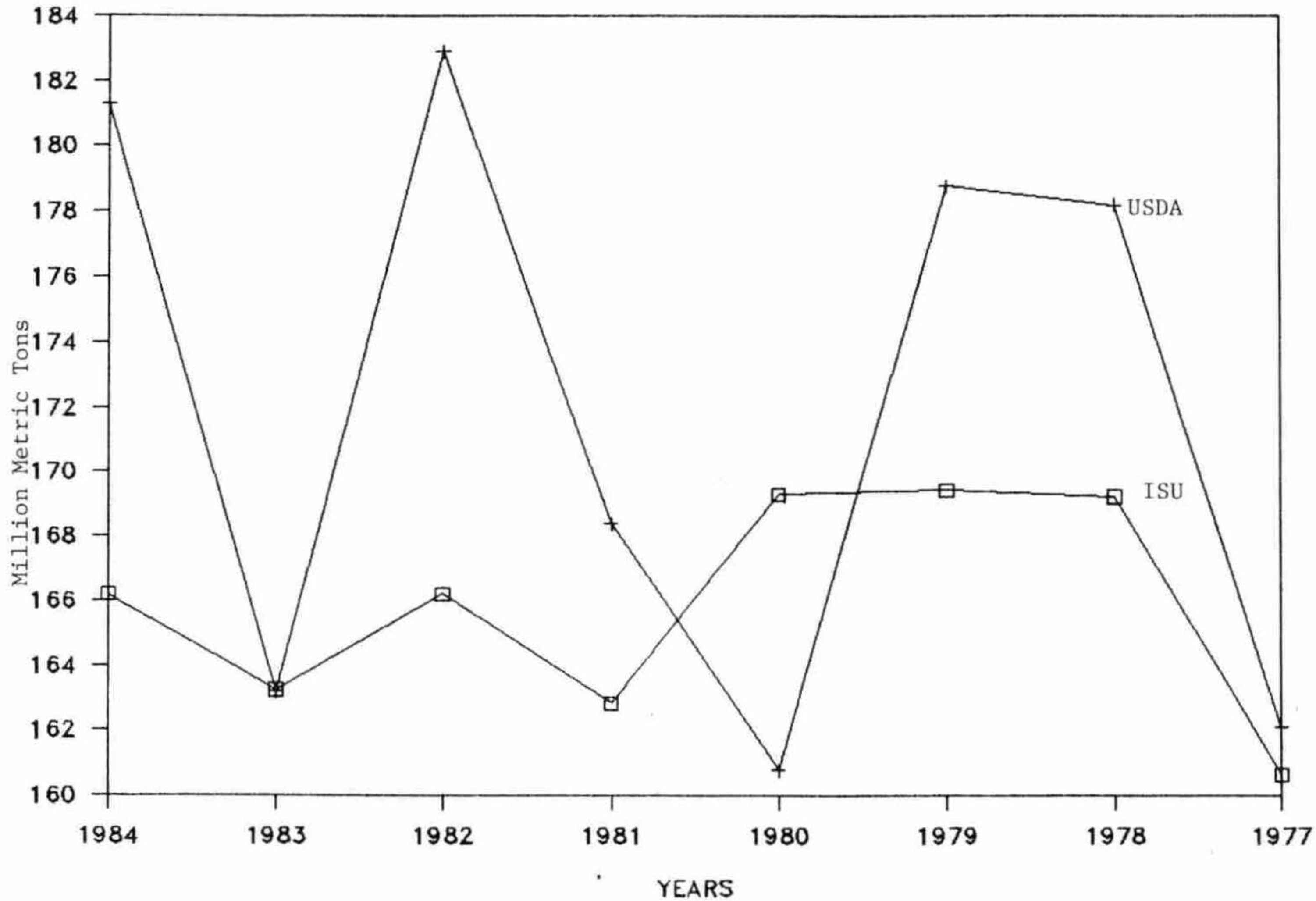

Figure 9.16. Total concentrates

While total feed consumption is similar, individual annual estimates do vary. Most of the variation between the annual estimates can be attributed to differences in estimates of individual species. This procedure estimates higher concentrate usage by dairy and beef cattle and hogs, but less concentrates used by feedlot cattle, sheep and miscellaneous animals, and poultry. Although most of the difference between the two estimates for each species is explained by different assumptions about management practices, the fluctuation in the differences is more difficult to decipher. The wide swings in concentrates consumed by hogs and feedlot cattle as estimated by the USDA do not appear to coincide with inventory changes. In addition, the poultry feed consumption estimates differ greatly. Because production in the poultry industry is tightly controlled, one would expect the two estimates to be closer than they are. Most of this difference appears to be estimates of feed for the layers, broiler hens and replacements. This procedure is based on reported production and inventory and the feed-efficiency values reported by the ERS Animal Product branch. The poultry feed estimates, as well as the wide fluctuations from year to year in the USDA feed estimates should be investigated in more detail.

Future Considerations

While the major factors determining feed consumption by each class of livestock and poultry have been identified, and regional and seasonal differences (where they exist) have been estimated, continued updating and refinement of these estimates will be necessary as the technological and economic environments in these industries continue to evolve. Year-to-year changes in crop yields and prices, temperature, rainfall, feeding and marketing practices, and government policies will influence feed consumption. Technological advancements, genetic improvements and new feed additives or regulations will also impact feed demand. Keeping abreast of these changes will be necessary to refine and modify these estimates in the future. Also, the extent of substitution between grains, grains and high protein supplements, and concentrates and forages needs further consideration, as well as, the price relationships that cause such substitution. Periodic surveys of knowledgeable producers, extension nutritionists, livestock production specialists, feed companies, and nutritional consultants can provide the necessary information to update these estimates.

These professionals from the livestock and feed industries should be contacted to determine actual feeding practices. Theoretical, textbook, and linear optimization approaches to feed demand estimation may be combined with the actual information, but should not be used in place of it. When individuals in the field are contacted, it is important to gather information about the "typical" livestock operation in their area. Many people are eager to talk about the unusual or the exceptional producer, but these producers do not accurately represent the actual feeding practices of a region. It is also necessary to view the information in light of seasonal management practices or extenuating circumstances, such as severe weather or unusual price relationships.

This report has presented a detailed method for estimating feed intake and ration composition for the major livestock and poultry species. The method utilizes scientific estimates of the nutritional requirements of the animal, along with representative management practices of producers to estimate feedstuff disappearance. Using the software program outlined in the USDA technical report and livestock and poultry inventories these feed use estimates can be used to estimate aggregate feedstuff demand on a regional or national basis (Lawrence, Hayenga, Jurgens, 1986).

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