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Forecast of Farm Animal Numbers and Feed and Fertilizer Requirements to 1990 for Connecticut and New England


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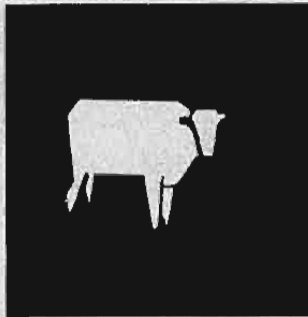
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Tsung-Chao Lee and Stanley K. Seaver*

Introduction¹

The New England livestock-feed sector remains a large utilizer of production and marketing resources. And, the resources employed in the fertilizer industry are to a very large extent dependent upon demands generated by the livestock industry. Many important investment decisions must be made now in anticipation of future levels of production. Therefore, knowledge of livestock numbers has far reaching policy implications for producers, consumers and marketers.

New England livestock and poultry production depends heavily on feed grains supplied by the midwest. Importing nearly 100 percent of concentrated requirements means that livestock producers are vulnerable to changes in feed grain prices and freight rates. Given the expected output and input prices, the current fixed resources, producers decide the number and weight of farm animals to produce. If the number of farm animals is known, the derived demand for feed can be estimated. Thus, knowledge about current and future animal numbers would be of interest to many decision makers, especially

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managers of mixing plants. Managers of both feed and fertilizer mixing plants must plan for adequate supplies of ingredients and for sufficient storage well in advance of the ultimate utilization time.

The main purpose of the study was to forecast the number of farm animals in Connecticut and the New England states, and from these results forecast feed requirements until 1990. A secondary purpose was to forecast Connecticut fertilizer needs from 1979 to 1990. Both livestock numbers and fertilizer requirements are based on annual observations.

Forecast of Farm Animals

One of the approaches in measuring the quantity of feed grains consumed is to estimate the future number of farm animals. Then, given standard feed rations for each class of farm animals, projections can be made of total feed grain requirements.

To forecast the number of farm animals, alternative approaches are discussed in an article by Lee and Seaver (1980).¹ The method used in this research is a revision of the method used in the previous publication. The revision considers the convenience of an unconditional forecast over the conditional forecast and utilizes the autoregressive type of function in addition to the linear trend. The basic form of the forecast function is:

$$y_t = \alpha + \beta y_{t-1} + \gamma t + u_t$$

where α , β and γ are parameters to be estimated, y_t is the number of animals in year t and u_t is a stochastic term assumed to have zero expectation $E(u_t) = 0$ and constant variance $E(u_t^2) = \sigma^2$.

For milk and beef cows, a two-year lag is added to the above basic form since they have longer production cycles than other animals. For milk cow estimates, a milk feed ratio, (pounds of feed that a pound of milk can buy) is also used with a two year lag. For chickens, an egg-feed ratio, (pounds of feed equivalent in value to a dozen of eggs) is used in the regression and is lagged one year. The analysis is based upon data from 1942-1979 except for the Connecticut pig crop which covered a twenty-six year period. The data are shown in Appendix Tables A1, A2 and A3. The results of the estimated equations for Connecticut and New England are given in Tables 1 and 2, respectively.

Based on the equations in Tables 1 and 2, the number of farm animals are forecast through 1990 given the initial number of animals in 1978 and 1979 in order to provide for the two year lag for milk and beef cows. The results are

¹ Tsoung-Chao Lee and Stanley K. Seaver, "Forecasts of Farm Animal Production in the New England States and in the U.S." *Journal of Northeast Agricultural Economics Council*, Vol. IX, No. 1, April 1980, pp 23-28.

TABLE 1
Forecast Equations for Farm Animals in Connecticut, 1944-1979

Y_t (1,000)	Constant Intercept	Lagged Value		Time t	Product Feed Ratio		R^2	F	N ^a D-W
		Y_{t-2}	Y_{t-1}		x_{t-2}	x_{t-1}			
Milk Cows	819.1377	-0.4121 (-2.65)**	1.2048 (7.33)**	-0.4056 (-2.33)**	-6.2589 (-1.53)	1.3492 (0.35)	0.9951	1170.78	35 1.82
All Chickens	-64,509.68	--	0.6586 (4.24)**	33.3791 (3.42)**	--	58.5492 (1.17)	0.8854	79.84	35 2.03
Pig Crop	37.0316	--	0.6823 (5.22)**	-0.0186 (-1.25)	--	--	0.9423	187.76	26 1.36
Sheep and Lambs	27.0382	--	0.8842 (11.19)**	-0.0134 (-1.21)	--	--	0.8742	111.17	35 1.13
Lamb Crop	23.1877	--	(0.7833) (7.51)**	-0.0113 (-1.25)	--	--	0.6833	34.52	35 2.30
Beef Cows	-106.0743	0.0059 (0.03)	0.7740 (4.13)**	0.0543 (2.43)*	--	--	0.9629	285.87	37 1.91

^a Top number = N

Bottom number = D-W test statistic d

* 5 percent level of significance

** 1 percent level of significance

(.) The numbers in the parentheses are t statistics

TABLE 2
Forecast Equations for Farm Animals in New England, 1944-1979

Y _t (1,000)	Constant Intercept	Lagged Value		Time t	Product Feed Ratio		R ²	F	N ^a D-W
		Y _{t-2}	Y _{t-1}		X _{t-2}	X _{t-1}			
Milk Cows	5,128.698	-0.5497 (-3.95)**	1.3166 (8.66)**	-2.5298 (-3.03)**	-28.1498 (-1.13)	1.6987 (0.07)	0.9940	963.96	35 1.78
All Chickens	-212,841.2	--	0.7274 (5.01)**	109.2047 (3.03)**	--	348.4255 (1.85)	0.7641	44.47	35 2.41
Pig Crop	5,913.98	--	0.5095 (4.07)**	-296.1674 (-3.35)**	--	--	0.9718	534.06	34 1.62
Sheep and Lambs	102.7742	--	0.9067 (13.62)**	-0.0503 (-0.49)	--	--	0.9255	198.73	35 0.41
Lamb Crop	72.9964	--	0.9187 (13.02)**	-0.358 (-0.54)	--	--	0.8920	127.99	34 1.17
Beef Cows	-361.7073	-0.1839 (-1.00)	1.0163 (5.54)**	0.1867 (1.88)	--	--	0.9556	229.31	36 2.02
Broilers									
Maine	-112,497.2	--	0.9516 (13.98)**	59.8457 (0.31)	--	--	0.9898	1557.11	35 1.46
New England	260,121	--	0.9358 (20.63)**	-129.0846 (1.09)	--	--	0.9542	333.02	35 1.37

^a Top number = N
 Bottom number = D-W test statistic d

** 1 percent level of significance

(.) The numbers in the parentheses are t statistics

given in Tables 3 and 4 for Connecticut and New England, respectively. In order to forecast milk cows and chickens, feed ratios are projected through 1990 using the following recursive equations.

For milk feed ratio

$$y_t = -4.954 + 0.7482 y_{t-1} + 0.0027t \quad (3.1)$$

(6.4611)** (1.5882)

$$R^2 = 0.7613$$

For egg feed ratio

$$y_t = 41.6531 - 0.2548 y_{t-1} - 0.0206t \quad (3.2)$$

(1.4461) (8.9565)**

$$R^2 = 0.7714$$

The numbers in parentheses are t statistics, and the asterisks indicate statistical significance at the 99 percent confidence level. Based on the above two equations, the forecast of the product feed ratios are given in Table 5.

Forecasted number of farm animals in Connecticut are in general declining. Exceptions are chickens and beef cows. Milk cows are decreasing two to three thousand each year. Sheep and lambs and the lamb crop are decreasing at a rate of about one-hundred head a year. Beef cows decrease by 1,000 and then return to the original 1979 level. Chickens are estimated to increase in Connecticut from 5,840,000 in 1980 to 6,346,000 in 1990. The forecast of the pig crop is difficult because of the increase in pig crops in the past three years. The historical trend of pig crop shows a steady decline from the peak of 60,000 in 1945 to the low of 9,800 in 1975, but during the past three years the number increases to 12,000 in 1976, 14,300 in 1977, and 14,500 in 1978. If the trend since 1945 is followed, there will be no pig crop in 1984. If the upsurge phenomenon of the past three years is followed, the forecast would increase at an unbelievable rate. Our final forecast considers only the trend of the past twenty-five years. The results show a decreasing trend at a moderate rate of 500 to 1,000 a year.

The trend in the number of farm animals in Connecticut is quite typical of that in New England (Table 4). Milk cows in New England are forecast to decrease twelve to thirteen thousand a year. Chickens will increase slowly in the early 1980's and then by about two hundred thousand birds a year in the late 1980's. The pig crop will decrease at the rate of about six thousand head a year in the late 1980's. Sheep and lambs and the lamb crop will decrease at the rate of five-hundred head a year. Beef cows will increase by 1,000 to 2,000 per year.

Broiler forecasts for New England presented a difficult problem. New Hampshire, Vermont and Rhode Island broiler numbers have been unreported

TABLE 3

Forecast of Farm Animals in Connecticut, 1979-1990

Year	Milk Cows	All Chickens	Pig Crop	Sheep	Lamb Crop	Beef Cows
				and Lambs		
----- (in 1,000) -----						
1979	49	5,871	12.8	5.1	3.8	9
1980	46	5,840	11.3	5.0	3.7	8
1981	43	5,841	10.2	4.8	3.7	8
1982	40	5,869	9.2	4.7	3.6	8
1983	37	5,910	8.4	4.6	3.6	8
1984	35	5,958	7.6	4.4	3.5	8
1985	33	6,017	6.9	4.3	3.5	8
1986	31	6,078	6.2	4.2	3.4	8
1987	29	6,140	5.6	4.0	3.4	9
1988	27	6,208	5.0	3.9	3.3	9
1989	25	6,275	4.4	3.8	3.3	9
1990	23	6,346	3.8	3.7	3.2	9

TABLE 4

Forecast of Farm Animals in New England, 1979-1990

Year	Milk Cows	All Chickens	Pig Crop	Sheep	Lamb Crop	Beef Cows	Broilers
				and Lambs			
----- (in 1,000) -----							
1979	366.3	21,026	121.7	38.7	31.2	42	87,816
1980	347.2	21,013	111.2	38.3	30.7	42	81,000
1981	330.8	21,043	102.9	37.9	30.3	43	35,810
1982	317.0	21,139	95.7	37.4	29.9	44	17,000
1983	304.7	21,249	89.1	37.0	29.5	45	17,000
1984	293.3	21,368	82.7	36.6	29.0	46	17,000
1985	282.3	21,529	76.5	36.1	28.6	47	17,000
1986	271.0	21,686	70.4	35.6	28.2	48	17,000
1987	259.4	21,839	64.3	35.2	27.7	49	17,000
1988	247.5	22,025	58.3	34.7	27.3	50	17,000
1989	235.5	22,200	52.2	34.2	26.9	52	17,000
1990	223.4	22,402	46.2	33.7	26.4	54	17,000

TABLE 5

Forecast of Egg Feed Ratio and Milk Feed Ratio, 1979-1990

Year	Egg Feed Ratio ^a	Milk Feed Ratio ^b
1979	6.7	1.59
1980	6.5	1.60
1981	6.4	1.62
1982	6.2	1.63
1983	6.0	1.64
1984	5.9	1.66
1985	5.7	1.67
1986	5.5	1.68
1987	5.4	1.69
1988	5.2	1.70
1989	5.1	1.71
1990	4.9	1.72

^a Number of pounds of poultry feed equivalent in value at local market prices to one dozen eggs.

^b Pounds of concentrate equal in value to one pound of whole milk sold by farmers to plants and dealers.

since 1970, and Massachusetts essentially ceased production in 1973. The last reported number of broilers in Connecticut was 1,083,000 in 1977. If these five states were not included and New England forecasts were based entirely upon Maine production, the result would be an increasing broiler production through 1990. If one believes that Maine broiler production may follow the same declining trend as the other New England states and forecasts were entirely based on the aggregate New England data, the results would be a declining broiler production as confirmed by the negative linear trend shown in Table 2.

Extraneous micro information regarding Maine broiler production should help make forecasts. Disaster hit the Maine broiler industry in 1980-81. By January 1, 1981, the Maplewood Plant had ceased operation. Since their output of approximately 14,000,000 birds was constantly being reduced during the year, full production for 1980 was 81 million broilers (88 million in 1979 minus 7 million).¹ This meant that the January 1, 1981 number of broilers was reduced to 74 million (88-14). By July 1, 1981 the Hillcrest, Lipman and Fort Halifax Plants were closed. These three firms combined accounted for about 57 million birds but were in full production for only four months, hence, produced 18,810,000 broilers. The Penobscot Plant output is about 17,000,000, plus the 18,810,000 results in a 1981 production of 35,810,000

¹ This and all following Maine estimates are based upon discussions with knowledgeable Maine individuals.

broilers (Table 4). All indications are that the Penobscot firm is economically sound and will continue at about the present level of output until 1990.

The results of the forecasts of New England broiler production based on the above three conceptions of the future are as follows:

Year	Forecasts Based on the Past Trend of Maine	Forecasts Based on the Past Trend of New England (000's)	Forecasts Based on Additional Micro Information
1979	87,816	86,715	87,816
1980	89,563	85,556	81,000
1981	91,284	84,342	35,810
1982	92,983	83,078	17,000
1983	94,659	81,764	17,000
1984	96,314	80,406	17,000
1985	97,948	79,007	17,000
1986	99,563	77,568	17,000
1987	101,160	76,092	17,000
1988	102,740	74,582	17,000
1989	104,303	73,040	17,000
1990	105,850	71,467	17,000

In deriving the feed requirement, the forecasts that incorporate information on the current status of Maine broiler industry are used.

Forecast of Feed

Given the future number of farm animals and feed rations, the feed requirement in Connecticut and New England can be calculated.

For milk cows, beef, sheep and lambs, and the lamb crop, a suggested dairy formula was obtained from Dairy Feeding Programs published by the New England College Conference, 1979.¹ The formula contains 20 percent protein and the ingredients include 37 percent hominy or corn, 15 percent wheat middlings, 10 percent distillers dried grain, 7 percent corn gluten feed or brewers dried grain, 20 percent soybean meal, 8 percent cane molasses, and 3 percent minerals and salt. On a per animal per year basis, a dairy cow is assumed to consume 5,160 pounds in 1979 and increase 40 pounds annually. Breeding stock sheep and lambs consume 100 pounds and fattening lambs 400 pounds per animal per year. For beef cattle, a steer (450 to 1,050 pounds) consumes 2,900 pounds a year, while the cow herd consumes only 200 pounds. It is assumed that one-third of beef cattle are steer and two-thirds are cow herds. On the average the beef herd consumes 1,100 pounds of feed.

Slaughter pigs require about 3.5 pounds of feed per pound of gain. Thus, it will require 595 pounds of feed per pig to gain 170 pounds. The feed ration

¹ "New England College Conference Dairy Feeding Programs," published by The University of Connecticut.

for pigs is made up of about 95 pounds of commercial supplement, primarily soybean meal, and 500 pounds of grain, with 400 pounds being corn and 100 pounds wheat middlings. A layer requires 110 pounds of feed (20 pounds for a pullet and 90 pounds for a layer) and a broiler requires 8.2 pounds of feed. The feed rations for chickens and broilers are the 1976 recommended Chicken and Turkey Rations prepared by the New England College Conference Board. The layer ration used in making the estimates contained 16 percent protein. It consists of 70 percent ground yellow corn, 17 percent soybean meal, plus ground limestone, miscellaneous minerals and vitamins. The broiler ration consists of approximately 62 percent ground yellow corn, 21 percent of soybean meal plus fish meal, meat and bone meal, yellow grease and miscellaneous ingredients.

Based on the formulas described above and the forecast of animal numbers, the feed required by the seven animal classes considered are calculated and shown in Table 6, Table 7, and Appendix Tables A4 through

TABLE 6
Forecast of Total Feed Required in
Connecticut and New England, 1979-1990

Year	Milk	All	Pig	Sheep	Lamb	Beef	Broilers	Total
	Cows	Chickens	Crop	and Lambs	Crop	Cows		
----- tons -----								
CONNECTICUT								
1979	126,420	322,905	3,810	255	760	4,950		459,100
1980	119,600	321,200	3,360	250	740	4,400		449,550
1981	112,660	321,255	3,035	240	740	4,400		442,330
1982	105,600	322,795	2,735	235	720	4,400		436,485
1983	98,420	325,050	2,500	230	720	4,400		431,320
1984	93,800	327,690	2,260	220	700	4,400		429,070
1985	89,100	330,935	2,055	215	700	4,400		427,405
1986	84,320	334,290	1,845	210	680	4,400		425,745
1987	79,460	337,700	1,665	200	680	4,950		424,655
1988	74,520	341,440	1,490	195	660	4,950		423,255
1989	69,500	345,125	1,310	195	660	4,950		421,735
1990	64,400	349,030	1,130	185	640	4,950		420,335
NEW ENGLAND								
1979	945,055	1,156,430	36,205	1,935	6,240	23,100	360,045	2,529,010
1980	902,720	1,155,715	33,080	1,915	6,140	23,100	332,100	2,454,770
1981	866,695	1,157,365	30,615	1,895	6,060	23,650	146,820	2,233,100
1982	836,880	1,162,950	28,470	1,870	5,980	24,200	69,700	2,130,050
1983	810,500	1,168,695	26,505	1,850	5,900	24,750	69,700	2,107,900
1984	786,045	1,175,240	24,605	1,830	5,800	25,300	69,700	2,088,520
1985	762,210	1,184,095	22,760	1,805	5,720	25,850	69,700	2,072,140
1986	737,120	1,192,730	20,945	1,780	5,640	26,400	69,700	2,040,815
1987	710,755	1,201,145	19,130	1,760	5,540	26,950	69,700	2,034,980
1988	683,100	1,211,375	17,345	1,735	5,460	27,500	69,700	2,016,215
1989	654,690	1,221,000	15,530	1,710	5,380	28,600	69,700	1,996,610
1990	625,520	1,232,110	13,745	1,685	5,280	29,700	69,700	1,977,740

A9. Table 6 shows tons of feed required for each animal class in Connecticut and New England from 1979 through 1990. The major feed ingredients are itemized in Table 7.

Table 6, shows that the total feed required for the seven animal classes in Connecticut is about 460 thousand tons in 1979. By 1990, the feed required will be about 420 thousand tons. Feed consumption in Connecticut is about 18 percent of New England consumption in 1979 and increases to 21 percent in 1990. The six feed ingredients in Table 7 accounted for 90 percent of the total feed required by Connecticut (Table 6) in 1979. This falls to approximately 88 percent in 1990 because of the rather large reduction in dairy cow numbers.

TABLE 7
Forecast of Major Feed Ingredients Required in
Connecticut and New England, 1979-1990

Year	Yellow	Wheat	Distillers	Corn	Soybean	Cane
	Corn	Middlings	Dried Grain	Gluten Feed	Meal	Molasses
----- tons -----						
CONNECTICUT						
1979	276,922	20,498	13,239	9,267	82,237	10,591
1980	272,713	19,314	12,499	8,760	80,396	9,999
1981	269,977	18,266	11,804	8,273	78,963	9,443
1982	268,250	17,103	11,096	7,766	77,761	8,819
1983	267,025	15,986	10,377	7,263	76,672	8,302
1984	267,002	15,248	9,912	6,938	76,154	7,930
1985	267,401	14,507	9,442	6,609	75,735	7,553
1986	267,841	13,752	8,961	6,273	75,314	7,169
1987	268,517	13,074	8,529	5,971	75,003	6,823
1988	269,187	12,299	8,033	5,623	74,621	6,427
1989	269,795	11,516	7,530	5,271	74,216	6,024
1990	270,521	10,717	7,018	4,913	73,830	5,614
NEW ENGLAND						
1979	1,413,813	152,534	97,633	81,845	474,174	78,106
1980	1,378,356	145,641	93,388	79,141	459,194	74,710
1981	1,250,364	139,890	89,831	76,917	413,058	71,865
1982	1,194,201	135,125	86,893	75,122	391,549	69,514
1983	1,187,379	130,823	84,245	73,526	386,972	67,396
1984	1,182,047	126,982	81,897	72,136	383,091	65,518
1985	1,178,399	123,164	79,559	70,751	379,631	63,647
1986	1,174,159	119,161	77,094	69,274	375,887	61,675
1987	1,169,290	114,966	74,501	67,704	371,848	59,600
1988	1,165,241	110,584	71,780	66,041	367,865	57,424
1989	1,160,674	106,168	69,038	64,364	363,740	55,230
1990	1,156,887	101,842	66,221	62,629	359,718	52,977

The dairy cow ration contains a larger percentage of ingredients not covered by the six ingredients than does the poultry ration. The reverse holds for New England where the percentage increases from 88 to 91 over the 12 year period.

Table 8 shows the total tons of feed manufactured by Connecticut mixers in 1979.

TABLE 8
Total Tons of Feed Manufactured and
Total Tons of Pellets, Mash and Corn, 1979

		Tons
Total Feed		584,500
Pellets	226,000	
Mash	358,500	
 Total Corn		 291,290
Corn in Pellets	85,920	
Corn in Mash	205,370	

A considerable amount of the tonnage shown in Table 8 goes to supply out-of-state producers in Rhode Island, and most of six counties in Massachusetts. In addition, some deliveries are made in Southern Vermont and Southern New Hampshire. Therefore, the difference between the 459,100 tons for 1979 (Table 6) and the 584,500 tons produced in Connecticut (Table 8) is a very accurate measure of the out-of-state shipments. From the standpoint of rail transportation, Connecticut's needs must be based on total manufactured feed and not upon Connecticut requirements. Hence, total requirements in Table 6 have been increased by 27.3 percent as well as total forecast requirements shown in Table 9. The forecasts are based on the assumption that out-of-state shipments will continue as a constant proportion of Connecticut requirements.

The rate of decline in total feed mixed in Connecticut slows considerably after 1983. This is due to the slowing in the rate of decline in dairy cow numbers and the continuing increase in chickens (layers).

The ingredient requirements for Connecticut, Table 7, are also increased by 27.3 percent to obtain total requirements for feed mixers shown in Table 10.

The six ingredients account for approximately 90 percent of the total feed requirements in 1979. The six actually account for 96.75 percent of the dairy ration and 87 percent of the layer ration, with 50 pounds of meat and bone meal and 153 pounds of ground limestone per ton not included in the latter ration. The percent of total feed requirements, accounted for by the six ingredients, falls to 88.4 percent in 1990 due to decreasing dairy cow numbers and increasing layer numbers.

TABLE 9

**Forecast of the Total Feed Produced by
Connecticut Mixers, 1979-1990**

Year	Total Feed Produced by Connecticut Mixers
	----- tons -----
1979	584,500
1980	572,000
1981	563,000
1982	556,000
1983	549,000
1984	546,000
1985	544,000
1986	542,000
1987	541,000
1988	539,000
1989	537,000
1990	535,000

TABLE 10

**Forecast of Major Feed Ingredients Required by
Connecticut Mixers to Meet Combined Connecticut
and Out-of-State Requirements, 1979-1990**

Year	Yellow	Wheat	Distillers	Corn	Soybean	Cane
	Corn	Middlings	Dried Grain	Gluten Feed	Meal	Molasses
1979	352,522	26,094	16,853	11,797	104,688	13,482
1980	347,164	24,587	15,911	11,151	102,344	12,729
1981	343,681	23,253	15,026	10,532	100,520	12,021
1982	341,482	21,772	14,125	9,886	98,990	11,227
1983	339,923	20,350	13,210	9,246	97,603	10,568
1984	339,894	19,411	12,618	8,832	96,944	10,095
1985	340,401	18,467	12,020	8,413	96,414	9,615
1986	340,962	17,506	11,407	7,986	95,875	9,126
1987	341,822	16,643	10,857	7,601	95,479	8,686
1988	342,675	15,657	10,226	7,158	94,993	8,182
1989	343,449	14,660	9,586	6,710	94,477	7,669
1990	344,373	13,643	8,934	6,254	92,713	7,147

Forecasts of Fertilizer

The tonnage of commercial fertilizer used in Connecticut has declined from 93,915 tons in 1950 to 59,966 tons in 1979. However, the total plant nutrient consumption has been quite stable. As a matter of fact, the total N-P-K nutrients increased slowly from 16,734 tons in 1947 to about 18,000 tons in 1979. The use of nitrogen has almost doubled from 4,467 tons in 1947 to about 7,600 tons in 1979. The peak use of nitrogen was 9,018 tons in 1973. Phosphate (P_2O_5) and potash (K_2O) consumption decreased during the 1970's after being quite stable prior to 1970. The percentage of nutrients to the total commercial fertilizers increased from a low of 19.9 in 1949 to 30 percent in 1979. The highest percentage was 31.9 in 1976. It indicates that low grade mixed fertilizers, such as 10-6-4, 5-10-5, 8-6-4, or 5-8-7 were often used during the early ears, while high grade mixed fertilizers, such as 10-10-10, 15-10-10, were used more often in recent years.

Based on the above trends and component structures, autoregressive regression equations are estimated using data from 1947 to 1979. The results are given in Table 11. Notice that the linear time trend coefficient for nitrogen is positive (56.1283) and the time trend coefficients for P_2O_5 and K_2O are negative. The geometric trends (or the coefficients of y_{t-1}) range from 0.44 to 0.61.

Given the initial observations in 1979, the future trends are recursively forecast, and the results are shown in Table 12. The average analysis shows that the percentage of the total plant nutrient to the total commercial fertilizers is 30 percent in 1979, and increases to 41.4 percent in 1990. Connecticut will consume 18,968 tons of plant nutrients in 1980 and 20,385 tons in 1990. Since the commercial fertilizers will be high grade mixed fertilizers, the tonnage will

TABLE 11

Forecast Equations for Commercial Fertilizers and Plant Nutrients, Connecticut, 1947-1979

y_t	Constant	y_{t-1}	t	R ²	F
Commercial Fertilizers	1,134,884	0.4395 (2.72)**	- 0.0006 (- 3.03)**	0.7315	39.51
Nitrogen	- 107,575.3	0.6091 (3.77)**	56.1283 (1.99)*	0.8619	90.50
P_2O_5	72,137.02	0.5249 (3.37)**	- 35.0953 (- 2.45)**	0.6014	21.87
K_2O	51,735.64	0.5088 (3.45)**	- 24.7380 (- 2.06)*	0.4180	10.41

* 5 percent level of significance

** 1 percent level of significance

TABLE 12

**Forecast of Commercial Fertilizers and Total Plant
Nutrients in Connecticut, 1979-1990**

Year	Commercial Fertilizers	Plant Nutrients				Average Analysis (%)
		N	P ₂ O ₅	K ₂ O	Total	
		----- tons -----				
1979	59,966	7,600	5,300	5,100	18,000	30.0
1980	59,077	8,188	5,430	5,350	18,968	32.1
1981	58,130	8,603	5,464	5,452	19,519	33.6
1982	57,157	8,911	5,446	5,479	19,836	34.7
1983	56,173	9,155	5,402	5,468	20,025	35.6
1984	55,184	9,360	5,343	5,438	20,141	36.5
1985	54,193	9,541	5,278	5,398	20,217	37.3
1986	53,200	9,707	5,208	5,353	20,268	38.1
1987	52,207	9,865	5,136	5,305	20,306	38.9
1988	51,215	10,017	5,064	5,256	20,337	39.7
1989	50,222	10,166	4,991	5,206	20,363	40.5
1990	49,228	10,312	4,917	5,156	20,385	41.4

decrease from 59,077 in 1980 to 49,228 tons in 1990. The decrease in gross weight of commercial fertilizers will save transportation costs.

The above forecasts are based on the existing time trends. Other factors such as harvested crop acreage and pounds of fertilizer per acre harvested are also observed. They do not consistently explain the use of fertilizers because the use of lawn fertilizers cannot be estimated. Although the harvested crop acreage declined from 222 thousand acres in 1965 to only 143 thousand acres in 1978, the area of newly developed residential lawn, which also needs fertilizers, is increasing.

An analysis of average plant nutrients shows a moderate increase in the use of high grade mixed fertilizers (41.4 percent in 1990). As a reference, the farm in Iowa used 55.5 percent ingredient mixture in 1978, while Illinois farmers used 53 percent.

Summary and Conclusions

The number of farm animals in Connecticut and New England is forecast to 1990. In a previous study by the authors (1980) reduced form equations were utilized in which the number of farm animals was expressed as a function of a number of predetermined variables. A simplified model which yielded good results hypothesized the reduce form supply equations as functions of

lagged own price, lagged corn price and lagged own quantity. The results reported in this study are based on a revision of the former models and utilize the autoregressive type function in addition to linear trend in arriving at an unconditional forecast. The forecast equations for both Connecticut and New England yielded very satisfactory results. The lagged values y_{t-1} were all significant at the one percent level for all classes of livestock for Connecticut and New England (Table 1 and 2). For milk cows in Connecticut and New England the two year lagged values were significant at the one percent level, but for beef cows, neither the one or two year lag was significant. The R^2 's are all above .87 except for the Connecticut lamb crop and all chickens for New England.

The forecast equation for milk cows utilized a milk-feed price ratio and for all chickens an egg feed price ratio. Neither of these proved significant in forecasting milk cows and layers. With the exception of chickens and beef cows all classes of livestock are forecast as continuing to decline in Connecticut. Layers are forecast to increase from 5,840,000 in 1980 to 6,346,000 in 1990. Beef cows stay constant at about the 1979 level.

New England follows the same trend as Connecticut with beef cows increasing at the rate of about 1,000 per year and layers increasing slightly. Milk cows are forecast to decrease 12 to 13 thousand per year. Because of the almost complete demise of the broiler industry in Maine, a drastic reduction occurs. From almost 90 million broilers in 1979, it is estimated that output will decline to 17 million and remain at that level until 1990.

Applying standard rations to the livestock numbers forecasts of feed requirements are made to 1990. Connecticut requirements are reduced from 459,000 tons in 1979 to 420,000 tons in 1990. New England requirements are substantially reduced from 2,529,000 tons in 1979 to 1,978,000 in 1990 due to the large decrease in broilers and a 40 percent fall in milk cow numbers. Feed requirements are estimated for six ingredients, namely, yellow corn, wheat middlings, distillers dried grain, corn gluten feed, soybean meal and cane molasses.

Finally, total fertilizer and ingredient requirements for Connecticut are forecast to 1990. Autoregressive regression equations are estimated using annual data from 1947 to 1979 (Table 11). The values for y_{t-1} (geometric trends) are all significant at the one percent level. The linear time trend coefficient for nitrogen is positive while those for phosphorus and potash are negative.

Given the initial observations in 1979, the future trends, for total and ingredient requirements, are recursively forecast. Total fertilizer requirements fall about 1,000 tons per year. Plant nutrient utilization, however, does not fall. Nitrogen is estimated to increase about 35 percent by 1990, P_2O_5 will fall slightly while K_2O remains constant. Actually, total plant nutrients increase from 18,000 tons in 1979 to 20,385 tons in 1990. The increase in plant nutrients, while tons of commercial fertilizer falls, is due to the increasing use of higher nutrient fertilizers. The 10-6-4 and 5-10-5 commercial fertilizers are being replaced with 10-10-10 and higher nutrient content fertilizers.

APPENDIX

TABLE A1
Connecticut Livestock Data, 1942-1979

Year	No. of Milk Cows on Farms (100)	Pig Crop (100)	All Sheep and Lambs (100)	Lamb Crop (100)	All Chickens on Farms (1,000)	Broilers (1,000)	Beef Cows (1,000)	Egg Feed Price Ratio ^a	Milk Feed Price Ratio ^a
1942	1,170	—	—	—	—	—	1	14.2	1.32
1943	1,180	—	—	—	—	—	1	14.5	1.35
1944	1,190	460	70	40	3,933	7,500	1	11.5	1.38
1945	1,160	600	60	40	3,696	10,350	1	13.4	1.42
1946	1,150	520	60	30	3,953	8,176	1	11.3	1.38
1947	1,140	440	60	40	3,444	7,767	1	11.1	1.18
1948	1,080	490	60	40	3,577	9,243	1	11.4	1.26
1949	1,080	460	70	50	3,435	11,461	1	13.2	1.29
1950	1,080	440	70	40	3,966	13,982	1	10.3	1.25
1951	1,070	420	70	50	3,801	17,198	1	12.0	1.29
1952	1,070	420	80	50	3,946	21,154	1	10.0	1.28
1953	1,080	320	90	60	4,075	23,904	2	12.3	1.25
1954	1,090	320	90	60	4,009	25,099	2	9.4	1.20
1955	1,090	330	90	60	3,840	25,852	2	10.8	1.28
1956	1,070	290	90	60	3,956	30,505	2	10.9	1.36
1957	1,000	260	90	60	3,927	28,370	2	10.9	1.39
1958	940	270	80	60	3,731	30,356	2	11.3	1.41
1959	900	260	70	50	3,890	26,713	2	9.2	1.43
1960	880	250	70	50	3,693	22,184	2	10.9	1.45
1961	850	220	72	50	3,867	19,966	3	10.6	1.45
1962	820	210	73	50	4,225	13,976	3	9.9	1.40
1963	780	200	73	50	4,476	12,299	3	8.1	1.36
1964	750	190	64	50	4,824	12,299	3	8.1	1.38
1965	730	170	54	36	4,853	11,806	3	8.1	1.40
1966	700	167	45	33	4,897	10,271	4	9.1	1.53
1967	690	159	49	35	4,945	9,038	4	7.3	1.56
1968	670	135	52	38	4,844	8,134	4	8.5	1.69
1969	660	124	55	40	4,619	6,657	4	10.0	1.74
1970	610	127	51	38	4,628	6,254	4	9.3	1.74
1971	580	123	48	35	5,230	4,539	5	7.2	1.70
1972	580	113	48	37	5,230	3,329	6	7.2	1.72
1973	570	104	48	37	5,012	2,730	6	7.9	1.46
1974	530	106	51	40	4,675	1,836	7	7.0	1.34
1975	540	98	55	42	4,830	1,039	7	7.0	1.40
1976	530	120	50	44	5,390	1,041	7	7.8	1.53
1977	520	143	51	44	5,280	1,083	7	7.3	1.57
1978	500	145	51	39	5,940	0	9	6.9	1.75
1979	490		51	38	5,871	0	9	(6.7)	(1.59)

^a Number of pounds of poultry ration equal in value to one dozen eggs.

^b Pounds of concentrate ration equal in value to one pound of whole milk.

TABLE A2

New England Data, 1942-1979

Year	Milk Cows (100)	Pig Crop (100)	All Sheep and Lambs (100)	Lamb Crop (100)	All Chickens on Farms (1,000)	Broilers (1,000)	Beef Cows (1,000)	Maine Broilers
1942	7,320						10	
1943	7,380						10	
1944	7,560	3,900	900	520	18,342	16,200	12	1,210
1945	7,450	3,510	770	510	16,707	22,878	13	1,452
1946	7,300	3,100	690	440	17,980	17,590	12	871
1947	7,190	2,990	630	390	15,021	18,959	12	2,299
1948	6,930	2,990	590	370	15,109	27,051	12	6,506
1949	6,850	2,940	540	360	15,280	38,034	11	13,012
1950	6,740	2,680	530	350	17,689	48,107	11	16,916
1951	6,570	2,950	540	360	16,509	59,008	11	21,145
1952	6,730	3,040	620	400	17,073	66,684	12	23,048
1953	6,980	2,790	690	460	16,347	76,612	17	27,888
1954	7,020	2,720	730	500	16,745	82,088	17	30,677
1955	7,000	2,780	780	540	16,183	86,329	18	33,438
1956	6,870	2,510	800	570	16,375	103,300	20	43,469
1957	6,530	2,520	800	520	16,539	103,189	19	50,424
1958	6,220	2,600	780	540	16,217	111,354	18	56,475
1959	6,040	2,520	760	550	16,361	105,072	18	58,169
1960	6,000	2,450	770	550	15,417	93,471	19	54,148
1961	5,972	2,260	762	500	15,621	94,105	20	58,480
1962	5,835	2,170	744	520	16,135	90,343	20	61,989
1963	5,619	2,080	735	480	16,508	89,732	20	63,849
1964	5,411	1,830	649	470	17,150	90,623	20	67,680
1965	5,195	1,699	559	391	17,134	89,394	20	68,357
1966	4,906	1,769	500	355	17,389	91,366	24	72,458
1967	4,738	1,778	486	349	17,958	91,434	24	73,907
1968	4,611	1,670	477	344	17,500	88,026	24	72,429
1969	4,519	1,611	469	330	18,209	84,415	25	72,900
1970	4,434	1,604	437	316	17,955	84,039	26	76,068
1971	4,389	1,614	418	300	18,564	77,278	31	72,014
1972	4,092	1,398	396	294	19,636	74,873	32	71,344
1973	3,989	1,380	383	287	19,917	78,372	45	75,642
1974	3,999	1,360	400	306	20,040	79,262	48	77,426
1975	3,989	1,335	396	306	20,481	82,074	47	81,035
1976	3,965	1,323	393	300	20,461	87,700	49	86,659
1977	3,880	1,374	388	313	19,680	88,021	46	86,938
1978	3,787	1,366	408	316	21,393	87,895	46	87,895
1979			387		21,026	87,816	42	87,816

TABLE A3

Connecticut Fertilizer Data, 1947-1979

Year	Commercial Fertilizer	Plant Nutrient Contents		
		N	P ₂ O ₂	K ₂ O
		----- tons -----		
1947	82,412	4,467	7,019	5,248
1948	78,568	4,093	6,632	5,255
1949	89,113	4,584	7,290	5,866
1950	93,915	4,502	8,017	6,524
1951	88,953	4,633	7,221	6,846
1952	87,234	4,575	7,239	6,926
1953	87,668	4,775	6,977	7,225
1954	90,236	5,110	7,394	7,552
1955	88,481	5,176	7,279	7,395
1956	76,684	4,542	7,202	6,393
1957	84,353	5,295	8,049	7,140
1958	76,947	5,343	7,431	6,864
1959	78,882	5,960	7,606	7,139
1960	72,017	5,835	7,358	6,660
1961	70,030	5,642	6,562	6,044
1962	72,961	5,888	7,259	6,447
1963	72,815	6,646	7,713	6,754
1964	73,364	6,769	7,932	6,925
1965	83,691	7,961	7,559	6,800
1966	88,220	8,583	6,940	7,545
1967	84,261	9,096	7,981	7,068
1968	71,721	8,059	6,561	6,175
1969	73,935	8,035	6,876	6,783
1970	57,179	6,492	5,539	5,646
1971	60,036	7,372	5,398	5,625
1972	61,385	7,766	5,828	5,829
1973	69,582	9,018	6,703	6,821
1974	70,470	8,583	5,528	7,278
1975	57,454	7,698	5,237	5,351
1976	66,461	8,319	6,552	6,338
1977	63,586	8,924	5,809	4,776
1978	59,963	7,780	5,311	5,134
1979	59,966	7,600	5,300	5,100

TABLE A4

Forecast of Corn Required in Connecticut
and New England, 1979-1990

Year	Tons							Total
	Milk Cows	All Chickens	Pig Crop	Sheep and Lambs	Lamb Crop	Beef Cows	Broilers	
Connecticut								
1979	46,459	225,711	2,560	94	279	1,819		276,922
1980	43,953	224,519	2,260	92	272	1,617		272,713
1981	41,403	224,557	2,040	88	272	1,617		269,977
1982	38,808	225,634	1,840	86	265	1,617		268,250
1983	36,169	227,210	1,680	85	265	1,617		267,025
1984	34,472	229,055	1,520	81	257	1,617		267,002
1985	32,744	231,324	1,380	79	257	1,617		267,401
1986	30,988	233,669	1,240	77	250	1,617		267,841
1987	29,202	236,052	1,120	74	250	1,819		268,517
1988	27,386	238,667	1,000	72	243	1,819		269,187
1989	25,541	241,242	880	70	243	1,819		269,795
1990	23,667	243,972	760	68	235	1,819		270,521
New England								
1979	347,307	808,345	24,340	711	2,293	8,489	222,328	1,413,813
1980	331,750	807,845	22,240	704	2,256	8,489	205,072	1,378,356
1981	318,511	808,998	20,580	696	2,227	8,691	90,661	1,250,364
1982	307,553	812,689	19,140	687	2,198	8,894	43,040	1,194,201
1983	297,859	816,918	17,320	680	2,168	8,894	43,040	1,187,379
1984	288,871	821,493	16,540	673	2,132	9,298	43,040	1,182,047
1985	280,112	827,682	15,300	663	2,102	9,500	43,040	1,178,399
1986	270,892	833,718	14,080	654	2,073	9,702	43,040	1,174,159
1987	261,203	839,600	12,860	647	2,036	9,904	43,040	1,169,290
1988	251,039	846,751	11,660	638	2,007	10,106	43,040	1,165,241
1989	240,599	853,479	10,440	628	1,977	10,511	43,040	1,160,674
1990	229,879	861,245	9,240	628	1,940	10,915	43,040	1,156,887

TABLE A5

**Forecast of Wheat Middlings Required in
Connecticut and New England, 1979-1990**

Year	Milk Cows	Pig Crop	Tons			Total
			Sheep and Lambs	Lamb Crop	Beef Cows	
Connecticut						
1979	18,963	640	38	114	743	20,498
1980	17,940	565	38	111	660	19,314
1981	16,899	510	36	111	660	18,266
1982	15,840	460	35	108	660	17,103
1983	14,763	420	35	108	660	15,986
1984	14,070	380	33	105	660	15,248
1985	13,365	345	32	105	660	14,507
1986	12,648	310	32	102	660	13,752
1987	11,919	280	30	102	743	13,074
1988	11,178	250	29	99	743	12,299
1989	10,425	220	29	99	743	11,516
1990	9,660	190	28	96	743	10,717
New England						
1979	141,758	6,085	290	936	3,465	152,534
1980	135,408	5,560	287	921	3,465	145,641
1981	130,004	5,145	284	909	3,548	139,890
1982	125,532	4,785	281	897	3,630	135,125
1983	121,575	4,455	278	885	3,630	130,823
1984	117,907	4,135	275	870	3,795	126,982
1985	114,332	3,825	271	858	3,878	123,164
1986	110,568	3,520	267	846	3,960	119,161
1987	106,613	3,215	264	831	4,043	114,966
1988	102,465	2,915	260	819	4,125	110,584
1989	98,204	2,610	257	807	4,290	106,168
1990	93,828	2,310	257	992	4,455	101,842

TABLE A6

**Forecast of Distillers Dried Grain Required in
Connecticut and New England, 1979-1990**

Year	Tons				Total
	Milk Cows	Sheep and Lambs	Lamb Crop	Beef Cows	
Connecticut					
1979	12,642	26	76	495	13,239
1980	11,960	25	74	440	12,499
1981	11,266	24	74	440	11,804
1982	10,560	24	72	440	11,096
1983	9,842	23	72	440	10,377
1984	9,380	22	70	440	9,912
1985	8,910	22	70	440	9,442
1986	8,432	21	68	440	8,961
1987	7,946	20	68	495	8,529
1988	7,452	20	66	495	8,033
1989	6,950	19	66	495	7,530
1990	6,440	19	64	495	7,018
New England					
1979	94,505	194	624	2,310	97,633
1980	90,272	192	614	2,310	93,388
1981	86,670	190	606	2,365	89,831
1982	83,688	187	598	2,420	86,893
1983	81,050	185	590	2,420	84,245
1984	78,604	183	580	2,530	81,897
1985	76,221	181	572	2,585	79,559
1986	73,712	178	564	2,640	77,094
1987	71,076	176	554	2,695	74,501
1988	68,310	174	546	2,750	71,780
1989	65,469	171	538	2,860	69,038
1990	62,552	171	528	2,970	66,221

TABLE A7

**Forecast of Corn Gluten Feed or Brewers Dried Grain
Required in Connecticut and New England, 1979-1990**

Year	Tons					Total
	Milk Cows	Sheep and Lambs	Lamb Crop	Beef Cows	Broilers	
Connecticut						
1979	8,849	18	53	347		9,267
1980	8,372	18	62	308		8,760
1981	7,886	17	62	308		8,273
1982	7,392	16	50	308		7,766
1983	6,889	16	50	308		7,263
1984	6,566	15	49	308		6,938
1985	6,237	15	49	308		6,609
1986	5,902	15	48	308		6,273
1987	5,562	14	48	347		5,971
1988	5,216	14	46	347		5,623
1989	4,865	13	46	347		5,271
1990	4,508	13	45	347		4,913
New England						
1979	66,154	135	437	1,617	13,502	81,845
1980	63,190	134	430	1,617	13,770	79,141
1981	60,669	133	424	1,656	14,035	76,917
1982	58,582	131	419	1,694	14,296	75,122
1983	56,735	130	413	1,694	14,554	73,526
1984	55,023	128	406	1,771	14,808	72,136
1985	53,355	126	400	1,810	15,060	70,751
1986	51,598	125	395	1,848	15,308	69,274
1987	49,753	123	388	1,887	15,553	67,704
1988	47,817	121	382	1,925	15,796	66,041
1989	45,828	120	377	2,002	16,037	64,364
1990	43,786	120	370	2,079	16,274	62,629

TABLE A8

**Forecast of Soybean Meal Required in Connecticut
and New England, 1979-1990**

Year	Tons							Total
	Milk Cows	All Chickens	Pig Crop	Sheep and Lambs	Lamb Crop	Beef Cows	Broilers	
Connecticut								
1979	25,284	55,152	608	51	152	990		82,237
1980	23,920	54,861	537	50	148	880		80,396
1981	22,532	54,870	485	48	148	880		78,963
1982	21,120	55,133	437	47	144	880		77,761
1983	19,684	55,519	399	46	144	880		76,672
1984	18,760	55,969	361	44	140	880		76,154
1985	17,820	56,524	328	43	140	880		75,735
1986	16,864	57,097	295	42	136	880		75,314
1987	15,892	57,679	266	40	136	990		75,003
1988	14,904	58,318	238	39	132	990		74,621
1989	13,900	58,947	209	38	132	990		74,216
1990	12,880	59,614	181	37	128	990		73,830
New England								
1979	189,011	197,518	5,781	387	1,248	4,620	75,609	474,174
1980	180,544	197,396	5,282	383	1,228	4,620	69,741	459,194
1981	173,339	197,678	4,888	379	1,212	4,730	30,832	413,058
1982	167,376	198,580	4,546	374	1,196	4,840	14,637	391,549
1983	162,100	199,613	4,232	370	1,180	4,840	14,637	386,972
1984	157,209	200,731	3,928	366	1,160	5,060	14,637	383,091
1985	152,442	202,243	3,634	361	1,144	5,170	14,637	379,631
1986	147,424	203,718	3,344	356	1,128	5,280	14,637	375,887
1987	142,151	205,156	3,054	352	1,108	5,390	14,637	371,848
1988	136,620	206,903	2,769	347	1,092	5,500	14,637	367,865
1989	130,938	208,547	2,480	342	1,076	5,720	14,637	363,740
1990	125,104	210,444	2,195	342	1,056	5,940	14,637	359,718

TABLE A9

Forecast of Cane Molasses Required in Connecticut
and New England, 1979-1990

Year	Tons				
	Milk Cows	Sheep and Lambs	Lamb Crop	Beef Cows	Total
Connecticut					
1979	10,114	20	61	396	10,591
1980	9,568	20	59	352	9,999
1981	9,013	19	59	352	9,443
1982	8,448	19	58	352	8,819
1983	7,874	18	58	352	8,302
1984	7,504	18	56	352	7,930
1985	7,128	17	56	352	7,553
1986	6,746	17	54	352	7,169
1987	6,357	16	54	396	6,823
1988	5,962	16	53	396	6,427
1989	5,560	15	53	396	6,024
1990	5,152	15	51	396	5,614
New England					
1979	75,604	155	499	1,848	78,106
1980	72,218	153	491	1,848	74,710
1981	69,336	152	485	1,892	71,865
1982	66,950	150	478	1,936	69,514
1983	64,840	148	472	1,936	67,396
1984	62,884	146	464	2,024	65,518
1985	60,977	144	458	2,068	63,647
1986	58,970	142	451	2,112	61,675
1987	56,860	141	443	2,156	59,600
1988	54,648	139	437	2,200	57,424
1989	52,375	137	430	2,288	55,230
1990	50,042	137	422	2,376	52,977

Most of the raw data included in the appendix tables were obtained from **Agricultural Statistics**. This source was supplemented by other U.S.D.A. publications concerned specifically with dairy, meat animals and poultry and eggs.