Reciprocal Relationship of Soil, Plant and Animal

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What is soil? Soil is basically fragmented rock ground down by the action of streams, by erosion from rain, by wind, by the mechanical breakdown from animal life, by the chemical action of growing elements within it, by the expansion and contraction of freezing and thawing, by the action of energy from the sun, by the trituration of rock by glaciers, by growing vegetation, by the action of bacteria and molds, by the acids and bases that are created by growing organisms, by the minute root systems that help to break it down, such as the microrhizomes that find their way into the smallest crevices of rocks to cleave them by the force of growing and dissolve the exposed surfaces by the chemical elements which they contain.

Good soil is teeming with fungi, bacteria, protozoa, earth worms, beetles, crustacea and larvae of insects, as well as reptiles, and even small animals. The root systems of our crops and their productivity are actually altered as the population within the soil changes. Man alters these by the addition of organic and inorganic elements, by governing the moisture, varying the temperature, and controlling radiant energy.

What does man remove from the soil? Man removes plants and animals and their products. He removes much of the plants, the animals and the excrements without returning them. These are considered of organic nature. Of what do they consist? Primarily they are proteins, fats, carbohydrates, minerals, and water. Plants and animals are produced from a living soil. Their return to the soil constitutes the completion of the ecological cycle. They are basically made from inorganic rock, the water of the ocean, the gas of the air, and the energy of the sun.

Some students of ecology argue that only the proper combination of the mineral elements needs concern us for water is obtainable, air is all about us, and radiant energy can even be produced artificially. Others hold staunchly to the theory that it is the return of organic elements to the soil that is all important to the production of the most beneficial crops for man's use. They further believe that true plant and animal health comes only with a large return to the soil of the organic wastes, manure, garbage, carcasses of animals, and the plants themselves that have been broken down into humus by the action of bacteria, molds, and the earthworm.

Though hydroponic solutions of water, inorganic elements, air and radiant energy, produce plants, they ask, "What is the effect of consuming such plants as food on the optimum development of animal life, not only for the present, but for the generations of future animals?"

There are those who feel that there is the middle ground where soil not only needs the mineral element, but that activators from organic material returned to the soil enhance plant growth, either through making the mineral elements more readily available or also by actually being incorporated into the new plants. They recognize that the leaf is a great chemical factory for transforming water, mineral, organic materials from the soil, gasses from the air, and radiant energy from the sun into the nutrients for growth and reproduction of root, stem, flower, leaf, and seed.

Modern man measures the value of his soil by the bushels per acre, and, with the exception of those technically interested, pays little attention to the composition of the crop. To him a bushel of corn is a bushel of corn, and should give him feed for his children or his animals in the light of its quantity. To the ecologist the fact that X-bushels of corn equal Y-pounds of pork on the farm, or Z-rabbits in his laboratory is not sufficient. To him the question is "Was there a difference in X-bushels of corn from soil A, B, C, D, and E?" "Was there a difference in the ear as to size, to shape, to natural resistance to pest," and many other questions. If there were differences, why did soil A differ from B and C? Can his chemists detect the differences? If not, how can he explain? Through painstaking experiment, long after the original crop from these soils had been forgotten except as statistics, his experiments may produce some of the answers. But in the meantime, the rats in the granary have long since disclosed that they had a preference for one of the lots of corn over the others. Such an observation would frequently go unnoticed except by the curious such as the care-taker who was piqued by the spoiled photographic films in Roentgen's Laboratory, and an alert scientist. But why did the rats prefer one corn over the other? Will corn A produce a strain of animals that differ from the animals raised on corn B? The question has to be answered in the mind of the ecologist. So he chooses the rabbit and conducts a "controlled experiment." (Table 1). First he grows Korean Lespedeza on the five soil types: the Eldon Sandy loam, the Putnam silt loam, Clarksville gravelly loam, Grundy silt loam, and the Lintonia fine sandy loam. In each instance he uses both fields treated with lime and phosphorus and untreated fields. First, he studies the character of the hays. He describes the hays from the treated and untreated plots. He describes the rabbits, how they looked, how much they gained in weight, how much hay they had to eat to gain a gram, how much hay he obtained from an acre of soil and how many pounds of rabbits he could produce on each soil. He found a rather close correlation between rabbit gain, hay yield, and pounds of rabbits per acre. However, his curiosity did not stop there.

He wishes to know something about what the hays did to the physiology of the animal as well as to their weight. I am sure he would like to know about the offspring of these animals and their physical efficiency in other respects, but he has to satisfy his curiosity by looking at their bones. (Table 2). These he prepares, weighs and measures as to length and diameter, thickness of cortex, their

TABLE 1-RATES AND EFFICIENCIES OF ANIMAL GAINS AND YIELDS AS HAY AND AS ANIMAL GAINS PER ACRE ON DIFFERENT SOIL TYPES WITHOUT AND WITH SOIL TREATMENTS.

Soil Type	Rabbit Gains, Grams		Hay Consumed per Gram of Gain*		Yields of Hay, Lbs. per Acre		Yields as Lbs. of Gain per Acre*	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
Putnam	315.7	419.9	13.23	9.41	2,180	3.800	116	254
Clarksville	419.0	616.6	7.85	5.49	520	2,020	39	233
Eldon	504.7	674.8	6.79	5.88	2,500	4,500	241	471
Lintonia	561.4	741.9	6.95	5.06	2,250	2,800	180	316
Grundy	637.1	593.9	7.43	6.47	2.400	3,760	180	303
Average	487.6	609.4	8.45	6.46	1,970	3.376	151	315
Range of difference, %	101.8	79.1	94.9	86.0	380.8	122.7	507.7	101.2

*Assuming all gains from the hay.

(From paper Biological Assays of Some Soil Types Under Treatments, Soil Science Soc. of Am., Vol. 8, 1944; McLean, Eugene O.; Smith, G.E.; and Albrecht, Wm.A.)

TABLE 2-PROPERTIES OF THE BONES OF RABBITS FED ON HAYS FROM DIFFERENT SOIL TYPES WITHOUT AND WITH SOIL TREATMENTS.

Soil Type	Weight gm.	Length, cm.	Diameter, cm.	Thickness, mm	Breaking Strength, lbs.	Volume cc	Specific Gravity	Retained From Feed in Grams per Pen of Animals		
								P	Ca	Ca/P
Without Soil Treatments										
Eldon	2.26	6.88	0.520	0.70	22.8	3.11	0.71	25	163	6.4
Putnam	2.02	6.77	0.525	0.59	18.9	2.65	0.76	36	171	4.6
Clarksville	2.09	6.77	0.520	0.58	22.1	3.03	0.69	20	165	6.3
Grundy	3.07	7.24	0.570	0.84	30.0*	3.94	0.77	58	225	3.8
Lintonia	2.59	6.95	0.530	0.73	27.6	3.31	0.78	43	22.7	5.2
Average	2.40	6.92	0.533	0.69	24.3	3.21	0.74	36	190	5.3
Maximum difference,%	52.0	6.9	9.6	44.8	58.7	48.7	13.6	189	39	66.6
With Soil Treatments										
Eldon	2.96	7.20	0.560	0.72	25.2	3.48	0.85	44	261	5.8
Putnam	2.35	6.88	0.540	0.77	26.4	3.21	0.72	34	179	5.2
Clarksville	2.63	6.93	0.548	0.71	24.2	3.29	0.79	37	165	4.3
Grundy	2.85	7.20	0.530	0.95	30.0*	3.63	0.78	60	201	3.3
Lintonia	3.26	7.33	0.565	0.82	30.0*	3.79	0.86	79	379	4.7
Average	2.81	7.11	0.549	0.79	27.2	3.48	0.80	51	237	4.7
Maximum difference, %	38.7	6.5	6.6	33.8	19.1	18.1	18.4	131	129	74.0

*In these cases the bones withstood the limit of pressure possible on the testing machine.

(From Biological Assays of Some Soil Types Under Treatments. Soil Science Soc. of Am., Vol. 8, 1944; McLean, Eugene O.; Smith, G.E.; and Albrecht, Wm.A.)

volume and how heavy they are when weighed in water. Then he breaks them and measures how much force they require to fracture. Here he finds that the soil treatment improves all bones in strength and they approach closer a 3 to 1 calcium-phosphorus ratio.

So it is that our friend, W. A. Albrecht, studies soils. He wants to know *what kind of animals and men it will produce, not just how many tons and bushels per acre.*

In our own laboratory, while Dr. Albrecht was working on soils, we found by accident that in the cooking of meat and milk unidentified heat labile factors were altered. Without this unidentified fraction in the dietary of cats, imperfect health in the older animal and imperfect development in the kitten ensue. We also found by accident that the excrement of animals on such diets does not promote normal plant growth. Furthermore, we found that adult cats can exist on a total cooked food diet for a maximum of one year seven months, most dying in less than a year. However, they pass deficiency on to their kittens even though they are returned to the normal uncooked diet, and that it takes four generations of animals to restore the strain on normal dietary.

The diets used were basically carcass meat, including muscle and viscera, especially brain, liver, and intestines, some skin and glands, milk and cod liver oil. In all experiments the control animals were fed raw meat from all parts of the animal and milk unheated, plus cod liver oil. In the meat experiments where cooked meat was studied, raw milk was used. Several grades of raw milk were investigated including commercial raw milk from cattle receiving only dry feeds as well as raw milk from cattle on green pasture or green cut feeds, pasteurized, evaporated and sweetened condensed milk. In the milk studies the animals were given ⅓ of the diet as raw carcass meat and ⅔ of the milk under study.

Our first purpose was to standardize experimental adrenal extracts on the totally adrenalectomized animal. In so doing we unexpectedly began to find out what heat treatment of meat did to adrenalectomized cats. The original observations were that animals fed cooked meat did not stand adrenalectomy well. Adrenalectomy was reported by others to affect mineral metabolism. We therefore studied the calcium and phosphorus of the femurs of 18 adult cats who died in the pens. Two raw meat fed cats had had no operative procedures, dying from disease. Four cats fed cooked meat and two fed raw meat had had one adrenal removed and two fed cooked meat and eight fed raw meat had had both adrenals removed. In the cooked meat fed group, the calcium range was from 11.8% to 14.8%, and the phosphorus from 5.9% to 6.8%. In the raw meat fed animals the range of calcium was 11.5% to 18.6%, while the phosphorus varied from 5.1% to 8.3%.*(2)

*Method of preparation of bones. Calcium and phosphorus were determined on whole bone. Upon death of the animal, the femurs were removed and placed in an ice chest at -25° C. for 24 hours. At the end of this time, all fat and muscular tissue could easily be peeled off the bones. Organic matter was destroyed by oxidation with nitric and perchloric acids.(3) Calcium was determined by titration with permanganate, a modification of the method used for serum calcium being used.(4) Phosphorus determinations were carried out by a modification of the method of Fiske and Subbarow.(5) The amounts of calcium and phosphorus found are expressed in terms of percent of the whole femur.

Two cats, acting as controls, died of other causes than surgery. The trend of calcium and phosphorus was higher in the raw meat fed cat than the cooked meat fed animals.

We had previously noted many differences in the appearance of the raw and cooked meat fed cats. This showed especially in their fur, which, in the raw meat cat, was sleek with a good sheen. These animals had a good disposition and were active. They reproduced normally and their viscera had good tone. In contrast, the cooked meat fed animals were riddled with fleas, sickly, lacked energy, reproduced poorly and passed their deficiencies on to the next generation, regardless of whether they had been replaced on a good diet before breeding.

There were marked differences in the mouths of the animals. Cats raised to adulthood on a normal dietary, when put on a cooked meat diet, developed gingivitis, pyorrhoea, loss of teeth, and their kittens showed poor skull development resulting in crooked teeth.

In Table 3, 18 adult cats comparable as to size and background and general development were studied. Of 12 raw meat fed and 6 cooked meat fed animals,

TABLE 3-CALCIUM AND PHOSPHORUS CONTENT OF FEMURS OF ADULT CATS

Cat Number	Normal or Deficient	Sex	Weight of Cat Grams	Weight of Femur Grams	Weight of Femur Body Weight Per cent	Calcium in Femur Per cent	Phosphorus in Femur Per cent
1	N	M	2947	11.44	0.39	11.22	5.26
2	N	F	1503	9.37	0.62	11.60	5.17
3	D	F	1531	5.14	0.33	11.74	5.86
4	D	F	2370	10.47	0.44	11.80	5.55
5	D	F	1490	6.51	0.43	12.99	6.38
6	N	M	2745	12.40	0.45	13.25	6.39
7	D	M	3120	15.40	0.49	13.36	6.73
8	N	M	1025	3.78	0.36	13.70	6.94
9	D	F	----	10.78	---	14.00	6.35
10	N	F	3300	12.29	0.37	14.30	6.66
11	D	F	2754	8.24	0.30	14.70	6.70
12	N	M	----	11.26	---	15.49	7.31
13	N	M	2390	7.80	0.26	15.67	8.15
14	N	F	1950	6.86	0.35	16.08	7.50
15	N	F	2295	9.58	0.42	16.40	7.92
16	N	F	1285	6.16	0.48	16.72	8.00
17	N	F	2650	8.39	0.31	17.02	8.14
18	N	F	3312	9.28	0.28	18.37	6.25
Averages	N		2309	9.05		14.98	6.91
	D		2253	9.42		13.10	6.26
	N	C/P 2.1					
	D	C/P 2.09					

the average weight was 2253 grams compared with 2309 grams for the raw meat fed adult cats alone. The femurs of the cooked meat fed cats showed an average weight of 9.42 grams to 9.05 for the raw meat fed cats. The calcium was 14.98 percent for the raw to 13.10 percent for the cooked; phosphorus, raw, 6.91 percent to cooked, 6.26 percent. The calcium-phosphorus ratio was constant, N–

2.1 and D- 2.09, but the total weight of these minerals was greater in the bones of the raw meat fed animals.

In Tables 4, 5 and 6 the kittens were maintained on the respective diets of their mothers, who, when fed cooked meat, were on the diet at least six months before conception and throughout pregnancy. Of the 21 raw meat fed and 20 cooked meat fed kittens, their ages ranged from 1 day to 14½ months. They were comparatively equally spread as to age. The marked superiority of the raw meat fed kittens as to weight of body and femur is evident—1008 grams, raw meat fed; 638 grams cooked meat fed average weight of body; and 4.23 grams raw meat fed to 3.35 cooked meat fed for the femur. Also the calcium content of raw meat fed, 9.48% to cooked meat fed, 5.53%, and phosphorus of the raw meat fed, 4.58%, and cooked meat fed, 2.63%, favoring the raw meat fed cats. The calcium-phosphorus ratio was found to be, raw meat fed, 2.07, to cooked meat fed, 2.63. The higher calcium-phosphorus ratio in cooked meat cats has been noted in other studies.(6)

The calcium percent of the bones analyzed was plotted on the abscissa and logarithm of age as the ordinate. (Fig. 1) Kittens showed a variability with age. However, it is to be noted that the peaks and dips are comparable in the two curves. Each of the major dips corresponds to periods of eruption of teeth.

When the experiment is repeated using milk as the test food, there is an equally profound change in the bones, the fur, the viscera, the strength, and the disposition of the animals.

TABLE 4-CALCIUM AND PHOSPHORUS CONTENT OF FEMURS OF RAW FOOD KITTENS

				Weight of Femur			
Cat Number	Sex	Age	Weight of Cat Grams	Weight of Femur Grams	Body Weight Per cent	Calcium Per cent	Phosphorus Per cent
1	---	1 da.	---	0.1091	---	10.06	6.02
2	---	5 das.	129	0.1305	0.10	12.23	5.78
3	F	5 das.	115	0.1451	0.12	14.25	7.15
4	---	3 wks.	---	0.75	---	5.31	2.26
5	M	5 wks.	335	0.98	0.28	7.04	3.89
6	F	5 wks.	393	1.06	0.27	7.50	3.74
7	M	5 wks.	377	0.79	0.21	10.59	5.28
8	F	8 wks.	965	4.77	0.49	4.73	2.25
9	M	8 wks.	977	5.21	0.53	5.97	2.85
10	F	8 wks.	715	4.25	0.59	6.48	3.10
11	F	12 wks.	1085	5.63	0.52	7.64	3.66
12	F	12 wks.	800	5.67	0.71	8.55	4.21
13	F	12 wks.	1062	5.87	0.55	8.61	4.09
14	M	12 wks.	1277	6.95	0.54	8.69	3.95
15	F	12 wks.	900	4.89	0.54	8.83	4.08
16	F	12 wks.	1300	6.17	0.62	9.45	4.31
17	M	12 wks.	1275	5.01	0.39	11.59	4.93
18	M	14 wks.	1117	4.53	0.41	15.03	7.35
19	F	10 mos.	1503	9.37	0.62	11.60	5.17
20	M	13.5 mos.	2732	8.48	0.31	12.40	6.02
Averages			1008	4.23		9.48	4.55
	C/P 2.08						

TABLE 5-CALCIUM AND PHOSPHORUS CONTENT OF FEMURS OF DEFICIENT KITTENS

Cat Number	Sex	Age	Weight of Cat Grams	Weight of Femur Grams	Weight of Femur / Body Weight Per cent	Calcium Per cent	Phosphorus Per cent
1	F	1 da.	112	0.0829	0.074	10.79	5.49
2	---	1 da.	---	0.1330	----	11.92	6.15
3	---	3 wks.	261	0.75	0.28	5.32	2.53
4	F	7 wks.	310	1.84	0.59	5.14	2.41
5	M	7 wks.	261	0.97	0.26	6.76	3.24
6	F	8 wks.	400	1.93	0.48	4.49	2.42
7	M	9 wks.	565	2.91	0.51	3.19	1.61
8	M	9 wks.	514	2.83	0.55	3.37	1.73
9	F	9 wks.	434	1.94	0.45	6.27	2.29
10	M	12 wks.	335	2.15	0.64	4.32	2.20
11	F	12 wks.	523	3.28	0.62	3.51	1.79
12	M	14 wks.	1120	5.25	0.46	2.88	1.53
13	M	14 wks.	610	4.39	0.72	4.12	1.84
14	M	15 wks.	890	6.31	0.71	3.95	1.73
15	M	16 wks.	730	5.29	0.72	2.44	1.24
16	F	16 wks.	885	2.65	0.29	7.45	3.64
17	F	16 wks.	915	4.94	0.54	6.74	3.22
18	M	18 wks.	915	4.24	0.49	4.80	2.03
19	F	8 1/2 mos.	1009	2.85	0.28	4.77	2.42
20	F	14 1/2 mos.	1335	5.97	0.45	8.52	4.22
			638	3.35		5.53	2.63
	C/P 2.63/1						

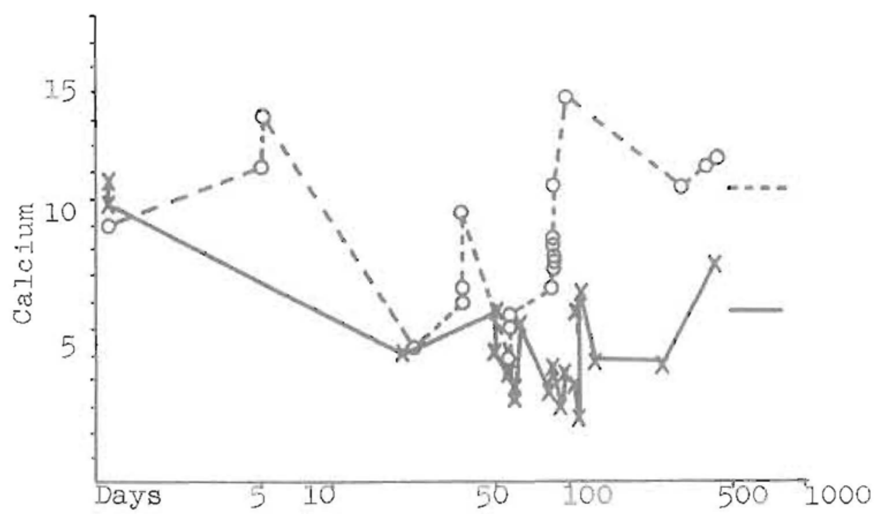

Fig. 1—Calcium content of femurs of raw food and deficient kittens.

TABLE 6-CALCIUM AND PHOSPHORUS CONTENT OF FEMURS OF NEW-BORN KITTENS AND THEIR MOTHERS

Cat Number		Type of Cat Diet	Sex	Age	Weight of Cat Grams	Weight of Femur Grams	Calcium in Femur Per cent	Phosphorus in Femur Per cent
A. Kittens:	a	Raw	---	1 da.	---	0.1091	10.06	6.02
	b	Raw	---	5 das.	129	0.1305	12.23	5.78
	c	Raw	F	5 das.	115	0.1451	14.25	7.15
	d	Cooked	---	1 da.	---	0.1330	11.92	6.15
		Cooked	F	1 da.	112	0.0829	10.79	5.49
B. Mother Cats:	a_1	Raw	F	13 mos.	3200	7.74	10.04	4.83
	c_1	Raw	F	14 mos.	1957	8.09	12.43	5.60
	d_1	Cooked	F	6 yrs.	4600	10.78	14.00	6.35

Mother of corresponding kitten indicated by subletter. Mother cats b, and e, are still alive.

We pursued the study of the health of raw fed and cooked fed cats to their effect on the soil. In 1939 we planted navy beans in each of three plots: (a) one in which the beans were fertilized with the non-composted excreta of cats fed raw meat, (b) one with the excreta of cats fed cooked meat, and (c) one in which no fertilizer was used. This was the control plot. Observation were made on the rate of growth, color and structure of the plants and beans produced. The beans were harvested and part of them analyzed for their various chemical constituents.

The following year, 1940, the experiment was repeated. The seed harvested from the plants fertilized with the excreta of cats fed raw meat, was planted and the plot treated with composted manure from raw-meat cats. This was repeated for the cooked meat and no-fertilizer groups. Two new plots were added. Some of the seed of the nonfertilized beans grown in 1939 was planted and one plot fertilized with the composted excreta of cats whose main diet consisted of pasteurized milk and the other fertilized with the excreta of cats whose main diet was certified raw-vitamin D milk. This made five plots, namely (1) pasteurized milk, (2) certified milk, (3) raw meat, (4) cooked meat, and (5) no fertilizer. The growth of the plants was again observed. The beans, plants, and pods harvested were subjected to chemical analyses.

In the 1939 experiment no apparent difference was noted in the size, color, or shape of the beans grown on the three different types of fertilizer.

The germination of the beans was graded as follows: no-fertilizer group, 96%, raw meat, 88%, cooked meat, 72%. Two weeks after planting, the no-fertilizer plants were the tallest; the raw meat and cooked meat were about equal in height. The plants on raw-meat fertilizer had the best form and color. Three weeks after planting, the cooked meat group of plants was the tallest, the no-fertilizer was next, and the raw meat, the shortest. This rate of growth obtained throughout the experiment. The plants on cooked meat fertilizer were pale green in color, had many more stems and leaves, and their stalks were thinner than the plants of the other two groups. Plants on raw meat fertilizer were short and squat, had a much deeper color, and were sturdier than the plants on cooked meat fertilizer. The no-fertilizer plants were intermediate between the raw and cooked meat groups with respect to the above mentioned features. The leaves of the plants on cooked meat fertilizer were flabby and thin and felt much like tissue paper, those on raw meat fertilizer were firm and heavy in texture, while those on no-fertilizer fell a little below the raw meat. The beans were transplanted to larger plots a month after planting. It was found that the roots of the plants on raw meat fertilizer were at least twice as numerous, tougher and longer than those of the others. The no-fertilizer plants were intermediate, while the roots of the cooked meat plants were less numerous, soft, and mushy.

The beans were analyzed for their moisture, ash, calcium and phosphorus content. The results of the analyses are given in Table 7.

TABLE 7-ANALYSIS OF NAVY BEANS. FIRST GENERATION.

	Type of Fertilizer	Moisture per cent	Ash per cent	Calcium mg. per 100g.	Phosphorus mg. per 100g.
Navy Beans	Raw Meat	11.56--11.82	4.15--4.08	148--140	377--389
	Cooked Meat	11.52--11.50	3.92--3.85	118--121	371--377
	No-fertilizer	13.21--13.49	3.48--3.55	153--155	398--392

In 1940, the observations made on the growth of the plants were similar to those of 1939. In the two plots fertilized with the excreta of cats on the milk diets, the beans of the certified milk group germinated ahead of, and the beans formed earlier than, those of the pasteurized milk group. The beans grown in the plot fertilized with the excreta of cats fed raw meat were by far the best. These plants were sturdier, their color better, and the texture of the leaves superior to any of the others.

Pasteurized Milk. The beans had a hard, smooth white surface. The most noticeable features were the flatness of the beans and their oblong shape.

Certified Milk. These beans exhibited the same general features as those of the pasteurized milk group.

Raw Meat. These beans also had a hard, smooth, white surface. Uniformity of size and plumpness of the beans distinguished them from the beans of all other groups.

Cooked Meat. In this group one-fourth of the beans were shriveled and yellow in color; the remainder were smooth and white. They also were more plump than the milk beans but they were not as plump as the raw meat beans. They also exhibited the peculiar oblong shape of the milk beans.

No-fertilizer. These were smooth and white. They were more plump than either of the milk beans but not as plump as the meat beans.

There was marked variation in the size and weight of the different groups of beans. Of the pasteurized milk beans, the variation in weight was from 72.2 milligrams to 198.5 milligrams with an average of 117.9 milligrams. In the certified milk group, the variation was from 74.5 milligrams to 203 milligrams with an average of 121.7 milligrams. For the raw meat beans, the smallest was 107 milligrams and the largest 210.4 milligrams with an average of 166.2 milligrams. For the cooked meat, the smallest was 35.8 and the largest 201.9 milligrams with an average of 146.7 milligrams. The no-fertilizer beans varied from 62.1 to 194.6 with an average of 113.5 milligrams. (Fig. 2)

A portion of the beans and the dried plants and pods was subjected to chemical analysis. The results obtained on the beans are given in Table 8, the plants in Table 9, and the pods in Table 10.

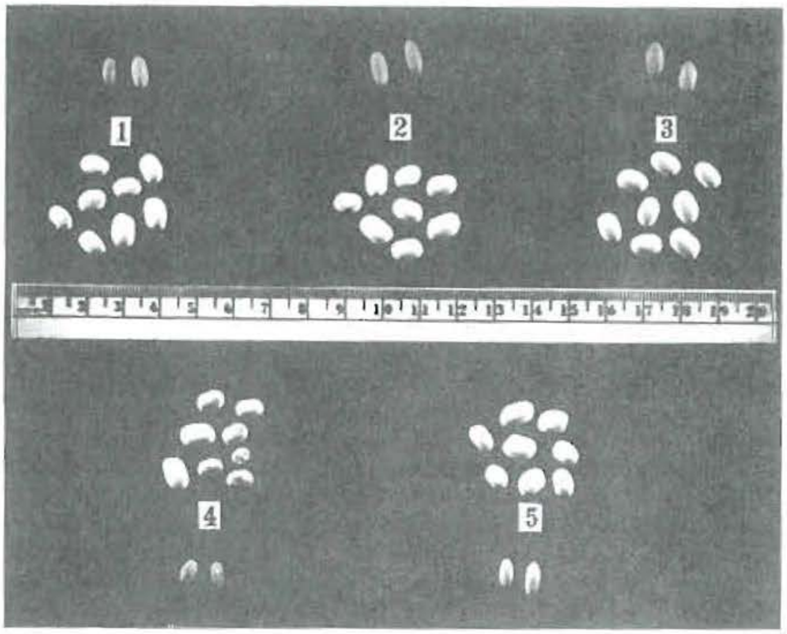

Fig. 2—Beans fertilized by composted cat manure and control. 1. Pasteurized milk beans. 2. Certified milk beans. 3. Raw meat beans. 4. Cooked meat beans. 5. No fertilizer beans.

TABLE 8-ANALYSIS OF NAVY BEANS: SECOND GENERATION

Type of Fertilizer Used on Beans	Moisture per cent	Ash per cent	Calcium mg. per 100g.	Phosphorus mg. per 100g
Pasteurized Milk	12.78 -- 12.97	4.33 -- 4.30	80.2 -- 78.8	489 -- 478
Certified Milk	12.22 -- 12.39	3.82 -- 3.81	67.4 -- 68.5	411 -- 412
Raw Meat	12.91 -- 12.97	4.14 -- 4.12	131.0 -- 130.0	448 -- 449
Cooked Meat	12.54 -- 12.61	3.94 -- 3.92	87.5 -- 89.0	455 -- 457
No Fertilizer	12.51 -- 12.66	4.15 -- 4.03	83.1 -- 86.3	490 -- 487

TABLE 9-ANALYSIS OF NAVY BEAN PLANTS: SECOND GENERATION.

Type of Fertilizer Used on Beans	Moisture per cent	Crude Fat per cent	Crude Fiber per cent
Pasteurized Milk	8.90 -- 8.92	5.11 -- 5.21	35.84 -- 35.44
Certified Milk	8.58 -- 8.43	5.28 -- 5.36	33.71 -- 32.88
Raw Meat	8.68 -- 8.56	5.82 -- 5.54	35.81 -- 35.74
Cooked Meat	7.70 -- 7.71	9.21 -- 9.73	27.01 -- 26.92
No Fertilizer	8.88 -- 8.71	5.81 -- 5.80	27.50 -- 27.67

TABLE 10-ANALYSIS OF NAVY BEAN PODS; SECOND GENERATION.

Type of Fertilizer Used on Beans	Moisture per cent	Crude Fat per cent	Crude Fiber per cent
Pasteurized Milk	9.61 -- 9.73	14.15 -- 14.43	26.89 -- 27.33
Certified Milk	8.75 -- 8.81	17.69 -- 17.96	28.63 -- 28.91
Raw Meat	11.29 -- 11.57	15.29 -- 15.39	28.54 -- 28.27
Cooked Meat	7.19 -- 7.16	24.81 -- 25.22	29.89 -- 30.31
No Fertilizer	11.04 -- 10.81	13.64 -- 13.37	26.70 -- 27.05

DISCUSSION

Definite conclusions cannot be drawn from this experiment, but it suggests the possibility that excreta of diseased and healthy animals contain principles which affect plant growth, and that the health of the animal determines to some degree the effect on the vitality of the plant and its seeds, as well as the chemical constituents of the plant, seed and pod of the beans studied. In view of the fact that some of the beans from the cooked meat fertilizer were smaller and more irregular than those beans not receiving fertilizer, elements toxic to plants may be present in the manure of deficient animals.

In 1942 we made a further simple observation which linked the health of animals to the condition of the soil. We had built the cat pens on land which had never served as a home for any animals. Each pen had an open air enclosure 12 feet long and 6 feet wide. A trench 18 inches deep was dug in this enclosure and filled with fresh washed sand from a common sand pile. A roofed area four feet deep, with a wooden floor, was built at the back of each pen to act as a shelter for the animals in inclement weather. The animals spent much of their time in the open part of the pen. They buried their excreta in the fashion normal for cats. The caretaker removed bones and uneaten portions of meat daily, and cleaned and refilled the water containers. Periodically, he screened the sand, composting the excreta into marked piles for future studies of soil.

Apart from the studies on beans we performed with the composed manure from the various pens, we observed the following circumstances in the pens which lay fallow for five months at the conclusion of the experiment: volunteer weeds came up in each pen. (Fig. 3 & 4) The number of weeds and their hardiness were in direct proportion to the health and vigor of the animals that had lived in the pens. The accompanying illustrations of these weeds also indicate that male and female cats on the same feed contributed a different degree of hardiness to the weeds.

Following the harvesting of the weeds, we planted navy beans in the pens. (Figs. 5, 6 & 7) The growth of these beans, in number, outward appearance, and in other respects (Table 11) bore the same distinct relationship to the health and vigor of the animals that had lived in the pens as did the volunteer weeds.

The following chart will indicate the principal observations. These beans were studied weekly and results of texture, state of growth, were all recorded.

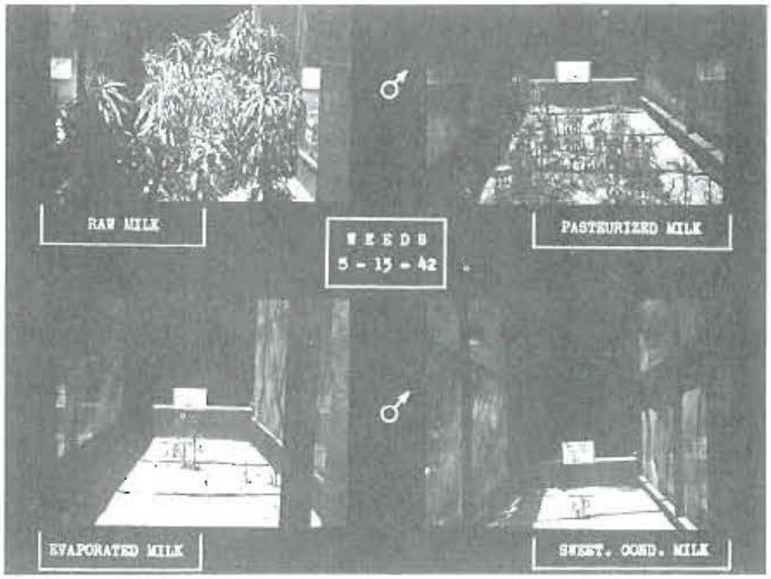

Fig. 3—Pen 18—raw milk-males. Pen 20—pasteurized milk-males. Pen 22—evaporated milk-males. Pen 24—sweetened condensed milk-males.

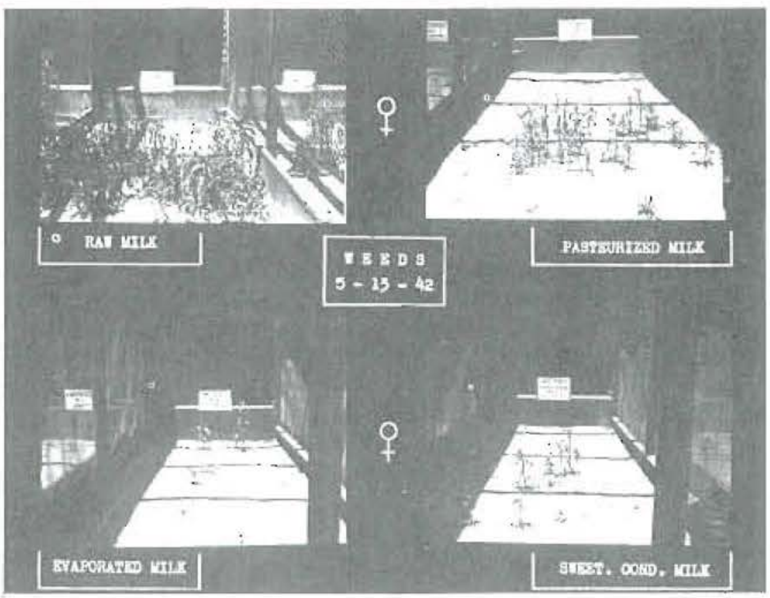

Fig. 4—Pen 17—raw milk females. Pen 19—pasteurized milk females. Pen 21—evaporated milk females. Pen 23—sweetened condensed milk females.

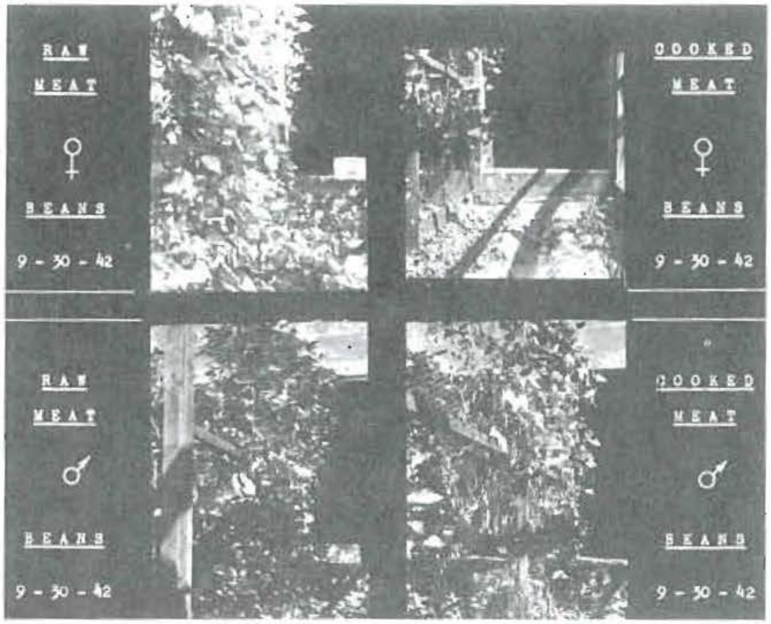

Fig. 5—Pen 13—cooked meat females. Pen 14—Cooked meat male. Pen 15—raw meat males. Pen. 16—raw meat females.

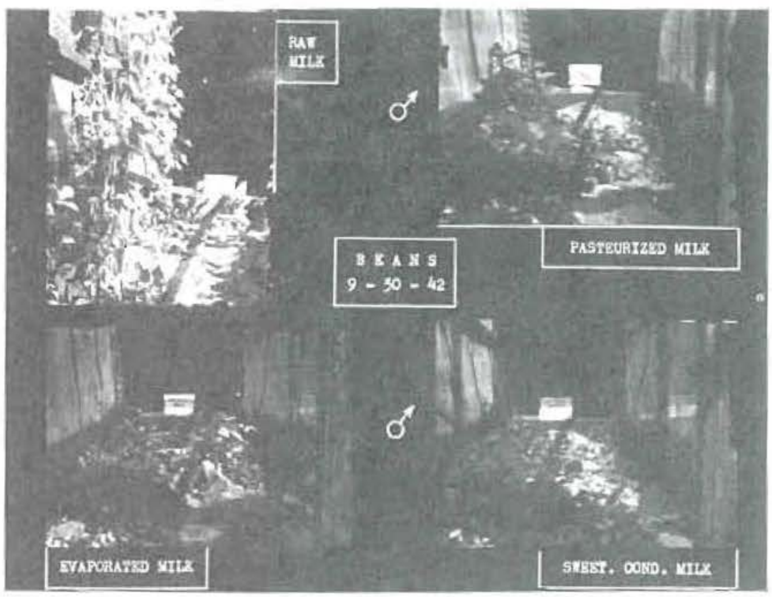

Fig. 6—Pen 18—raw milk males. Pen 20—pasteurized milk males. Pen 22—Evaporated milk males. Pen 24—sweetened condensed milk males.

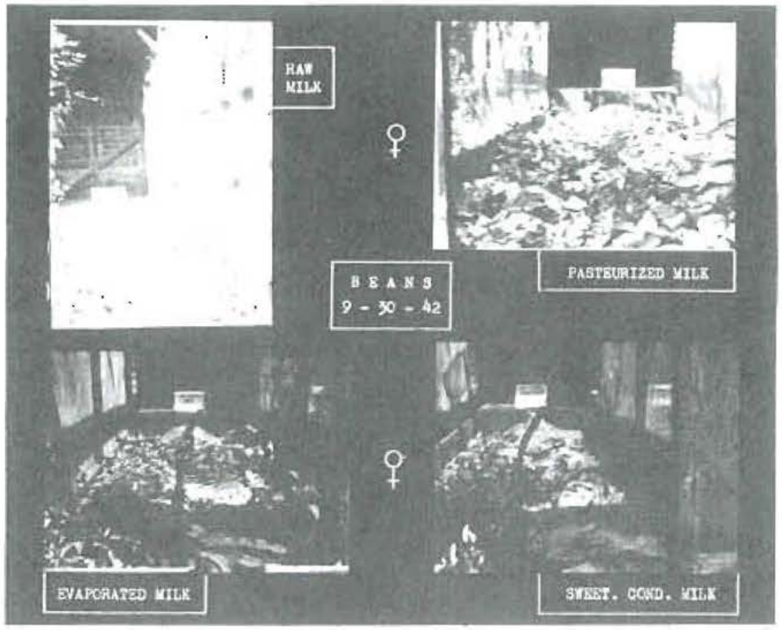

Fig. 7—Pen 17—Raw milk females. Pen 19—Pasteurized milk females. Pen 21—evaporated milk females. Pen 23—sweetened condensed milk females.

We wish to note that pens 13 and 14 had been used for breeding purposes, though pen 14 more frequently housed male cats alone and pen 13, female cats alone. This fact may have some bearing on the results.

The minutiae of the studies we made on the composted manures from the individual pens is unsuitable for inclusion in this report. However, the bean plants which grew on the composted soils behaved in almost identical manner to the volunteer weeds in the same pens.

We believe that the healthy animals in our pens returned to the soil materials which, in turn, raised healthy plants; that the sick animals returned to the soil materials inadequate or even toxic for the growth of the plants. The male cat likewise affects the soil with greater growth stimulation than the female for the navy bean and the volunteer weeds.

Though ecology is usually divided into parts and subparts, it is only as we look at the relationship of soil, plant, animal, and man, with environmental factors such as wind, humidity, clouds, sunshine, rain, and the hand of man as he applies inorganic and organic material for fertilizer, weed and pest control to the soil, and contaminates the atmosphere with gases of combustion from his

TABLE 11

	Pen	Color	Growth	1st Blossoms	No. of Blossoms	Period of bloom	No. of Beans	No. of Pods	Beans per pod	Life of plant (days)
Cooked meat-0 Males & females	13	good sl.yel.	mixed poor & excellent	70 days	500	49 days	700	134	5.2	147
Cooked meat-# Males & Females	14	good sl. yel.	mixed poor & excellent	63 days	2500	49 days	1886	451	4.2	147
Raw meat Males	15	deep green	Ex. thick stems	77 days	2000	70 days	1142	357	3.2	161
Raw meat Females	16	deep green	excellent	91 days	1800	56 days	684	220	3.1	161
Raw milk Females	17	bright green	good	63 days	550	49 days	1092	328	3.3	126
Raw milk Males	18	bright green	good	63 days	1200	49 days	3487	659	5.3	147
Past. Milk	19	poor	weak	63 days	500	42 days	615	146	4.2	126
Past. Milk Males	20	fair	fair	63 days	600	35 days	1045	298	3.5	126
Evap. Milk Females	21	fair	weak fine stems	63 days	300	49 days	120	42	2.8	126
Evap. Milk Males	22	fair	weak sprawled	63 days	300	49 days	339	126	2.7	126
Sweetened Coud. Milk Females	23	fair	poor	63 days	350	49 days	190	69	2.7	112
Sweetened Cond. Milk Males	24	fair	poor weak stems	63 days	350*	42 days	1252	407*	3.0	119

*Counts were made weekly. Some blossoms were probably missed.
O- Breeding pen normally housed female cats.
- Breeding pen uormally housed male cats.

engines and manufacturing plants, or the aresols and dusts from agricultural practices, that we get a total picture of the ecology of modern times.

The ecologic cycle has always been variable. The plant and animal population including man, has been physically modified as natural forces have altered environment. The simple factor of rainfall is continually changing. The rainfall may be gentle, evenly stretched over the so called rainy season, or it may fall all at once in the space of a few hours leaving catastrophe to animal, plant, and soil. When rain comes as a deluge, the total precipitation for the year may be high, but because of the short space of time involved the summation of the effects may be similar to those found in years of serious drought. There are years of cyclonic winds, sometimes accompanied by driving rains in a given area, altering the ecological pattern. In other years not only may the rainfall vary but variable humidity may be experienced; or a dust storm may be tragic to one area where the soil surface is eroded, yet may be a blessing to another where the soil is deposited.

The effect of weather on the living elements in the basic soil of a given region may alter its water retention and fertility. In turn the pattern of vegetation may be completely changed, the wild life pattern redistributed. The large animals may migrate. The lesser may die off in large numbers and those remaining become scrawny. It may be years before the former environmental factors return, if ever.

Man has been pointed to as the perpetrator of the greatest disasters to fertility and potential agricultural resources by ignoring the relation to each other of forests, soils, and the animals that dwell in them.

Marco Polo recounts the abundance of forests and animal life of China, but by modern times these have largely disappeared. Lack of conservation practices in the water sheds of the Tigris and Euphrates destroyed the fertility of the valleys and their civilization. In the desert areas of North Africa where shifting sands have swallowed the fertile fields of past civilizations, the adventurer finds the olive press and other evidence of human habitation in a vast sea of waste, again credited to the misunderstanding of total ecology by the men of that day.

Similarly, extensive areas of our own country have been transformed as the ecological pattern of soil, plant, animal, and human life have been altered.

Students of bionomics find today that the primordial life cycle from the soil to the plant, through the animal and back to the soil is frequently disrupted. Man fails to return to the soil much of his crops, his animals and excrements, thus breaking the natural cycle of life. So, in striving to maintain his economy, man must artificially return to the soil that which he removes.

In Japan and China it is reported that the human exrement from the well-to-do is considered more valuable than that from poorer populations. With the "honey bucket" the ecological cycle is only partially complete, since much of the produce of the soil is exported not only from the rural sections to the cities but to other countries as well.

It is a great pleasure to be asked to contribute to this testimonial Soils Conference in honor of Dr. William Albrecht. It is a privilege to pay tribute to an intrepid man whose interest is not confined to the ionic exchanges in the clays of the soil but what these ionic exchanges mean in the production of plant life, animal life, and man. Dr. Albrecht is not merely interested in the bushels per acre but believes that plant life must be interpreted in nutritive value, using its protein content as an index of quality. Again, he appreciates not just the protein of the plant but the quality of the protein. And finally, he knows how the quality of the plant will reflect on the health of the animals who consume the plant, and thus on to man. I owe my own debt of gratitude to Dr. Albrecht's discovery of these relationships.

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