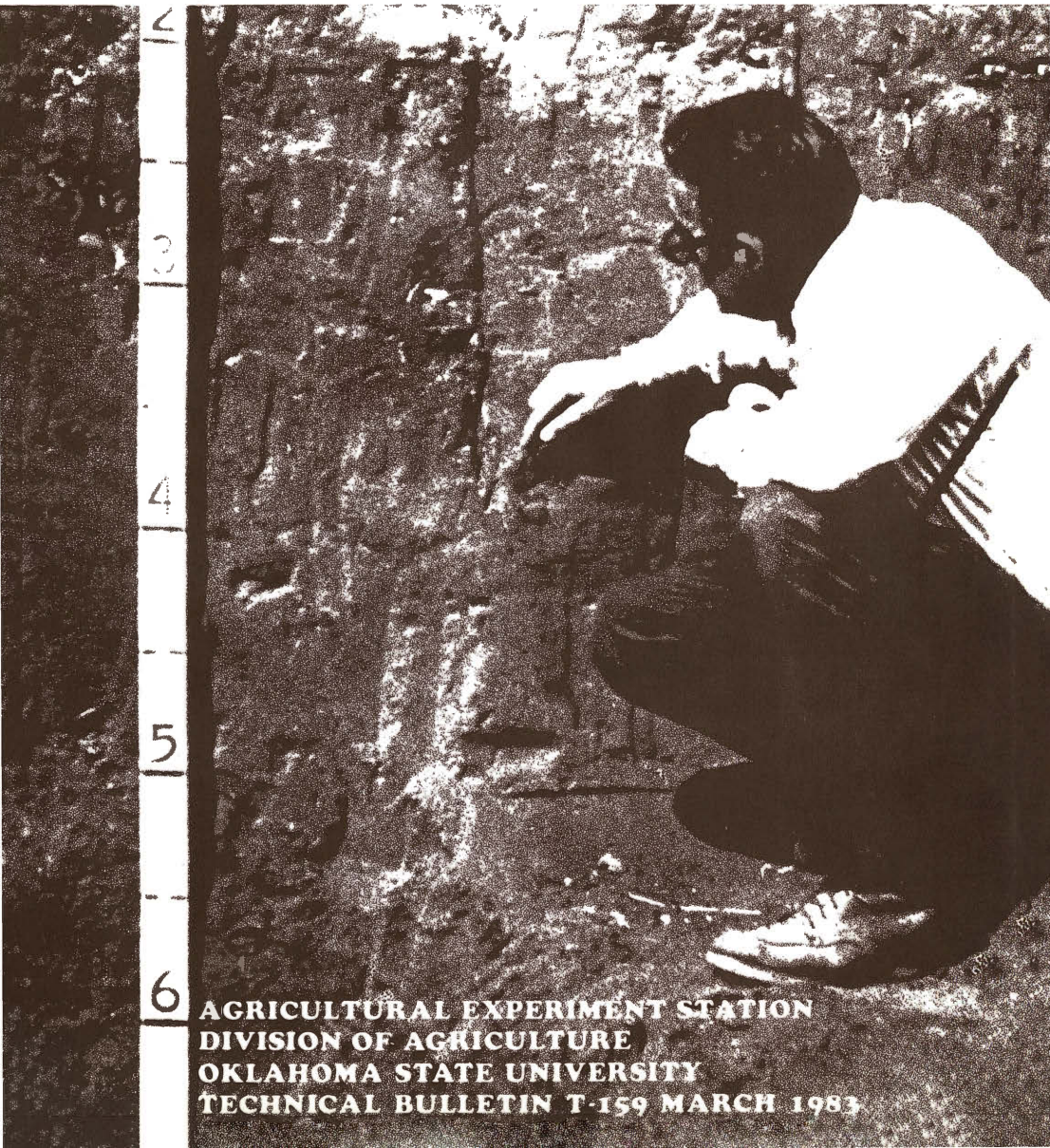
SELECTED PROPERTIES OF PAIRED VIRGIN AND CULTIVATED SOILS FROM MAJOR LAND RESOURCE AREAS



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Selected Properties of Paired Virgin and Cultivated Soils from Major Land Resource Areas

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Introduction

Present national interest has focused on the impact of erosion on soil fertility and productivity (Langdale and Shrader, 1982; Williams et al., 1981). Although soil erosion has been a problem in many agricultural areas of the U.S. for a long time, little specific information is available about its impact on either the short- or long-term fertility and productivity of cultivated soils. Until this information becomes available, selection of management strategies to optimize future crop production will be impossible

The National Soil Erosion-Soil Productivity Research Planning Committee has identified an urgent need for the development of a general model for simulating erosion and crop production (Williams et al., 1981). This model, EPIC (Erosion-Productivity Impact Calculator) consists of physically based components for simulating erosion, plant growth and related processes, and economic components for assessing the cost of erosion and implementation of optimal management strategies.

EPIC will provide projections of soil fertility and productivity following up to 50 years of given management practices. Validation of these predictions, however, will be formidable. One approach is to compare the model predictions with a data base from long-term cultivation experiments for similar management practices. To do this, a published data base of detailed information on the impact of long-term cultivation and fertilization on the distribution of nutrients in the soil profile is needed. The present report documents the distribution of nitrogen (N), phosphorus (P), carbon (C), exchangeable cations, and other properties in virgin soil profiles and their analogues which have been cultivated and fertilized for at least 15 years. The eight pairs of soils represent agriculturally important soil series from different U.S. cropping areas. Included are two soils from the Southern Plains, an area where soil erosion is of particular concern.

An example of how EPIC predictions can be utilized in conjunction with the virgin cultivated soil data base is given for the Houston Black clay. This Southern Plains soil is similar to the vertisols occurring in southeastern Oklahoma. The vertisols present many management problems due to their high shrink/swell characteristics. Consequently, they are expected to present a "worst case" for modeling purposes.

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Materials and Methods

Materials

The classification, location, and available management history of the selected soils are presented in Table 1. The cultivated sites represent average to above-average management treatments for each locality. All sites were on level areas, in order that any prior changes in soil properties due to erosion and/or deposition would be minimal. Virgin and cultivated soils were sampled on the same day by taking 2.5 or 7.5 cm diameter cores (generally three) at each site in 15 cm increments to a 90 cm depth. In the case of the Caribou virgin and Fargo virgin and cultivated soils, increments below 60 and 75 cm, respectively, were not made available. Cores were composited and packed in ice for immediate transportation to the laboratory. Thereupon, the samples were air-dried without delay, crushed with the aid of a porcelain mortar and pestle to pass a 60-mesh screen, mixed thoroughly, and stored in glass bottles with tight, sealed, screw-type lids.

Methods

Nitrogen. Total N was determined by a semimicro Kjeldahl procedure (Bremner, 1965a) and inorganic N forms (nitrite, nitrate, and exchangeable ammonium) were determined using procedures described by Bremner (1965b). The non-exchangeable ammonium procedure involved extraction with hydrofluoric acid solutions (2.5*N* HF - 0.1 *N* HCl), and was patterned after that described by Stevenson et al. (1967). Organic N was fractionated by hydrolyzing soil samples with HCl according to procedures described by Porter et al. (1964). Anaerobic N mineralization and autoclave-distillable N were determined using procedures described by Smith and Stanford (1971).

Phosphorus. The total and inorganic P contents of the selected soils were determined by extraction of ignited and non-ignited samples, respectively, with 0.5 M H_2SO_4 (Walker and Adams, 1958). Organic P content was calculated as the difference between total and inorganic P. Plant available P content was determined by the Bray-I procedure, where 1 g of soil was extracted with 20 ml of 0.03 *N* NH_4F and 0.025 *N* HCl for 5 min (Bray and Kurtz, 1945). The extracts were centrifuged (27,160 *g* for 5 min) and filtered (0.45 μm). The amount of P sorbed, x(μg/g), from one addition of 150 mg P/100 g soil (added as a solution of K_2HPO_4), after end-over-end shaking for 40 hr at a water:soil ratio of 100:1, was determined. The P sorption index was calculated using the quotient x/log C, where C is the solution P concentration (μg/ml) (Bache and Williams, 1971). This quotient was highly correlated with P sorption maximum calculated from a Langmuir sorption plot for a wide range of soils (Bache and Williams, 1971). It thus reflects the number of unsatisfied P sorption sites on a soil and amount of added fertilizer P that becomes relatively unavailable through sorption by soil material. For all samples the concentration of P was determined colorimetrically on filtered samples by the molybdenum-blue method (Murphy and Riley, 1962). Acid or alkali filtrates were neutralized prior to P determination.

Other properties. The particle size distribution of the soils was determined using a Bouyoucos hydrometer (Day, 1965), following dispersion of the samples with sodium hexametaphosphate. Organic carbon was determined by a wet combustion procedure (Mebius, 1960) and carbon dioxide production using a nonenrichment procedure describ-

ed by Russel and Stanford (1954). Moisture equivalent was determined by a suction procedure (Piper, 1951) and pH by a glass electrode using a 2:1 water:soil ratio. Calcium carbonate equivalent was measured by the gravimetric method for loss of carbon dioxide (Allison and Moodie, 1965). Exchangeable calcium (Ca), sodium (Na), magnesium (Mg), and potassium (K) content of the selected soils was determined by extraction with neutral 1N ammonium acetate (NH_4OAc) and flame photometry (Pratt, 1965). Base exchange capacity was calculated as the sum of potassium, calcium, sodium, and magnesium in the NH_4OAc extract, using flame photometry.

Results

Soil Properties. The following soil properties are presented for the 8 virgin and cultivated soils, at 15-cm increments to a 90-cm depth:

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Table 1. Classification, location, land resource region, major land resource area, and management history of the virgin and cultivated soils.

Soil	Designation	Location	Sampling date	Land Resource Region	Major Land Resource Area	Previous Management
Caribou silt loam	Alfic Haplorthods	Aroostook Co., Maine	Nov/71	North East Forage and Forest	Aroostook	Virgin site was forested. Cultivated site has been farmed approximately 50 yr. in potato-potato-fallow-red clover rotation. For last 10 yr. annual N rate on potatoes has been 168 kg/ha, with 65-87 kg P and 124-166 kg K/ha/yr applied for the last 30-35 yr.
Dundee silt loam	Aeric Ochraqualfs	Sunflower Co., Miss.	Jun/73	Mississippi Delta Cotton and Feed Grains	Southern Mississippi valley silty uplands	Virgin site was forested. Cultivated site has been cropped to cotton since clear cutting about 60 yr ago. Legume crops were used for N source up to 1944, then used periodically and supplemented with 34 kg N/ha annually until 1950. From 1950-64, annual N rate was increased to 56-67 kg/ha. Since 1964, annual N rate has been 101-112 kg/ha. No fertilizer P or K has been applied.
Fargo silty clay loam	Vertic Haplaquolls	Polk Co., Minn.	Sep/71	Northern Great Plains Spring Wheat	Red river valley of the north	Virgin site was in native grass. Cultivated site was farmed with small grains, alfalfa, and occasionally fallow for 60 yr. Since 1964, small grains were fertilized with 12-52 kg N/ha, 13-55 kg P/ha. No K has been applied.

Table 1. (Continued)

Soil	Designation	Location	Sampling date	Land Resource Region	Major Land Resource Area	Previous Management
Houston Black clay	Udic Pellusterts	Bell Co., Texas	Apr/72	Southwestern Prairies Cotton and Forage	Texas blackland prairie	Virgin site was in native grass. Cultivated site was farmed for 60 yr, with the last 15 yr in grain sorghum and 29 kg P and 55 kg K/ha/yr applied. From 1958-64, 67 kg N/ha/yr has been added. Since 1964, 101 kg/N/ha/yr has been applied.
Keene silt loam	Aquultic Haplaudalfs	Coshocton Co., Ohio	May/73	East and Central General Farming and Forest	Western Allegheny	Virgin site was forested. Cultivated site has been farmed for more than 30 yr. From 1940-71, land was in corn-wheat-meadow rotation, with corn and wheat crops each receiving 78 kg N, 40 kg P, and K/ha/yr (mainly in the form of manure) and meadow 44 kg P and K/ha/yr. Since 1971, land has been in continuous corn, receiving 224-336 kg N/ha/yr.
Leeper silty clay loam	Vertic Haplaquepts	Oktibbeha Co., Miss.	Jun/73	South Atlantic and Gulf Coast Cash Crop Forest and Livestock	Alabama and Mississippi blackland prairies	Virgin site was in native brush. Cultivated site was in soybeans for the past 15 yr, receiving 0 N, 24 kg P, and 46 kg K/ha/yr. Prior to this corn was planted for 25 yr, with 56-90 kg N/ha/yr and no P or K applied.

Table 1. (Continued)

Soil	Designation	Location	Sampling date	Land Resource Region	Major Land Resource Area	Previous Management
Reakor loam	Typic Caliorthids	Eddy Co., N. Mex.	Feb/72	Western Great Plains Range and Irrigated	Pecos-Canadian plains and valleys	Virgin site was in native range. Cultivated site was leveled for irrigation in 1956. Since then main crops have been cotton, barley, sorghum, and sudangrass. Average of 112 kg N, 14 kg P, and 0 kg K/ha/yr added for last 10 yr.
Webster clay loam	Typic Haplaquolls	Story Co., Iowa	Nov/72	Central Feed Grains and Livestock	Central Iowa-Minnesota till prairie	Virgin site was in native grass. Cultivated site was tilled about 1900 and since then corn, soybean, small grains, and meadow grown. For past 25 yr land was in row crops, receiving small amounts of N, P, and K fertilizer. In 1970 and 1971, corn received 168 kg N, 48 kg P, and 110 kg K/ha/yr.

Table 2. Total N content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Total nitrogen content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	3220	2030	641	444	4110	3040	2310	1170
15-30	1030	1720	400	310	1310	2760	1480	840
30-45	810	970	370	290	1050	1130	1140	700
45-60	1080	620	300	270	620	640	830	690
60-75	-	520	280	250	520	480	630	530
75-90	-	600	250	240	-	-	630	550
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	760	1268	1560	1019	860	940	3860	1700
15-30	400	890	850	860	730	1030	2730	1420
30-45	360	550	640	700	620	880	1680	1090
45-60	340	810	580	630	460	650	1160	580
60-75	320	680	800	580	390	560	590	300
75-90	350	550	960	530	350	440	280	180

Table 3. Nitrite-N content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Nitrite - N content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.42	0.16	0.10	0.05	0.34	0.10	0.20	0.30
15-30	0.10	0.10	0.08	0.02	0.08	0.14	0.16	0.10
30-45	0.15	0.21	0.06	0.05	0.16	0.41	0.13	0.18
45-60	0.09	0.07	0.07	0.03	0.28	0.74	0.07	0.11
60-75	-	0.13	0.07	0.06	0.32	0.67	0.19	0.15
75-90	-	0.16	0.04	0.10	-	-	0.18	0.14
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.20	0.22	0.19	0.16	1.74	1.34	0.26	0.06
15-30	0.14	0.21	0.13	0.10	1.32	2.04	0.39	0.06
30-45	0.14	0.15	0.07	0.08	0.97	1.50	0.29	0.10
45-60	0.15	0.18	0.08	0.10	1.08	1.12	0.32	0.11
60-75	0.12	0.19	0.06	0.09	0.79	0.92	0.27	0.12
75-90	0.14	0.16	0.07	0.09	0.98	0.77	0.29	0.09

Table 4. Nitrate-N content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Nitrate - N content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	3.8	4.9	7.0	10.1	5.3	8.0	7.9	17.5
15-30	2.1	0.9	4.5	8.6	5.7	27.4	4.2	5.7
30-45	2.6	5.1	4.5	9.3	6.2	20.8	7.5	4.1
45-60	3.6	3.4	5.0	10.4	7.2	23.3	7.0	5.1
60-75	-	5.5	5.3	11.1	4.3	14.0	4.3	3.0
75-90	-	9.1	5.7	10.7	-	-	4.5	3.8
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	3.0	6.4	11.0	11.5	5.4	25.4	14.9	16.2
15-30	1.8	11.0	7.3	8.5	3.2	12.9	10.0	14.9
30-45	1.1	9.6	5.9	8.6	6.1	4.9	8.2	11.9
45-60	2.0	17.8	5.6	6.5	27.9	10.2	7.2	17.6
60-75	2.2	22.2	4.6	4.4	67.4	9.2	8.4	18.2
75-90	1.0	17.8	2.4	3.4	91.8	7.6	7.2	19.9

Table 5. Exchangeable ammonium - N content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Exchangeable ammonium - N content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	11.2	5.0	Trace		8.7	3.7	6.0	4.0
15-30	5.8	6.6			4.4	5.3	6.4	3.7
30-45	3.2	2.4			3.9	3.8	3.4	2.8
45-60	3.5	0.0			1.5	8.4	2.8	2.0
60-75	-	0.0			3.0	4.5	3.8	3.6
75-90	-	0.0			-	-	2.3	1.9
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	Trace		Trace		3.1	5.7	3.0	6.3
15-30					6.6	5.4	2.6	3.4
30-45					5.0	6.7	2.4	3.7
45-60					4.8	2.8	2.9	3.0
60-75					4.0	0.0	3.2	2.8
75-90					4.0	0.0	2.5	1.6

Table 6. Non-exchangeable ammonium - N content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Non-exchangeable ammonium - N content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	289	325	163	166	157	177	68	62
15-30	272	296	182	182	123	151	59	57
30-45	293	310	176	184	74	83	56	53
45-60	286	311	183	184	75	82	60	59
60-75	-	336	189	184	69	71	40	56
75-90	-	357	188	197			48	50
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	139	162	76	89	65	66	129	192
15-30	150	168	62	92	71	66	115	185
30-45	169	175	65	89	60	61	97	146
45-60	158	234	65	86	57	72	84	113
60-75	175	247	84	72	52	61	68	56
75-90	190	278	78	70	34	56	70	50

Table 7. Content of organic -N (fractions I, II, and III) for the eight paired virgin and cultivated soils.

Soil depth (cm)	Organic -N content (% of total N)					
	Virgin			Cultivated		
	Fraction[+]			Fraction		
	I	II	III	I	II	III
			Caribou			
0-15	24	53	22	22	52	26
15-30	26	48	26	24	52	24
30-45	26	36	37	26	40	36
45-60	26	40	34	28	26	47
60-75	-	-	-	36	11	53
75-90	-	-	-	34	16	50
			Dundee			
0-15	22	48	30	23	45	32
15-30	26	41	33	28	37	35
30-45	24	30	46	28	27	45
45-60	31	27	42	30	20	50
60-75	37	19	44	34	19	47
75-90	42	18	40	42	15	43
			Fargo			
0-15	21	49	30	23	46	31
15-30	27	44	30	25	50	27
30-45	26	42	32	24	44	32
45-60	30	41	29	30	40	30
60-75	30	37	32	28	38	33
75-90	-	-	-	-	-	-
			Houston Black			
0-15	21	55	24	24	56	21
15-30	23	52	25	25	49	26
30-45	22	47	30	28	50	25
45-60	24	46	31	27	47	33
60-75	22	44	33	30	46	24
75-90	21	44	36	23	44	37
			Keene			
0-15	24	48	28	23	43	34
15-30	28	19	53	26	44	30
30-45	32	9	59	23	16	61
45-60	28	11	61	18	9	73
60-75	36	13	51	18	7	75
75-90	26	10	64	20	10	70
			Leeper			
0-15	27	58	15	26	54	20
15-30	37	53	10	40	45	15
30-45	37	54	9	31	45	24
45-60	36	44	20	30	44	26
60-75	29	44	27	30	44	26
75-90	29	48	23	31	42	27

Table 7. (Continued)

Soil depth (cm)	Organic -N content (% of total N)					
	Virgin			Cultivated		
	Fraction +			Fraction		
	I	II	III	I	II	III
	Reakor					
0-15	22	56	21	22	50	28
15-30	23	55	22	21	48	31
30-45	24	47	28	21	49	29
45-60	28	54	18	24	44	32
60-75	26	46	28	23	36	41
75-90	27	37	37	25	39	37
	Webster					
0-15	26	60	14	36	52	12
15-30	27	58	16	38	52	10
30-45	26	60	14	36	51	15
45-60	28	58	15	37	50	13
60-75	26	53	22	32	36	32
75-90	32	50	19	38	33	29

+ Fraction I (distillable acid-soluble NH_4^+-N) includes ammonia-N released during hydrolysis, amide-N, and amino sugar-N.
Fraction II (nondistillable and soluble N) includes amino acid-N.
Fraction III (acid-insoluble N) includes acid-insoluble humin-N or unhydrolyzed humin and N of insoluble residue.

Table 8. Content of autoclave - distillable N for the eight paired virgin and cultivated soils.

Soil depth (cm)	Autoclave - distillable N (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	150.0	107.0	27.5	18.2	54.5	37.8	21.1	9.2
15-30	46.0	83.4	13.6	9.2	17.5	25.6	9.4	4.6
30-45	35.0	39.3	7.8	6.6	10.7	12.2	7.4	3.9
45-60	45.4	20.7	7.4	4.5	4.7	6.8	3.4	2.7
60-75	-	14.5	6.4	3.2	3.1	3.5	2.8	2.5
75-90	-	17.5	6.4	3.5	-	-	2.0	2.0
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0.15	43.2	49.7	23.7	13.8	5.3	5.4	67.8	39.0
15-30	12.3	31.6	8.6	11.4	4.4	6.6	37.8	25.2
30-45	5.8	15.5	6.4	10.0	2.6	5.0	22.6	14.6
45-60	5.1	9.6	5.3	6.0	1.6	4.1	14.4	9.4
60-75	3.3	5.6	8.4	5.2	1.2	3.3	7.0	3.1
75-90	1.8	6.3	10.1	3.8	0.6	2.0	1.8	1.3

Table 9. Nitrogen mineralization potential of the eight paired virgin and cultivated surface soils (0-15 cm only).

Soil	N mineralization potential (μg/g soil)	
	Virgin	*Cultivated*
Caribou	717	310
Dundee	33	17
Fargo	395	272
Houston Black	361	175
Keene	217	201
Leeper	204	101
Reakor	65	72
Webster	568	266

Table 10. Total P content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Total P content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	953	1922	393	294	665	666	608	665
15-30	440	1542	437	406	496	672	530	488
30-45	413	1027	457	428	441	446	469	409
45-60	446	576	519	617	399	388	404	396
60-75	-	525	610	620	376	380	342	397
75-90	-	506	566	584	-	-	342	386
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	313	566	501	338	399	754	762	548
15-30	257	301	440	230	434	659	654	410
30-45	264	243	404	199	425	608	508	342
45-60	276	509	402	186	374	515	452	376
60-75	296	747	306	172	348	408	354	364
75-90	304	608	246	144	357	384	353	342

Table 11. Inorganic P content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Inorganic P content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	646	1746	170	201	234	551	331	567
15-30	166	1426	287	281	259	437	341	311
30-45	190	405	302	302	322	314	333	331
45-60	362	361	395	477	304	311	310	319
60-75	-	288	434	485	296	314	306	300
75-90	-	289	411	469	-	-	305	340
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	47	230	158	56	178	562	156	259
15-30	27	44	228	36	234	441	190	102
30-45	31	30	221	20	235	429	238	108
45-60	37	21	211	19	242	388	224	207
60-75	27	21	79	16	223	292	229	307
75-90	18	12	38	16	292	275	284	298

Table 12. Organic P content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Organic P content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	307	176	223	93	431	115	277	98
15-30	274	116	150	125	237	235	189	77
30-45	223	222	156	126	119	132	135	78
45-60	184	215	124	140	95	77	94	77
60-75	-	237	176	135	80	66	36	97
75-90	-	217	155	115	-	-	37	46
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	216	336	343	202	221	192	606	289
15-30	230	257	212	194	200	218	464	308
30-45	223	213	181	179	190	179	270	234
45-60	239	488	191	161	132	127	228	168
60-75	269	726	227	156	125	116	125	57
75-90	286	596	208	128	65	109	69	44

Table 13. Available P content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Available P content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	23.5	41.8	69.3	34.4	15.3	108.5	1.0	1.3
15-30	24.0	229.7	66.6	39.2	8.9	31.8	1.0	1.2
30-45	26.4	101.6	61.4	57.0	0.9	1.4	1.0	0.9
45-60	28.8	81.9	61.3	64.4	0.2	4.7	0.3	0.3
60-75	-	31.6	72.5	61.2	0.3	3.5	0.1	0.2
75-90	-	45.4	54.3	65.5	-	-	0.1	0.3
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	13.3	26.3	1.4	14.5	0.9	1.3	9.4	18.9
15-30	2.2	35.5	0.9	3.3	0.8	0.9	2.9	1.7
30-45	1.1	1.2	0.3	2.4	0.3	0.3	3.0	2.3
45-60	1.0	1.2	0.3	1.9	0.2	0.3	3.2	1.8
60-75	0.5	1.5	2.0	1.3	0.1	0.2	1.3	0.1
75-90	0.4	1.9	2.5	1.0	0.1	0.1	0.1	0.1

Table 14. Phosphorus sorption index of the eight paired virgin and cultivated soils.

Soil depth (cm)	P Sorption Index							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	523	208	64	73	103	55	162	76
15-30	343	286	70	74	211	162	298	256
30-45	283	251	77	89	313	290	311	247
45-60	237	149	125	137	373	342	354	221
60-75	-	99	113	97	584	581	391	406
75-90	-	103	23	23	-	-	225	196
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	169	121	150	159	129	147	96	95
15-30	210	145	296	179	228	222	140	103
30-45	215	154	322	178	271	246	134	101
45-60	197	147	315	173	347	275	144	90
60-75	189	91	154	213	690	740	420	405
75-90	167	122	151	180	573	518	357	371

Table 15. Particle size analysis of the surface 15 cm of the eight paired virgin and cultivated soils.

Soil	Particle size analysis (%)+					
	Virgin			Cultivated		
	Sand	*Silt*	*Clay*	*Sand*	*Silt*	*Clay*
Caribou	30	52	18	28	42	30
Dundee	12	72	16	12	68	20
Fargo	20	45	35	12	52	36
Houston Black	7	37	56	7	33	60
Keene	7	69	24	3	61	36
Leeper	24	39	37	21	32	47
Reakor	31	46	23	30	32	38
Webster	23	42	35	19	40	41

+Sand - 2.0 to 0.050 mm, silt - 0.050 to 0.002 mm, clay - less than 0.002 mm.

Table 16. Organic carbon content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Organic carbon content (μg/g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	47600	20500	5000	3500	47200	27500	24000	13600
15-30	12700	20000	3000	2500	13600	27600	16200	8600
30-45	8600	9200	2200	2300	10300	10200	14400	9100
45-60	12700	4000	1800	1500	5800	5300	10700	9100
60-75	-	2800	1400	1200	4800	3900	8300	7800
75-90	-	3800	1500	1200	-	-	8800	7400
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	13800	13700	17200	11800	7600	9200	46000	21000
15-30	3700	9700	8400	11000	6000	8600	30400	18100
30-45	2100	6800	6800	10100	4400	7300	19400	11200
45-60	3100	13100	6700	7900	4300	5400	12400	5500
60-75	2600	9500	10300	7900	2800	4600	6800	2800
75-90	2700	4800	12000	7700	2800	3600	3400	1600

Table 17. Carbon/nitrogen ratio of the eight paired virgin and cultivated soils.

Soil depth (cm)	Carbon/nitrogen ratio							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	14.8	10.1	7.8	7.9	11.5	9.1	10.4	11.6
15-30	12.3	11.6	7.6	8.0	10.4	10.0	10.9	10.2
30-45	10.6	9.5	6.0	7.8	9.8	9.0	12.6	13.0
45-60	11.8	6.5	6.0	5.5	9.4	8.3	12.9	13.2
60-75	-	5.4	5.1	4.9	9.2	8.1	13.2	14.7
75-90	-	6.3	6.0	5.1	-	-	13.9	13.5
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	18.3	10.3	11.0	11.6	9.2	9.8	11.9	12.3
15-30	9.4	10.9	9.9	12.7	8.2	8.4	11.1	12.7
30-45	5.9	12.5	10.7	13.0	7.1	8.3	11.5	10.3
45-60	9.2	16.1	11.5	11.6	9.4	8.3	10.7	9.5
60-75	8.2	13.9	12.8	13.7	7.2	8.2	11.5	9.3
75-90	7.6	8.8	12.5	14.5	8.0	8.2	12.1	8.9

Table 18. Carbon dioxide production of the eight paired virgin and cultivated soils.

Soil depth (cm)	Carbon dioxide production (μg/100 g soil)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	291	118	71	65	252	96	104	66
15-30	71	88	54	60	56	95	50	39
30-45	66	61	56	56	38	32	55	23
45-60	81	55	56	51	26	23	39	28
60-75	-	43	43	43	23	23	24	22
75-90	-	44	54	40	-	-	22	19
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	84	95	110	32	39	35	218	103
15-30	47	78	43	32	21	35	112	76
30-45	32	34	29	43	24	30	78	51
45-60	40	43	23	46	17	13	49	38
60-75	29	32	23	45	8	13	34	10
75-90	29	29	34	40	8	4	16	7

Table 19. Moisture equivalent of the eight paired virgin and cultivated soils

Soil depth (cm)	Moisture equivalent (% water content)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	35.9	25.2	30.3	28.3	51.1	45.7	56.0	48.3
15-30	28.2	39.5	22.4	27.8	39.0	50.3	58.7	52.6
30-45	28.3	31.5	23.1	30.3	45.9	45.7	45.2	56.3
45-60	31.4	24.4	26.8	31.5	41.9	40.5	54.4	59.5
60-75	-	24.8	27.9	30.2	43.2	41.0	54.0	61.0
75-90	-	23.6	30.3	20.0	-	-	56.4	59.3
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	32.3	33.3	46.8	36.4	24.4	23.2	39.6	27.6
15-30	30.6	30.8	38.9	40.3	30.3	26.2	44.3	38.6
30-45	35.4	33.9	39.1	38.4	32.8	26.3	37.6	35.7
45-60	37.1	50.6	38.5	40.8	31.2	29.9	34.6	29.7
60-75	39.8	45.3	35.3	42.8	33.4	31.8	31.4	25.8
75-90	40.2	40.4	39.6	44.7	31.0	33.1	29.0	25.0

Table 20. pH of the eight paired virgin and cultivated soils

Soil depth (cm)	Soil pH							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	5.0	5.6	6.2	5.7	7.8	8.3	7.9	7.9
15-30	5.3	5.4	6.0	5.0	8.2	8.0	8.0	8.3
30-45	5.3	5.4	5.4	4.9	8.6	8.6	8.2	7.8
45-60	5.2	5.5	5.4	4.9	8.7	8.8	7.8	8.1
60-75	-	5.5	5.1	4.7	8.5	8.5	8.0	8.2
75-90	-	5.5	5.1	5.1	-	-	8.1	8.2
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	4.3	6.3	7.9	7.9	8.2	8.1	7.4	6.3
15-30	4.3	6.4	7.8	7.9	7.8	8.0	7.3	6.5
30-45	4.5	4.8	8.1	7.6	7.8	7.8	7.8	6.8
45-60	4.6	4.4	8.0	7.1	7.8	7.7	7.8	7.3
60-75	4.6	4.4	7.9	7.2	7.9	7.6	7.9	8.1
75-90	4.9	4.4	7.6	6.9	7.8	8.0	7.9	8.0

Table 21. Calcium carbonate equivalent of the eight paired virgin and cultivated soils.

Soil depth (cm)	Calcium carbonate equivalent (%)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	-	-	-	-	2.9	6.2	32.7	38.2
15-30	-	-	-	-	15.8	8.4	33.9	37.7
30-45	-	-	-	-	24.6	27.3	43.2	39.6
45-60	-	-	-	-	41.1	43.5	38.5	38.9
60-75	-	-	-	-	41.0	43.9	41.1	38.1
75-90	-	-	-	-	-	-	40.6	38.5
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	-	-	18.4	3.5	20.9	18.4	5.5	0.3
15-30	-	-	34.0	1.4	27.1	16.5	9.4	1.6
30-45	-	-	49.2	0.6	39.6	19.7	7.6	0.1
45-60	-	-	23.5	0.8	36.3	22.8	6.8	4.5
60-75	-	-	6.3	0.4	39.9	26.1	8.9	15.9
75-90	-	-	3.1	0.7	40.1	30.7	11.8	20.7

Table 22. Exchangeable calcium content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Exchangeable calcium content (meq./100g)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	1.60	2.52	3.20	3.20	28.00	28.00	49.00	48.00
15-30	0.24	2.24	4.52	5.80	27.00	32.00	53.00	48.00
30-45	0.44	0.84	5.00	5.76	21.00	20.52	46.24	45.00
45-60	1.24	1.52	4.76	5.76	20.80	19.62	47.00	43.00
60-75	-	3.60	5.00	5.80	22.40	18.20	47.00	46.00
75-90	-	4.32	5.60	6.60	-	-	48.00	46.00
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	1.32	4.80	36.52	32.00	25.00	23.00	35.52	15.76
15-30	0.40	6.92	31.52	32.00	24.57	23.52	30.00	16.52
30-45	0.76	5.61	27.52	23.00	25.00	24.52	27.52	15.00
45-60	0.44	4.60	27.24	21.60	22.68	23.60	25.00	19.60
60-75	0.36	3.40	35.00	24.52	24.52	28.00	25.00	21.52
75-90	0.32	2.52	32.00	24.52	23.00	24.00	22.52	20.00

Table 23. Exchangeable sodium content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Exchangeable sodium content (meq./100g)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.10	0.07	0.03	0.04	0.09	0.11	0.06	0.07
15-30	0.06	0.06	0.04	0.09	0.10	0.15	0.08	0.03
30-45	0.06	0.07	0.13	0.13	0.17	0.13	0.12	0.06
45-60	0.06	0.05	0.20	0.19	0.26	0.18	0.21	0.09
60-75	-	0.05	0.17	0.26	0.30	0.42	0.36	0.10
75-90	-	0.05	0.17	0.30	-	-	0.52	0.08
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.02	0.03	0.05	0.05	0.05	0.11	0.07	0.07
15-30	0.04	0.05	0.04	0.06	0.12	0.10	0.06	0.07
30-45	0.04	0.05	0.04	0.07	0.15	0.08	0.07	0.07
45-60	0.04	0.05	0.09	0.08	0.18	0.10	0.07	0.07
60-75	0.04	0.05	0.07	0.08	0.18	0.10	0.06	0.07
75-90	0.05	0.04	0.09	0.08	0.21	0.13	0.07	0.07

Table 24. Exchangeable magnesium content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Exchangeable magnesium content (meq./100g)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.44	0.35	0.96	1.11	13.33	15.00	1.80	1.73
15-30	0.13	0.27	1.13	1.33	15.87	18.93	1.53	1.67
30-45	0.20	0.13	1.47	1.60	14.67	15.33	1.33	1.67
45-60	0.53	0.27	1.60	2.07	11.87	14.40	1.20	1.67
60-75	-	0.73	1.87	2.33	12.93	15.40	1.20	1.60
75-90	-	0.73	2.00	2.60	-	-	1.27	1.73
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.29	2.33	0.83	0.39	3.20	5.13	4.20	4.33
15-30	0.27	1.73	0.47	0.20	3.20	4.40	3.67	4.20
30-45	1.73	2.19	1.87	0.40	4.20	3.80	5.20	4.13
45-60	2.80	2.73	0.33	0.20	11.87	7.00	4.67	3.47
60-75	4.20	2.80	0.33	0.25	5.40	6.87	4.40	2.73
75-90	4.80	2.67	0.20	0.25	6.07	6.47	4.40	3.00

Table 25. Exchangeable potassium content of the eight paired virgin and cultivated soils.

Soil depth (cm)	Exchangeable potassium content (meq./100g)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.13	0.18	0.27	0.14	0.39	0.48	0.79	0.65
15-30	0.11	0.15	0.22	0.16	0.32	0.42	0.49	0.47
30-45	0.10	0.14	0.24	0.16	0.29	0.27	0.54	0.50
45-60	0.08	0.12	0.17	0.16	0.26	0.25	0.55	0.55
60-75	-	0.14	0.17	0.16	0.27	0.25	0.44	0.47
75-90	-	0.13	0.17	0.17	-	-	0.46	0.48
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	0.21	0.27	0.23	0.20	0.61	0.76	0.21	0.21
15-30	0.18	0.15	0.19	0.16	0.50	0.83	0.15	0.16
30-45	0.18	0.18	0.16	0.16	0.49	1.01	0.14	0.14
45-60	0.25	0.22	0.19	0.21	0.36	1.13	0.14	0.17
60-75	0.21	0.18	0.16	0.19	0.36	0.16	0.16	0.14
75-90	0.19	0.16	0.16	0.19	0.39	0.11	0.14	0.15

Table 26. Base exchange capacity of the eight paired virgin and cultivated soils.

Soil depth (cm)	Base exchange capacity (meq./100g)							
	Caribou		Dundee		Fargo		Houston B.	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	2.27	3.12	4.46	4.49	41.81	43.59	51.65	50.45
15-30	0.54	2.72	5.91	7.38	43.29	51.50	55.10	50.17
30-45	0.80	1.18	6.84	7.65	36.13	36.25	47.23	47.23
45-60	1.91	1.96	6.73	8.18	33.19	34.43	48.96	45.31
60-75	-	4.52	7.11	8.55	35.90	34.27	49.00	48.17
75-90	-	5.23	7.94	9.67	-	-	50.25	48.29
	Keene		Leeper		Reakor		Webster	
	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.	Vir.	Cult.
0-15	1.84	7.43	37.63	32.64	28.86	29.00	40.00	20.37
15-30	0.89	8.85	32.58	32.42	28.34	28.85	36.88	20.95
30-45	2.71	8.03	29.59	23.63	29.84	29.41	32.93	19.34
45-60	3.53	7.60	27.85	22.09	35.09	31.83	29.88	23.31
60-75	4.81	6.43	35.56	25.04	30.46	35.13	29.62	24.46
75-90	5.36	5.39	32.45	25.04	29.07	30.70	27.13	23.22

Table 27. Change in the nutrient content of the 0-15 cm depth of virgin Houston Black soil following cultivation for 60 years and change predicted by the EPIC model over a 50 year period (Williams et al., 1981).

Soil Property	Change in Nutrient Status							
	0-15 cm soil depth				75-90 cm soil depth			
	Measured		EPIC		Measured		EPIC	
	Amount	*Percent*[+]	*Amount*	*Percent*	*Amount*	*Percent*	*Amount*	*Percent*
	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)
Total N	1140	−49	1063	−40	80	−13	558	−36
Total P	57	+9	283	−18	44	+13	265	−25
Inorganic P	236	+71	147	−9	35	+11	155	−18
Organic P	179	−65	179	−55	9	+24	111	−57
Available P	0.3	−30	46.6	−83	0.2	+200	29.1	−75
Organic C	1.04	−43	1.23	−41	0.14	−16	0.13	−15
pH	No change		No change		0.1	+1	No change	

[+] Represented as a percent of that in the virgin soil.

Discussion

Soil properties. The eight soil series presented in this report comprise five soil orders, representing major agricultural areas of the United States. As is evident from detailed information in the respective tables, the soil profiles reflect an extremely wide range in chemical, physical, and biological properties. Also, the cultivated soils represent most major crops, with average to above-average fertilizer treatments. Previously, certain summary information regarding the distribution of N and P in the soils was noted (Smith and Young, 1975; Sharpley and Smith, 1983). It was not possible, however, to list the complete soil profile data due to space limitations. To the authors' knowledge, no such detailed information on paired virgin-cultivated soil profiles exists in the published literature. The preceding soil profile data is documented here because it provides a unique data base for use in testing models simulating nutrient cycling in the soil profile.

Model Test Example. The present data is used to evaluate prediction by the EPIC model (Williams et al., 1981) of soil fertility following long-term cultivation. The EPIC model can be divided into eight major components: hydrology, weather, erosion, nutrients, plant growth, soil temperature, tillage, and economics. The two plant nutrients considered are N and P, which require soil C, exchangeable cation and particle size information to run the nutrient component of the model. In addition, the soil profile is divided into a maximum of ten layers (the top layer thickness is set at 10 mm and all other layers may have variable thickness).

The only true direct test of model predictions is to conduct field experiments having the same management practices and length of time as input in the model. As EPIC was developed to simulate long-term effects of up to 50 years, field validation is, thus, impractical. One indirect method to evaluate estimates of EPIC is to compare predictions of the model with measured nutrient contents of paired virgin and cultivated soils of similar management to that input in the model. Consequently, the preceding data provide one method of evaluating predictions of the EPIC model.

The EPIC model (Williams et al., 1981) was run for Houston Black clay, cropped to a three-year rotation of cotton-grain sorghum-wheat for a 50-year period. Respective fertilizer N applications of 52, 160, and 30 kg N/ha/yr and for P 32, 32, and 0 kg P/ha/yr were made for each crop. Predictions of soil N, P, and C status from this run can be compared with the measured data for 60 years of cultivation of Houston Black clay given in this report. The predicted and measured percent change in nutrient content of both surface (0-15 cm) and subsoil (75-90 cm) following cultivation is given in Table 27. Reasonable estimates of the change in N, organic P, and C content of the surface soil (0-15 cm) following cultivation were provided by EPIC. In contrast, changes in the content of total and inorganic forms of P were not adequately described. Close predictions were also obtained for sub-soil changes (75-90 cm) in total N and organic C.

The above model test example using Houston Black clay illustrates how the virgin-cultivated soil profile data may be used as a general guide in evaluating EPIC predictions for cultural practices in the Southern Plains. The N and C components of the EPIC run compared favorably with the measured field values, whereas the comparison for P was poorer. Thus, for the given application with this soil and cultural practices,

the P subroutine in the EPIC program may require additional calibration and/or modification. Utilization of the virgin-cultivated soil profile data in conjunction with EPIC applications in the other land resource regions is anticipated to provide a similar guide for evaluating model predictions of nutrient cycling in soils.

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