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Field Appraisal of Resource Management Systems
FARMS

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Field Appraisal of Resource Management Systems FARMS

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ABSTRACT

This document presents objectives and results of the Field Appraisal of Resource Management Systems (FARMS) study's second year. The principal objectives of FARMS were to study the relationship of crop yields to soil erosion and to simulate the economic nature of this relationship. Crop management, soils, conservation practices and management, crop yields, soil chemistry, and sociological data were collected from 800 plots in 1981. This report presents statistics for rill and sheet soil erosion which are estimated by the Universal Soil Loss Equation (USLE) and assumed to represent a long term rather than short term effect. The report also presents summary statistics for each of the factors in the USLE: for potato yields and quality, for yields of six other field crops, and for soil nutrient analyses.

No general response of potato yield and quality to predicted soil erosion was found. However, individual potato varieties responded differently to predicted soil erosion. Potato yields and specific gravity were found to be significantly related to the Cover and Management factor (C). Potato yield was found to decrease as intensity of potato production increased in the rotation period. Potato yields were significantly reduced when the previous crop was potatoes in comparison to grain or hay.

INTRODUCTION AND LITERATURE REVIEW

Soil erosion is a major problem on land planted to row crops in Aroostook County, Maine. The cropped area is one of the more intensively farmed areas in the United States. During recent years a major portion of this cropland area has been planted to potatoes with 96,000 acres planted to potatoes in 1981.

Potato culture is particularly tillage intensive which leads to organic matter depletion, unprotected soil and increased soil erosion. Frequently the rows are oriented up and down slope to ensure surface drainage and to prevent the detrimental effects of ponding on the crop. Additionally, tillage required to hill potato rows during the growing season creates ridges. Oriented up and down the slope these potato ridges can intensify the effects of moving water. Harvesting operations also cause deep soil disturbance and are usually carried out too late in the fall to permit the establishment of winter cover crops. All these conditions aggravate soil erosion on cropland (15).

Soil erosion has an immediate and a long range effect. Of immediate concern is the damage caused by transported soil particles which contribute to the sediment load and pollution of surface water. Water is polluted by the soil particles themselves and also by agricultural chemicals adsorbed on transported soil particles.

A future concern is the loss of productivity due to year upon year of soil erosion. Since soil is the basic medium on which plants grow, there is reasonable concern that high rates of erosion for enough years could produce declines in productivity which cannot be offset by technological advances. To some extent crop management has allowed farmers to mask or compensate for high rates of erosion. In the future, improvements in agricultural technology may result more in maintaining crop yields and quality rather than improving them.

The concern about soil erosion in Aroostook County is due to estimates of the amount of erosion and to the potential consequences to the soil resource base for the agricultural industry if these high rates of erosion continue. The study of Non-Point Agricultural Pollution (SNAP) estimated that the average annual rate of soil erosion varied between 5.2 and 6.3 tons per acre per year for land in row crops during the years 1979 to 1983 (2). Soil loss in excess of 3.0 tons per acre per year is considered sufficiently serious to more than offset natural processes of soil formation in most Aroostook County soils. This tolerable rate of erosion (T) serves as a practical means for identifying areas most in need of conservation treatment.

Conservation practices have been applied in Aroostook County to varied degrees over the past 40 years. These practices address one or more of the factors contributing to the rate at which cropland erodes. However, only 41 percent of crop land has been adequately treated according to recent estimates reported by the SNAP study (3).

This bulletin presents preliminary analyses of the 800 plots sampled in 1981. It is the third in a series of reports which will eventually summarize the FARMS data collection and analysis work. The analyses of the 1982 data, a summary of all three years, and a report concerning the economics of erosion consequences and control are scheduled for publication in the near future.

Objectives and Assumptions of "Farms"

The Field Appraisal of Resource Management Systems (FARMS) study was initiated to address two general objectives. The first concerns the relationship of crop yield and quality to predicted soil erosion rates, conservation management, crop management, soil and soil fertility. The impact of soil erosion on crop yield and quality is examined by using erosion rates predicted by the USLE (15). This current estimate is assumed to represent past, long-term erosion effects. Erosion phases, (14), a more traditional long-term indicator of erosion, cannot be consistently measured for the thinly developed, deeply disturbed soils of this Major Land Resource Area, MLRA 146.

The second general objective of the FARMS study concerns the adoption of conservation practices by farmers. By evaluating the effects of different combinations of practices on net farm income, crop budget procedures should help farmers make informed choices in controlling erosion. Farmers should also be better able to assess the long-term value of investments in conservation.

This report is designed to provide information on the following specific questions raised at both the State and National levels during the recent Resources Conservation Act (RCA) process - a process designed to make soil and water conservation efforts more efficient and effective.

1. Is there a relationship between predicted amounts of soil erosion and crop production?

2. Is there a relationship between predicted rates of soil erosion and crop quality?

3. Do conservation rotations improve crop quality and increase crop yields, and, if so, to what extent?

4. What are the effects of soils on crop yields?

5. What soils are being used for crop production in Aroostook County?

6. Can, and are increased rates of fertilizer offsetting productivity loss caused by soil erosion?

7. Do some varieties of potatoes produce better yields and quality with similar management practices on the same soils?

The FARMS study assumed that the farmers in Aroostook County have carried out a wide array of conservation management from very good to very poor over several decades. It is also assumed that the conservation management observed at the time of the study reflects the past history of conservation management. It is further assumed that the USLE (15) provides an adequate assessment of the levels of soil erosion and conservation management for the purpose of estimating their effect on potato yield and quality.

METHODS

The FARMS study area is located primarily within MLRA 146 and is almost entirely within Aroostook County in northeastern Maine. Four townships in northern Penobscot County which are included in the Southern Aroostook Soil and Water Conservation District are also within the Project Area. The FARMS study area encompasses 2,721,733 acres. About 9 percent of the FARMS study area is used for row crops. The major crop is potatoes with which significant acreages of oats, hay and peas are grown in rotation. Most of the remaining land is forest, or idle land that is being allowed to revert to forest.

The topography of the central and southern part of the study area consists of long rolling ridges with broad, gently sloping crests that reach 500 to 800 feet above sea level. The land is steeper in the northern part of the study area with some hills above the 1,000 foot elevation. Nearly level to gently sloping river terraces and flood plains are along waterways throughout the area.

Average annual precipitation is 36 to 40 inches and is evenly distributed throughout the year. Snowfall averages 100 inches per year. The average annual temperature ranges from 37 degrees F to 42 degrees F, and the frost-free period ranges from 100 to 120 days.

The area's many perennial streams and lakes provide an abundance of surface water. Ground-water yield is high in the outwash and alluvium deposits in the valleys, but is relatively low in the glacial till deposits and bedrock of the uplands.

Most of the soils sampled in the study area have medium to coarse texture, a frigid temperature regime, mixed mineralogy and are on nearly level to strongly sloping glacial till ridges (6,7). More than 50 percent of the plots in the study area contained soils developed in weathered limestone influenced glacial till. The major soils are the very deep, well drained Caribou, moderately well drained and somewhat poorly drained Conant, and the shallow, well drained and somewhat excessively drained Mapleton soils. More than 25 percent of the plots in the study area contained soils developed in glacial till with little or no limestone influence. The major soils are the very deep, well drained Bangor and Plaisted, moderately well drained Chesuncook and Perham, somewhat poorly drained Telos and Daigle, the shallow somewhat excessively drained Thorndike and Monson and the moderately deep, well drained Elliottsville and Winnecook soils. Other plots contained soils developed in glacial outwash and soils in recent alluvium on flood plains. These soils are important to agriculture but their total area is small.

Twenty four hundred experimental plots were selected through a two stage randomization. Three hundred 80 acre blocks of cropland were selected at random from all possible 80 acre blocks of cropland. Eight plots were located at random within each block. One hundred blocks, i.e., 800 different plots were studied each year. Plot size for crop yields was 43.56 square feet, or 1/1000 acre (5).

The data collected for the FARMS study fall into six major categories:

1. SOILS. A 24 inch diameter pit was excavated to 40 inches or refusal (bedrock or boulder) on each plot, and the soil described. Color, texture, thickness, structure, consistence, roots, and rock fragments were described for each major soil horizon or layer (Ap, Upper B, Lower B, and C). Depth to mottling, water table, and bedrock or a root restricting zone were recorded for each profile. The percent slope, aspect, stoniness, and rockiness were recorded for each plot. All plots were located on published soil survey atlas sheets and the map symbol for each was recorded. The soil at each plot was classified by series. Soils names used in this report are based on the most recent Soil Conservation Service (SCS) classification information available and in some cases will differ from the published soil survey reports. The crop at the time of soils investigation was also recorded. A quart sample of soil for laboratory analyses was collected from the plow layer from a minimum of 15 points within each plot. Soils were analyzed for 10 nutrients by pH 3.0 ammonium acetate (8), Walkley-Black organic matter (12), water pH (12), exchangeable cations by pH 7.0 ammonium acetate (12), potassium chloride acidity (12), and barium chloride-trietha-

nolamine acidity (8) by the analytic laboratory of the Department of Plant and Soil Sciences, UMO.

2. CROP HISTORY. Information on the rotation employed over at least the past four years, disposal of residues, use of manure, and basic tillage were collected.

3. CONSERVATION PRACTICE. Data on length and steepness of slope, crop row orientation in reference to the slope, and water control were recorded. Several component factors of the USLE were also determined and recorded.

4. CROP MANAGEMENT. Information was collected and recorded regarding crop, variety, seed source and quality, intended market, fertilizer applied and the pesticides used in order to raise the crop.

5. CROP YIELDS. Crop yields were obtained from each plot. Potatoes were subjected to detailed grading for official grades as well as for defects. Specific gravity was also determined for potatoes.

6. SOCIOLOGICAL DATA. Sociological information was collected on the farm operator and the farm operator's family, for use in evaluating various soil conservation policy alternatives. The analysis of these data will be incorporated in a future economic report on the FARMS study.

The USLE is used to predict average annual sheet and rill erosion soil losses from a particular cropland area (12).

The USLE formula is: $A = R \times K \times LS \times C \times P$ where

A = Soil Loss: Average annual predicted soil loss in tons per acre.

R = Rain and Snowfall: The R factor reflects intensity and frequency of rainfall events. Heavy snowfall also would increase R. The study area was considered uniform and an R value of 75 was used for all USLE estimates.

K = Soil Erodibility: Some soils erode more easily than others. More erodible soils have the higher K values.

LS = Length and Steepness of Slope: Susceptibility to erosion increases as slope length or steepness increases. These measurements are combined mathematically into a single topographic factor (LS).

C = Cover and Management: This factor considers rotations, and the type and time of tillage operations. The type and amount of surface residue also affects the rate of erosion and is considered in assigning a value to this factor.

P = Conservation Practice: The value for this factor is assigned primarily to account for up and down hill farming, contour farming, contour stripcropping, and diversions or other techniques designed to reduce length of slope.

The USLE equation does not predict soil losses for a particular year, rather it predicts average annual soil losses. Furthermore, the USLE does not predict how much soil ends up in a lake or stream. It predicts how much soil erodes from a particular field or area of a field. The following example demonstrates a typical conservation application of the USLE on agricultural crop land:

> A field in Aroostook County, Maine has Caribou silt loam soil on a six percent slope 600 feet long. The rotation, three years, is potatoes, potatoes, oats. All crops are moldboard spring plowed and farmed up and down hill. Under these conditions R is 75, K is 0.28, LS is 1.65, C is 0.31, and P is 1.00. The USLE average soil loss for this field is 10.7 tons per acre each year. Conservation management can be used to lower the rate of soil erosion by changing LS, C, and P. Diversions installed across the slope at 200-foot intervals would lower the LS value to 0.95. Adopting a two year rotation of potatoes and oats (stubble mulched) reduces the C factor to 0.18, and farming on the contour reduces the P factor to 0.5. Average annual soil loss with these conservation practices is 1.8 tons per acre, well below the T level of 3 tons per acre.

The SAS statistical package was used for all data analyses (13). Since all analyses involved unbalanced data, the GLM procedure was employed including both continuous and discontinuous independent, i.e., treatment variables. Treatment means were adjusted through the least squares procedure employing the 5 percent level for significance.

RESULTS AND DISCUSSION

Soils and Soil Erosion

Table 1 shows the distribution of plots by soil, Soil and Water Conservation District (SWCD), and Prime Farm Land. More than 42 percent of the plots are on Caribou soils. Three soils, Caribou, Conant and Mapleton, all developed in weathered limestone influenced glacial till, constitute 61 percent of the 1981 plots. It should also be noted that few if any of the soils are proportionally represented in the three SWCD's.

Sixty five percent of the study plots were located on prime farm land. Prime farm land has the best combination of physical and chemical characteristics for producing food.

Estimates of Tolerable Soil Loss (T) are also presented in Table 1. T represents the amount of soil loss that can be experienced without reducing the long term agricultural productivity of the soil. The soils in the FARMS study area will not tolerate appreciable soil erosion as evidenced by the fact that all but eight plots have T values of 3 or less.

The individual USLE factors were either measured or estimated for each plot. The means and variability for A and the individual USLE factors K, LS, C, and P, are given in Table 2. The average estimated soil loss was 4.21 tons per acre, with a large standard deviation and coefficient of variation. The average estimated soil loss in 1981 was 0.5 tons less than was observed in 1980 (10), and considerably less than the 6.2 and 5.7 tons per acre for Aroostook County in the 1979 and 1982 SNAP inventories (1,2). The standard deviation was also smaller in 1981 than in 1980. This was probably due to several 1980 plots with rates of erosion in excess of 25 tons. The distribution of plots by increments of predicted erosion, A, is given in Table 3. This distribution is skewed with over half the plots having levels of A from 3.00 to 25 tons per acre per year. Since T, the tolerable soil loss, is 3 for most of the soils in the study area, half the plots need additional conservation treatment. The factor R for the entire study area was 75 and therefore does not affect the calculation of A from one plot to another. The two components of LS were measured from the point of overland flow, through the plot, to the point of deposition or interception for Tables 2 and 3. For analyses relating potato yield and quality to the USLE, the components of LS were measured from the point of overland flow to the plot.

The K values used were assigned values for each soil from the Maine Technical Guide Handbook (4) and then adjusted according to the soil texture and content of rock fragments as described for that individual plot. The average K values vary by soil from 0.12 for Masardis to 0.49 for Nicholville, Table 1. The Caribou, Conant and Mapleton soils,

Table 1. Distribution of Plots By Soil, Soil and Water Conservation District, Prime Farmland, Soil Erodibility (K), and Tolerable Soil Loss (T), FARMS, 1981.

SOIL	Number of Plots					K	T
	Tot	StJ	Cen	Sou	Prime Farm Land		
Caribou	338	17	260	61	261	0.28	3
Conant	92	0	79	13	84	0.32	3
Mapleton	57	6	31	20	28	0.34	2
Thorndike	43	29	0	14	0	0.17	2
Chesuncook	35	15	18	2	27	0.27	3
Winnecook	32	22	0	10	30	0.17	3
Telos	26	8	14	4	0	0.28	3
Elliottsville	21	7	9	5	19	0.18	3
Monson	18	5	6	7	0	0.18	2
Plaisted	17	14	0	3	10	0.23	3
Bangor	17	10	0	7	14	0.18	3
Daigle	15	0	14	1	0	0.29	3
Perham	11	0	10	1	9	0.28	3
Masardis	10	0	10	0	0	0.12	3
Easton	9	0	5	4	0	0.22	3
Stetson	9	2	7	0	9	0.13	3
Allagash	8	3	5	0	7	0.26	3
Linneus	8	0	0	8	1	0.37	3
Madawaska	7	3	4	0	6	0.27	3
Monarda	6	6	0	0	0	0.26	3
Fryeburg	4	4	0	0	3	0.32	5
Machias	4	0	4	0	4	0.13	3
Howland	3	3	0	0	2	0.21	3
Berkshire	2	0	2	0	2	0.25	3
Dixmont	2	2	0	0	2	0.16	3
Lovewell	2	2	0	0	2	0.32	5
Ondawa	2	2	0	0	2	0.24	5
Nicholville	1	0	1	0	1	0.49	3
Skowhegan	1	0	1	0	0	0.16	3
TOTAL	800	160	480	160	523	-	-

StJ = St. John Valley, Cen = Central Aroostook,
Sou = Southern Aroostook, SWCD's.

Table 2. Summary Statistics for Estimated Soil Loss (A) in Tons Per Acre, and for Selected Factors of the Universal Soil Loss Equation, 800 Plots, FARMS, 1981.

Statistic	A	K	L	S	LS	C	P
Mean	4.21	0.27	433	4.99	1.06	0.25	0.90
Std. Dev.	3.51	0.07	248	2.65	0.86	0.09	0.13
CV	83	24	57	53	82	38	15
Maximum	24.68	0.49	1500	15	5.98	0.45	1.00
Quartile-3	5.64	0.31	550	6	1.40	0.30	1.00
Median	3.19	0.28	400	4	0.80	0.24	1.00
Quartile-1	1.79	0.24	250	3	0.45	0.19	0.75
Minimum	0.05	0.06	10	1	0.10	0.01	0.40

A = Estimated Annual Soil Loss-Tons Per Acre
K = Soil Erodibility Factor
L = Length of Slope Feet
S = Steepness of Slope Percent
LS = LS Factor
C = Soil Cover and Management Factor
P = Conservation Practice Factor

Table 3. Distribution of the 1981 FARMS Plots by Increments of Erosion (A) as Predicted by the USLE, FARMS, 1981.

Predicted Erosion	Number of Plots	Percent of Plots
0.00-1.00	80	10.0
1.01-2.00	153	19.1
2.01-3.00	146	18.3
3.01-4.00	117	14.6
4.01-5.00	71	8.9
5.01-6.00	55	6.9
6.01-7.00	42	5.3
7.01-8.00	22	2.8
8.01-9.00	28	3.5
9.01-10.00	23	2.9
10.01-15.00	54	6.8
15.01-20.00	7	0.8
20.01-25.00	2	0.3

which comprise almost 500 of the 800 plots, all have average K values from 0.28 to 0.34, somewhat higher than the weighted average of 0.27 for all plots. The practice of removing rocks from the fields to facilitate tillage operations has the effect of increasing the soil erodibility.

The conservation practice factor, P, has a limited variability, with 60 percent of the plots having the maximum P value of 1.00, and 97 percent of the plots had P values ranging from 0.75 to 1.00, Tables 2 and 4. Direction of rows in relation to the slope is a primary determinant for establishing the value of P. In 1981 row direction was up and down the slope for 374 plots. Thus 47 percent of the plots had the row direction affording the poorest protection ($P = 1.00$) against erosion. Cross slope farming, 385 plots, affords some protection ($P = 0.75$ to 0.95) against erosion. However, stripcropping and contour stripcropping which provide better protection are not well represented. Construction of diversions and waterways in conjunction with contour stripcropping provides the best protection. Increased use of stripcropping and grassed waterways would result in lower P values and reduced erosion. The practice of planting up and down the slope may in part be intended to prevent extended periods of ponding or flooding which potatoes do not tolerate. It may also result from efforts to maximize the efficiency of field operation, by orienting rows with the longer dimension of the field.

Table 4. Distribution of Plots by Conservation Practice (P), FARMS, 1981

Conservation Practice P	Number of Plots	Percent of Plots
0.40	1	0.1
0.43	1	0.1
0.50	16	2.0
0.60	6	0.8
0.75	205	25.6
0.80	91	11.4
0.85	2	0.3
1.00	478	59.8

Crop History

Table 5 presents typical C values for rotations replicated on 10 or more plots. The average C value is 0.25, with a normal distribution about this mean ranging from 0.004 to 0.45, Table 2. Factor C represents the relative soil cover or protection provided by plant material. Choice of rotation has a major impact on C values, Table 5. Continuous potatoes (P), and Potatoes-Peas (PPe) leave the soil exposed to the erosive force of rain drops as well as the movement of water across slopes, particularly in comparison to rotations such as Potatoes-Grain (PG), Potatoes-Hay (PH), or Potatoes-Grain-Hay (PGH).

Distribution of the crops by SWCD is given in Table 6. Potatoes were grown on 53 percent and oats on 22 percent of the plots. None of the crops were proportionally distributed over the three districts. Potatoes and oats were concentrated in the Central Aroostook SWCD. The Southern Aroostook SWCD had the lowest concentration of potatoes and oats. Hay and pasture were concentrated in the St. John Valley and Southern Aroostook SWCD's where a majority of the livestock are found. Peas, a crop of variable acreage from year to year, are concentrated in the Southern and Central Aroostook SWCD's. Very few plots of the other crops were encountered.

Table 5. Principal Rotations, FARMS, 1981.

Rotation	Typical C Values	Number of Plots	Percent
PG	0.24	142	17.7
PPG	0.31	114	14.3
PPPG	0.34	105	13.1
PPGH	0.21	75	9.4
P continuous	0.44	67	8.4
PPe	0.47	47	5.9
PPGG	0.25	28	3.5
PGPPe	0.36	26	3.2
PGH	0.13	25	3.1
H	0.004	21	2.6
PPPeG	0.38	16	2.0
PPPe	0.46	14	1.8
PGHH	0.11	13	1.6
PH	0.15	10	1.3
Miscellaneous		97	12.1
Total		800	100.0

a. P = potatoes, G = grain and buckwheat, H = hay-pasture, Pe = peas.
b. From Maine Technical Guide (4).

Table 6. Number of Plots by Crop and SWCD, FARMS, 1981.

CROP	CONSERVATION DISTRICT			TOTAL
	St.John	Central	Southern	
Potatoes	81	287	59	427
Oats	34	127	18	179
Hay-Pasture	26	16	31	73
Peas	8	28	22	58
Corn	0	0	11	11
Buckwheat	10	0	0	10
Millet	0	10	0	10
Rye	0	0	7	7
Wheat	0	0	4	4
Idleland	1	12	8	21
Total	160	480	160	800

Crop Yield

Yields from nine different crops were obtained in 1981, seven are listed in Tables 7 and 8. Rye and wheat were replicated on fewer than 10 plots and are not included. In general, crop yields for 1981 were similar to the yields obtained in 1980 (10). The considerable variability found in yields for all crops indicates a major opportunity for many farmers to improve yields, particularly since the average yield levels, while reasonable, were not outstanding. Percent pickout for the potatoes was 24 percent, leaving 76 percent US-1. US-1 potatoes averaged 236 hundredweight per acre with the middle half of the plots, Q-1 to Q-3, ranging from 184 to 285 hundredweight.

Potato yields were obtained from 412 plots in 1981. The plots were distributed unequally among 15 varieties and 24 soils. Since many of these varieties and soils were inadequately represented, a dataset was formed containing seven varieties on the seven most frequently encountered soils, Table 9. This dataset however, still lacks representation for 11 of 49 variety-soil combinations and is inadequately represented for many other combinations.

Yields for the seven varieties are presented in Table 10. Large significant differences were found associated with varieties, particularly for yield of US-1, percent US-1, and specific gravity. The round white varieties had a much higher percentage of US-1 than the russet varieties, Bur-

Table 7. Summary Statistics for Potato Yield and Quality, FARMS, 1981.

Statistic	Gross cwt.	US-1 cwt.	US-1 Pct.	Specific Gravity
Mean	310	236	76	1.075
Std. Dev.	80	78	14	0.008
CV	26	33	19	0.78
Maximum	561	497	97	1.095
Quartile-3	363	285	86	1.081
Median	310	232	79	1.074
Quartile-1	225	184	68	1.069
Minimum	12	0	0	1.051
No. of Plots	412	412	412	410

Table 8. Yields for Crops other than Potatoes, FARMS, 1981.

Statistic	Net Yield - Pounds Per Acre					
	Oats	Hay	Peas	Corn	Buckwheat	Millet
Mean	1786	3835	3116	35850	1831	1119
Std. Dev.	721	2324	1036	8363	288	634
CV	40	61	33	23	16	57
Maximum	4597	9467	5785	52600	2172	2070
Quartile-3	2220	5315	3810	41900	2075	1743
Median	1730	3118	3118	36400	1874	920
Quartile-1	1310	1925	2200	31000	1571	583
Minimum	250	570	1410	22650	1301	420
No. Plots	163	68	40	11	10	10

bank and BelRus. The russet varieties had the highest specific gravity, but significant variability still remained among the five round white varieties. In general, the Superior and Atlantic varieties performed best. BelRus, which had very low yields in 1981 as in 1980 would require a considerable premium at the market place to compensate for its low yields.

Table 9. Plot Distribution of the Seven Potato Varieties and Seven Soils with the Highest Frequencies, FARMS, 1981.

Soil	Variety							Total
	Su	RB	Kat	Bel	Ken	Ont	Atl	
Caribou	58	37	40	14	17	11	7	184
Mapleton	3	14	3	4	0	3	3	30
Conant	10	6	9	3	2	1	1	32
Chesuncook	9	5	1	1	0	1	0	16
Winnecook	3	1	5	5	0	0	0	14
Thorndike	2	1	7	1	0	1	0	12
Plaisted	6	2	1	0	0	1	0	10
Total	90	66	66	28	19	18	11	298

Su = Superior, RB = Russet Burbank, Kat = Katahdin,
Bel = BelRus, Ken = Kennebec, Ont = Ontario, Atl = Atlantic

Table 10. Yield and Quality of Potatoes as Related to Variety, Seven Variety-Seven Soil Dataset, FARMS, 1981.

Variety	Number of Plots	Yield---cwt.		US-1 Pct	Specific Gravity
		Gross	US-1		
Atlantic	11	292 ab	263 a	89 a	1.076 c
Superior	90	294 b	250 a	85 a	1.073 cd
Ontario	18	283 b	221 ab	77 b	1.066 f
Russet Burbank	66	329 a	218 ab	67 c	1.082 b
Kennebec	19	270 b	216 ab	79 b	1.071 de
Katahdin	66	281 b	215 b	77 b	1.069 ef
BelRus	28	218 c	150 c	69 c	1.086 a

*Any two means followed by a common letter are not significantly different, p = 0.05.

The response of potato yields and quality to soils for the Seven Variety-Seven Soil dataset is presented in Table 11. Significantly lower gross and US-1 yields were found with the Thorndike, Chesuncook and

Plaisted soils than with Caribou. Neither percentage of US-1 potatoes nor specific gravity were affected by soil.

Table 11. Yield and Quality of Potatoes as Related to Soil, Seven Variety-Seven Soil Dataset FARMS, 1981.

Soil	Number of Plots	Yield—cwt Gross	US-1	US-1 Pct	Specific Gravity
Caribou	184	318 a	250 a	79	1.076
Winnecook	14	298 abc	243 ab	82	1.075
Mapleton	30	311 ab	240 ab	77	1.077
Conant	32	295 abc	230 ab	77	1.075
Thorndike	12	269 bcd	215 abc	80	1.075
Chesuncook	16	258 cd	197 bc	76	1.075
Plaisted	10	217 d	158 c	72	1.071
				ns	ns

Significant differences were also associated with geographic location. The highest yields were in the Southern Aroostook SWCD while the lowest were in the North, the St. John Valley SWCD, Table 12. There were no differences in percentage of US-1 potatoes associated with District. Specific gravity was highest in the Southern District and lowest in the North.

The differences which appear to exist among districts might be associated with latitude or climate. However, Table 13 shows that the three lowest yielding soils (see Table 11) are dominant (27 of 43 plots) in the St. John district. Whether these soils alone account for yield differences

Table 12. Yield and Quality of Potatoes by SWCD, Seven Variety-Seven Soil Dataset, FARMS, 1981.

SWCD	Number of Plots	Yield—cwt Gross	US-1	US-1 Pct	Specific Gravity
St.John Valley	43	269 b	204 b	76	1.073 c
Central	217	311 a	244 a	79	1.076 b
Southern	38	338 a	264 a	79	1.078 a
				ns	

een in comparing the St. John Valley with other Districts is not clear. It s possible that latitude and climate could account for the poorer yields ıssociated with the three soils (Chesuncook, Thorndike, and Plaisted), since the growing season is a couple of weeks shorter and temperatures are lower in the St. John Valley SWCD resulting in fewer heat units than in the Southern Aroostook SWCD.

Table 13. Distribution of Plots of the Seven Principal Potato Varieties and Seven Soils among Aroostook County's Three SWCD's, FARMS, 1981.

VARIETY or SOIL	CONSERVATION DISTRICT			
	St. John	Central	Southern	Total
Superior	16	62	12	90
Russet Burbank	13	52	1	66
Katahdin	7	40	19	66
BelRus	0	22	6	28
Kennebec	0	19	0	19
Ontario	7	11	0	18
Atlantic	0	11	0	11
Total	43	217	38	298
SOIL				
Caribou	8	157	19	184
Conant	0	31	1	32
Mapleton	4	21	5	30
Chesuncook	8	8	0	16
Winnecook	4	0	10	14
Thorndike	9	0	3	12
Plaisted	10	0	0	10
Total	43	217	38	298

Soil Erosion and Potato Yields

A Three Variety-Three Soil (3VAR-3SOIL) dataset was formed from the varieties Superior, Katahdin, and Russet Burbank, on the soils Caribou, Conant, and Mapleton. This dataset consisted of 180 plots, Table 9, and was formed to avoid empty cells for the variety by soil combinations while studying the relationship of potato yield and quality to estimated soil erosion (A), and to the individual factors making up the USLE. The 3VAR-3SOIL dataset did not show a significant main effect response of potato yield or quality to A, the USLE estimated soil erosion. While some individual varieties exhibited significant responses for yield to estimated erosion there was no general trend either for the 3VAR-3SOIL dataset or for datasets with 7 or all 15 varieties. In 1980 the 3VAR-3SOIL dataset and the 7VAR-CARIBOU SOIL dataset exhibited significant decreases in yield associated with A as well as with factors K (Soil Erodibility) and C (Cover and Management) (10).

The USLE is a static multiplicative equation which predicts soil loss (A) in tons/acre/year from the product of five independent factors (15). The contribution of each of the individual factors to the estimate of A can be separately evaluated. All possible simple correlations among the factors, and between each of the factors and A, are presented in Table 14 for the 412 potato plots. The correlation data clearly show that A for this dataset is primarily a function of LS, the topographic factor. A further breakdown of LS showed that steepness of slope (S) is the primary component of LS which accounts for the determination of A. P and C are also contributing significantly to A, but their main effect contributions are much smaller. The relatively low correlations among the factors LS, C, K and P show that they are not positively or negatively reinforcing each other in this set of 412 potato plots.

The relation of yield and quality of potatos to the individual USLE factors was also studied.

Table 14. Simple correlations among A and the individual USLE factors, potato plots, FARMS, 1981.

USLE Factor	LS	C	K	P
A	0.87*	0.27*	0.00	0.37*
LS		0.00	-0.19*	0.26*
C			-0.20*	0.04
K				-0.05

*significant p=0.05, n=412.

The yield and quality responses to the topographic factor LS were negligible and similar to the response to A. The conservation practice factor, P, did not exhibit much variability as a majority of the 800 plots had the maximum P value of 1.00, Table 4. P therefore, could hardly be expected to, and did not explain any variability of potato yield or quality.

Potato yields and specific gravity did respond significantly to C, the Cover and Management factor. Gross yield, US-1 yield, and specific gravity all decreased with increasing values of C, Figures 1 and 2. Reduced yields and specific gravity were associated with rotations providing less crop cover protection to the soil. Specific varieties exhibited differential responses. Russet Burbank did not exhibit a significant yield trend to C. Superior and Katahdin showed dramatic yield reductions with increasing C. Varietal response of specific gravity showed Superior

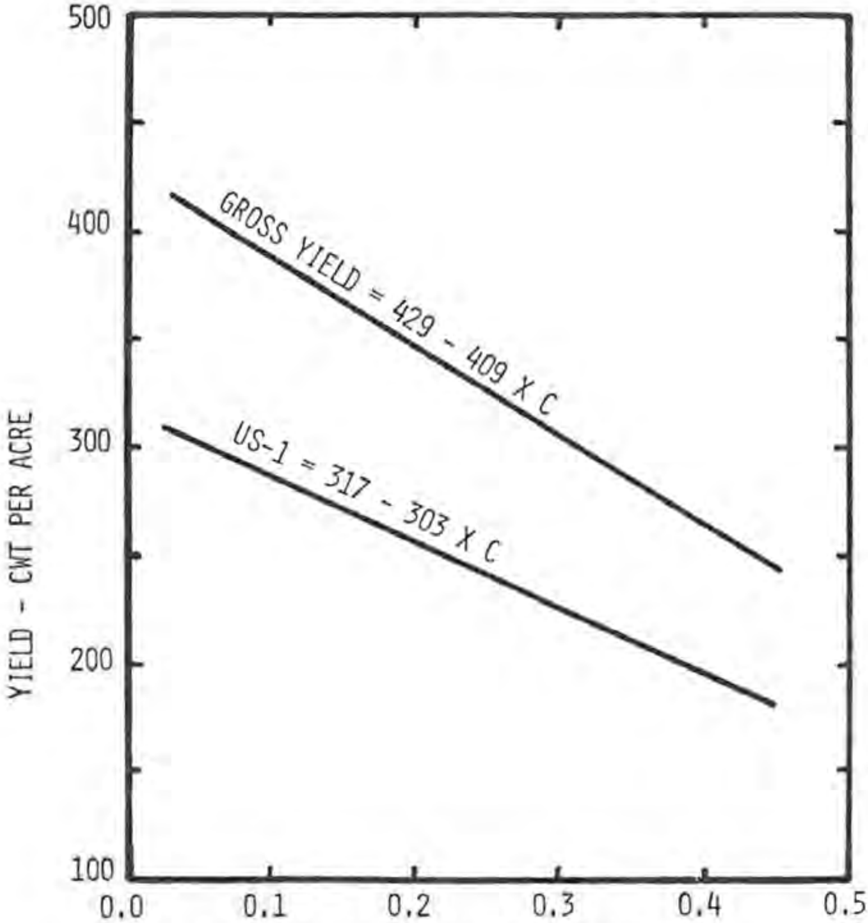

Figure 1. Yield of potatoes as related to C, the cover and management factor of the USLE; FARMS, 1981.

with increases but Russet Burbank and Katahdin with decreases as C values increased.

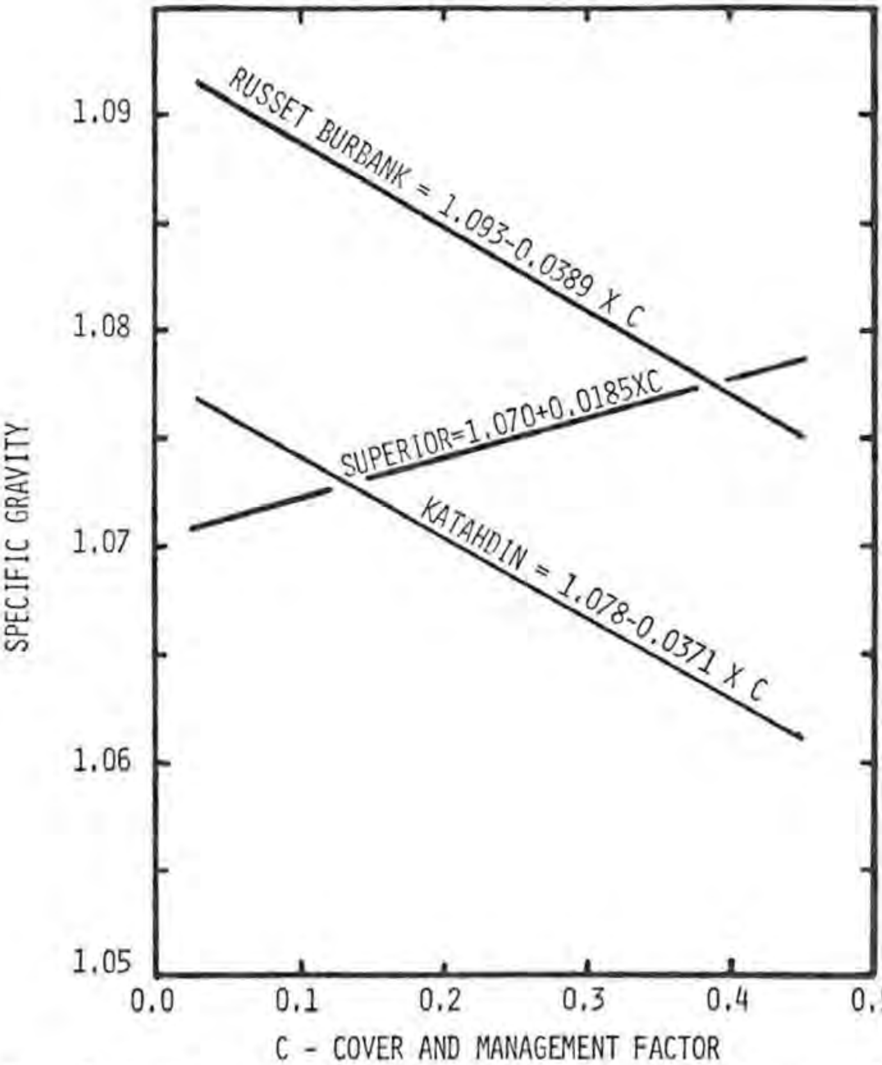

Figure 2. Specific gravity of three potato varieties as related to C, the cover and management factor of the USLE; FARMS, 1981.

Since C is determined by such practices as rotation and type and time of tillage, it is under direct control of the farm operator and therefore subject to management changes. These cultural practices may affect yield directly and for reasons other than their indirect influence on the rate of erosion. This prompted the examination of the relationship of potato yields to specific rotations. The first five rotations in Table 5 are the most common and also provide a set of rotations with increasing intensity of potato production.

The relation of potato yield and quality to rotation for the 3VAR-3SOIL dataset is presented in Table 15. Significant yield decreases associated with increased intensity of potato production are shown for both gross yield and US-1 yield. While there were differences in percentage of US-1 and specific gravity, these differences did not appear to be linearly associated with increasing intensity of potato production. Note however that the specific gravity for continuous potatoes (P) was significantly lower than for the other rotations.

Table 15. Effect of Rotation on the Yield and Quality of Potatoes, Three Variety-Three Soil Dataset, FARMS, 1981

Rotation	Number of Plots	Yield---cwt. Gross	US-1	US-1 Pct	Specific Gravity
PG	27	367 a	288 a	79 a	1.077 ab
PPGH	30	338 ab	263 ab	78 ab	1.074 b
PPG	28	304 b	224 bc	76 ab	1.077 ab
PPPG	20	247 c	166 d	72 b	1.078 a
P	12	224 c	168 cd	78 ab	1.067 c

The effect of the previous crop in the rotation on the yield and quality of a subsequent potato crop was also studied. The 3VAR-3SOIL dataset, and the five rotations listed in Table 15 were used for this purpose. There are three possible crops preceding potatoes in these five rotations: grain, hay, or potatoes. The comparisons are presented in Table 16. It should be noted that when hay is the preceding crop, actually grain-hay precedes potatoes for two years during which potatoes are not grown (PPGH); whereas when grain is the sole preceding crop, there is just one year in which grain replaces potatoes in the rotation (PG, PPG, or PPPG). Potatoes following grain, or grain-hay had similar yields and percentage US-1. Where potatoes followed potatoes, both gross and US-1 yields were about 70 hundredweight per acre lower. Percentage of US-1 was also significantly reduced. There was no significant effect of the previous crop on specific gravity. These data support the use of a two year rotation Potato-Grain (PG). With winter cover following grain in the PG rotation, potato yield and quality can be maximized while still maintaining the land in potato production 50 percent of the time.

Table 16. Effect of Previous Crop on the Yield and Quality of Potatoes, Three Variety-Three Soil Dataset, FARMS, 1981.

Previous Crop	Number of Plots	Yield—cwt Gross	US-1	US-1 Pct	Specific Gravity
Grain	60	342 a	264 a	79 a	1.077
Hay	26	332 a	264 a	79 a	1.074
Potatoes	31	261 b	181 b	72 b	1.074
					ns

Soil Fertility

Nutrient analysis, pH, cation exchange capacity, and organic matter were measured on each of the 800 plots, Tables 17 and 18. The average pH value was a little lower for 1981 than for 1980, and about the same as reported for Aroostook County for the years 1958 and 1968 by Hepler and Hutchinson (9). The standard deviation for pH indicates a considerable spread of the individual plots, while the quartile data show that the

Table 17. Summary Statistics for the Soil Test Nutrients in Pounds Per Acre, FARMS, 1981.

Statistic	Ca	K	Mg	P	Al	B	Cu	Fe	Mn
Mean	1577	408	167	30	527	0.19	4.1	17	52
Std. Dev.	1047	161	103	9	159	0.09	3.9	10	37
CV	66	39	61	31	30	50	96	59	72
Maximum	6060	1192	794	80	1100	0.87	36.4	117	292
Quart-3	1972	491	216	35	626	0.23	5.1	21	62
Median	1325	394	141	30	540	0.16	3.1	16	43
Quart-1	868	301	95	24	426	0.13	1.8	11	29
Minimum	206	40	13	4	24	0.05	0.0	4	5

central half the plots (Q-1 to Q-3) range from pH 4.7 to 5.3. The pH, calcium, and percent calcium saturation of the base exchange complex all indicate that increased liming should result in better nutrient balance and higher levels of fertility. The potassium levels, while lower than those found for the 1980 plots, are still excessive. The magnesium, like the calcium, should be increased to achieve a better balance among the three major cations: calcium, potassium, and magnesium (11).

Removal of nutrients through soil erosion would not be expected to result in lowered yields. Since fertility levels are so high, the loss of nutrients adsorbed to eroding soil particles would have a negligible effect on potato yields.

Table 18. Statistics for Soil pH, Cation Exchange Capacity, Percent Saturation and Percent Organic Matter, FARMS, 1981.

Statistic	pH	Cation Ex. Cap.		Pct. Cation Sat.			Organic Matter
		Act.	Pot.	Ca	K	Mg	Percent
Mean	5.0	6.5	19.8	56.4	8.6	10.5	2.92
Std. Dev.	0.5	2.3	3.7	18.0	3.4	5.5	0.79
CV	11	35	19	34	39	52	27
Maximum	7.5	17.3	46.9	94.2	25.7	32.8	8.29
Quart.-3	5.3	7.4	22.0	71.5	10.7	13.4	3.32
Median	4.9	6.0	19.9	57.2	8.3	9.3	2.91
Quart.-1	4.7	5.0	17.8	41.8	6.3	6.6	2.46
Minimum	3.8	1.4	5.0	12.3	0.3	1.9	0.46

Act. = Actual, Pot. = Potential

CONCLUSIONS

The 1981 data in many respects support the conclusions derived from the 1980 data (10). One difference was that while some varieties exhibited significant responses associated with A (annual rate of soil loss as predicted by the USLE) the overall effect in 1981 was no relationship to erosion predicted. C, the Cover and Management factor, was also highly associated with yield differences in 1981 as in 1980. Conclusions are further stated in reference to specific questions posed under the objectives.

1. There was no significant general potato yield response to predicted levels of soil erosion. There were significant varietal interactions with some varieties responding positively and others negatively to predicted soil erosion.

2. There were no significant responses to predicted soil erosion either of percentage of US-1 or of specific gravity.

3. C, the Cover and Management factor is the only USLE factor that has consistently affected yield and quality of potatoes. Increased intensity of potato production as related to rotations such as PG, PPG, PPPG, and P, resulted in lowered potato yields and specific gravity. Potatoes following potatoes yielded approximately 70 hundredweight less than potatoes following grain.

4. Apparent significant differences in potato yields were found associated with soils, Table 11. The predominant soil, Caribou, coincided with the highest yields while Plaisted and Chesuncook had significantly lower yields. Some differences in yields may be related to unequal representation by variety, Table 9, or location, Table 1. Differences in percentage of US-1 and specific gravity were not related to soils.

5. Twenty nine soils were identified in the 1981 sample, Table 1. Caribou soil was found on 42 percent of the plots and Conant on 11.5. Sixteen soils each accounted for from 1 to 7 percent of the 1981 dataset, while the other 11 soils were each represented by from 1 to 7 plots.

6. Differential fertilizer data have not yet been studied in detail. The soil test data show that pH is too low as are calcium and magnesium, potassium is excessive, and phosphorus is more than adequate. In general, erosion would not result in nutritional insufficiency unless there were drastic reductions in fertilizer applications.

7. Potato varieties as expected constitute a major source of variability not only for yield and for percentage of US-1, but particularly for specific gravity.

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