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DEVELOPING A SPATIALLY REFERENCED SOIL QUALITY DATABASE FOR LAND USE RESEARCH

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Introduction

New York is one of the most densely populated states in the U.S., but less than 10 percent of the State's 30.6 million acre land base is committed to residential, commercial, industrial and transportation uses; 55 percent is classified as forestland, and farm operators use about one-third for crops and livestock pasture (U.S. Department of Agriculture). Patterns of agricultural land use have traditionally taken on special significance for public programs which deal with energy use, soil and water conservation, real property taxation, and institutional arrangements for enhancing farm viability and maintaining farmland in its current use.

The effectiveness of such programs is conditioned to an important degree by the availability of research-quality data on rural uses of land. Recent technological developments for measuring and storing land-based information provide new avenues for accurate and cost-effective analysis of land utilization on farms. The purpose of this paper is to discuss our efforts to develop a computer-resident land information system for commercial farms in New York. Our study grew out of a 1987 survey of electric energy use by Upstate New York agriculture. A subset of the survey respondents identified their farm boundaries on photo-based soils maps. A

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microcomputer-based coordinate digitizer was used to analyze these maps and develop spatially referenced acreage estimates for each farm. The estimates control for soil mapping unit, tenure, and land cover. These results were linked to survey information on energy use, production of agricultural commodities, farm structure, and recent capital outlays for the farm business. As our study progresses, computer-resident secondary data on soil productivity and soil parameters from published soil surveys will also be merged to create a comprehensive and integrated information system for policy analysis.

The paper is organized into two sections. The first section outlines the techniques devised to assemble the information system. The second highlights our results and provides an illustration of the system's application. Discussion of these topics is prefaced by a section which highlights earlier efforts to incorporate land use information into policy analysis in New York.

Background

The information system discussed in this paper is an extension of work conducted in the Department of Agricultural Economics since the 1920s. As a guide for policymakers during the Great Depression, Cornell researchers devised procedures for arranging actively farmed land into classes which were thought to discriminate according to suitability for long-term agricultural use. Using counties as units of study, evaluations of soil quality, prevailing patterns of land use, topography, elevation, and size and condition of farm buildings were utilized in the classification work (see, for example, Keepper). Empirical results from studies of this kind were used to guide both public and private decisions on land use in rural New York during the years when the farm sector was plagued by low incomes, property tax delinquency and rapid technological change (Salter).

Such land classification efforts continued and even intensified after World War II. Rural land was released from agricultural use on a wide scale during the 1950s and 1960s and, as before, policymakers needed information on relationships between land resources and the viability of New York agriculture. The classification work evolved into an appraisal of "income expectancy" and culminated with the publication of a map showing the "economic viability of farming areas" (State of New York, Office of Planning Coordination). This map arranged the State's land base into classes based on its prospects for continued agricultural use, assuming farming is not precluded by future urban expansion.

Nearly 20 years have elapsed since this classification work was completed, but virtually all of the forces which made the effort relevant to public policy remain. These include urban expansion into farming areas, structural adjustments due to changing demand/supply relationships in national (and international) commodity markets, and abrupt rates of technological development in the production of food and fiber commodities. As in years past, information which links commercial agriculture to the State's land base is a prerequisite for definitive analysis of rural policy issues.

Approach

Our current efforts to develop land-based information systems can be divided into four components: (1) designing and selecting a farm sample, (2) identifying the geographic location of farm boundaries, (3) transforming farm maps into computer-ready data files, and (4) merging with farm survey information and background data on soil productivity and soil parameters from published soil surveys. Each of these components is discussed below.

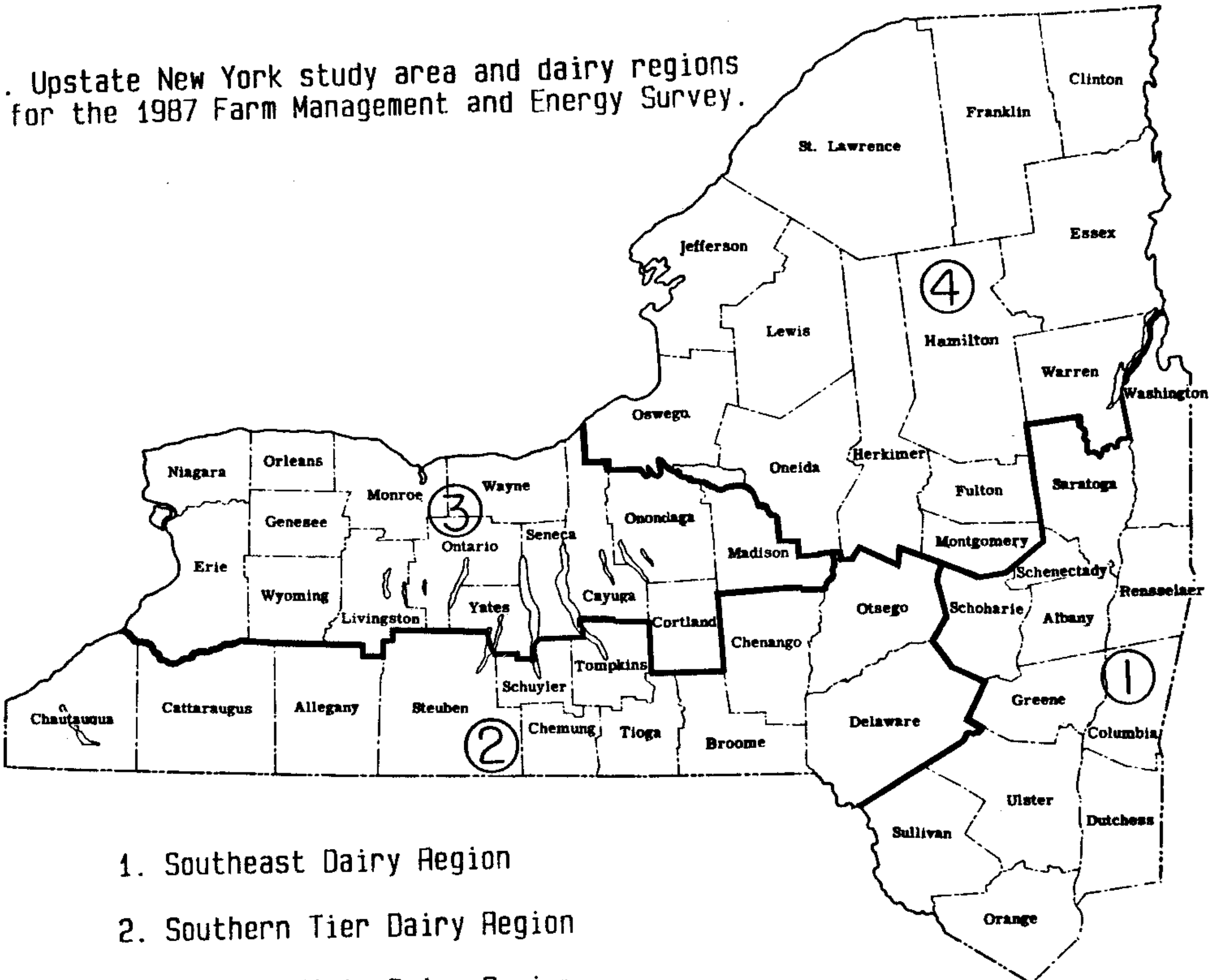
<u>Design and Selection of the Farm Sample</u>

Cornell University and the New York Agricultural Statistics Service (NYASS) conducted the 1987 Farm Management and Energy Survey to assemble new data on agricultural production, farm structure, and electrical energy use. The survey is part of the research project "Future Directions for the Upstate New York Agricultural Economy with Special Reference to the Potential for Electrical Energy Conservation", conducted by the Departments of Agricultural Economics and Agricultural Engineering. The project is funded by the Niagara Mohawk Power Corporation.

The survey was focused on Upstate New York farms with $10,000 or more of gross agricultural receipts during the 1986 calendar year (Kelleher and Bills). This farm universe excludes many small, part-time farms and farms located on Long Island and suburban New York City (figure 1). A disproportionate stratified random sample was designed with strata based on type of farm enterprise, gross receipts, and geographic regions for dairy producers. A sample of 1800 farm operations were selected from a list frame maintained by NYASS (table 1).

Due to time and resource limitations, a subsample of 602 farm operations were chosen for the farm boundary mapping exercise. Criteria for selecting the subsample were based on type of farm, availability of modern or photo-based soil survey information, and proximity to one of New York's larger core cities. Horticultural and vegetable producers were eliminated from the subsample because land used for these products is often influenced by special physical circumstances, e.g., availability of organic muck soils for vegetables. Also, product mix on these specialty farms is extremely

Figure 1. Upstate New York study area and dairy regions selected for the 1987 Farm Management and Energy Survey.



1. Southeast Dairy Region
2. Southern Tier Dairy Region
3. Western Plain Dairy Region
4. Northern Dairy Region

Table 1. Stratified random sample design for the 1987 farm management and energy survey

			Number of farms sampled
1. Poultry	a.	$10,000-$99,999	21
	b.	$100,000-$249,999	18
	c.	$250,000+	26
2. Vegetable	a.	$10,000-$99,999	25
	b.	$100,000-$249,999	40
	c.	$250,000+	105
3. Grapes	a.	$10,000-$99,999	37
	b.	$100,000+	23
4. Tree fruit	a.	$10,000-$99,999	25
	b.	$100,000+	35
5. Horticulture	a.	$10,000-$99,999	25
	b.	$100,000+	30
6. Dairy	a.	$10,000-$99,999	
		i. Eastern	45
		ii. Southern Tier	75
		iii. Western Plains	55
		iv. Northern	72
	b.	$100,000-$249,999	
		i. Eastern	85
		ii. Southern Tier	160
		iii. Western Plains	140
		iv. Northern	200
	c.	$250,000-$499,999	
		i. Eastern	48
		ii. Southern Tier	50
		iii. Western Plains	80
		iv. Northern	55
	d.	$500,000+	95
7. Other livestock	a.	$10,000-$99,999	50
	b.	$100,000-$249,999	32
	c.	$250,000+	8
8. Other crops	a.	$10,000-$99,999	45
	b.	$100,000-$249,999	33
	c.	$250,000+	12
9. Miscellaneous	a.	$10,000-$99,999	45
	b.	$100,000+	5
Total			1,800

variable, which compounds the difficulties associated with making generalizations about farm profitability and investment. Fortunately, these types of farms are relatively rare occurrences and account for less than 5 percent of the land in farms with $10,000 or more in gross receipts (U.S. Department of Commerce).

The sample design was further constrained by the absence of modern soil survey information. To date, modern soil surveys containing photo-based soils maps have been published in only 30 of the 54 Upstate New York counties. Obtaining aerial photographs for those areas not covered by modern photo-based soil surveys was considered. However, difficulties with photo availability, matching outdated soils information to air photos, and photo expense required us to limit the scope of the study to the 30 counties with published modern soil surveys. The most notable limitation of this approach was the exclusion of most counties in the Northern New York dairy region (see figure 1).

The final consideration in subsample selection was proximity to a core city with a population of 50,000 or more. Definitions of Standard Metropolitan Statistical Areas (SMSAs) were used to classify farm operations according to their location in urban, urban fringe, or rural counties (table 2). Urban counties are SMSA counties which contain a core city with a population of 50,000 or more; fringe counties are adjacent SMSA counties; rural counties are non-SMSA counties. An attempt was made to select 200 farms from each of the three SMSA categories. However, the number of farms in the larger sample which were located in urban or urban fringe counties was limited. The final composition of the subsample was 149 urban, 207 urban fringe, and 246 rural farm operations.

Table 2. Upstate New York counties with modern photo-based soil surveys, by SMSA proximity to a large core city

Urban	Urban fringe	Rural
Broome	Herkimer	Cayuga
Chemung	Madison	Chenango
Erie	Montgomery	Franklin
Monroe	Orleans	Genesee
Niagara	Oswego	Lewis
Onondaga	Wayne	Ontario
Schenectady		Orange
		Schoharie
		Schuyler
		Steuben
		Tompkins
		Ulster
		Washington
		Wyoming
		Yates

Identifying Farm Boundaries

NYASS enumerators worked with farm operators to identify and draw the farm boundaries on a photo-based soil map sheet. The farm's location on a map sheet was determined by referring to the map sheet index. Then, the boundaries for all parcels of land owned and/or rented by the survey respondent were drawn on the map and assigned the farm's survey number. Colored pencils were used to differentiate land parcels according to tenure. Tenure categories were land owned and operated, land owned and rented to others, and land rented from others.

Transformation of Farm Maps into Computer-Ready Data Files

Areas of maps have historically been measured using dot grids, weight proportion, transects, or planorimeters. Recent technological developments have made available microcomputer-based coordinate digitizers for more precise measurement of land areas. The computer-based system eliminates the need for manual entry of the land areas into data files and allows each sample unit to be spatially referenced to a standard coordinate system.

The Cornell Laboratory of Environmental Applications of Remote Sensing (CLEARS) used the farm maps to provide area estimates of farm acreage, controlling for soil mapping unit, tenure, and land cover for the farm. ERDAS software/hardware, supported at CLEARS for work on geographic information systems and image processing, was used to process the farm data. The ERDAS system incorporates a number of software/hardware packages to input, manipulate, store, and analyze map or image data. Map data are represented using grid cells, or pixels, having a value which corresponds to a map class. The map class, e.g., soil mapping unit or land class, is spatially referenced to a specified coordinate system.

A standard procedure was developed and used in this study: (1) catalog each map parcel by survey identification number; (2) photocopy and mosaic each soil map sheet so all parcels of a farm appear on one sheet; (3) delineate on the map sheet the land use classes (cropland, orchard/vineyard, and other); (4) register the map sheet on the coordinate digitizer and establish arbitrary reference grid, based on published map scale;[1] (5) digitize land parcels falling in each tenure category; (6) create GIS files by gridding polygon files; (7) produce summary files; and (8) output ASCII data files of land area estimates.

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[1] Photo-based soil surveys for New York counties have been published intermittently since 1956. The standard latitude/longitude reference system is not precise on most of the soil surveys. Further, even fewer of the soil surveys have been rectified for curvature of the earth. The decision was made, due to time and resource limitations, to use an arbitrary coordinate system at present. Three to five control points were digitized for each farm to allow for rectification and spatial referencing to a standard coordinate system at a later date.

Merges with Survey Information and Soils Data

Two different types of data files were developed to allow a merge of the mapped land area estimates with the enumerative survey results. The first was a DBASEIII file structure for microcomputer analysis. This data file was used to compare mapped area estimates with estimates provided by the survey respondent. Any deviations between the two estimates were identified, and any problems from data input or processing were corrected. After these checks for data consistency were completed, the microcomputer data files were uploaded to an IBM4381 mainframe computer. This allowed us to overcome size limits imposed by the microcomputer and interface with data files which contain the farm survey results. The two data sets were quickly merged using the farm identification number common to both.

Manipulating the information system in a mainframe environment also sets the stage for merging existing computer-ready data on soil productivity and soil parameters from published soil surveys. This task is just being completed at this writing. To help complete the illustration in the next section, land areas of each soil mapping unit were grouped according to the Land Capability Classes, as defined by the USDA's Soil Conservation Service. This classification discriminates among soils based on the severity of hazards encountered in crop production. Production hazards considered include erosion, wetness, and stoniness. These classes are used, for the purposes of this paper, as a rough indicator of the productivity of a farm's soil resource in field crop production. We intend to refine these relationships as our research progresses by incorporating agronomic data on expected crop yield into the information system.

Empirical Results

During April and May 1987, NYASS enumerators contacted 1800 farm operators. Seventy-four percent supplied some information about their farm operation. Usable survey data were compiled for 1068 farms that reported having $10,000 or more of gross farm receipts for the 1986 calendar year. Each survey response was weighted to provide estimates for the target population.

As part of the survey, 602 farm operators were asked to identify their farm boundaries on photo-based soils maps. Approximately 275 farm operators provided both survey data and mapped information to the enumerator.[2]

Survey Highlights

Individually operated businesses dominate New York agriculture (76 percent of all farms), followed by partnerships (18 percent), and corporations (6 percent). Net cash farm income averaged $19,800 per farm in 1986. Off-farm income averaged $7,400, or approximately 27 percent of an average farm household's total net income. Approximately 53 percent of all Upstate farms do not report income from a nonfarm source. Off-farm income averaged $15,619 for those respondents reporting income from this source.

The largest 8 percent of New York's farms (those with over $250,000 gross receipts) account for 33 percent of the gross receipts. In contrast, the 54 percent of the farms which have under $100,000 gross receipts account for 23 percent of the gross receipts. The remaining 37 percent of farms and 44 percent of the gross receipts are on mid-sized farms ($100,000-$249,999 gross receipts).

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[2] Because of operational problems with identifying, matching, and digitizing, map information on 262 of the farms is usable at present.

Many New York farms have more than one type of farm enterprise. We followed Census procedures and defined type of farm by the enterprise which provided 50 percent or more of total gross receipts. Any farms without one dominant enterprise were placed in a miscellaneous category. As expected, this technique shows that dairy farms dominate Upstate New York agriculture. Dairy farms account for 78 percent of all farms, 80 percent of the gross receipts, and 86 percent of total expenditures for electric energy. Except for dairy, no other type of farm accounted for more than 6 percent of the farms, 6 percent of the gross receipts, or 3 percent of the electric expense.

Farms in Upstate New York average 388 acres in size (table 3). Approximately 64 percent of this land is classified as cropland. More than one-third of all cropland is rented from others; farm operators paid an average of $22 per acre for land rented for cash. Cash rental is the dominant arrangement for rented cropland. Farmers obtain the use of some cropland without making a cash or crop-share payment to the landlord but may provide other services in lieu of rent.

Table 3. Summary of land use by type of farm, Upstate New York, 1986

Farm type	All land operated	Total cropland	Cropland rented from others
	- - - Acres per farm - - -		
Cash crop	561	442	238
Dairy	396	242	82
General livestock	260	149	27
Grape	187	107	31
Horticulture	114	87	31
Poultry	390	217	73
Tree fruit	197	156	44
Vegetable	460	400	211
All farms	388	246	89

Source: 1987 Farm Management and Energy Survey.

Cash crop and vegetable farms operate the largest cropland acreages per farm, with 442 and 400 acres, respectively. Horticultural and grape producers operate the least amount of cropland (table 3). Overall, farms in Upstate New York rent approximately 36 percent of the cropland from other landowners. On average, cash crop and vegetable farms rent over half of the cropland they operate. This is in sharp contrast with average general livestock farms which rent only 18 percent of total cropland operated.

Capital investments were made by 56 percent of all farms in 1986 (table 4). The average amount spent was $21,000. Real estate investments were the largest in absolute amount ($42,459) but were made with the lowest frequency (5 percent of all farms). Capital outlays for purchases of machinery and equipment were the most frequently reported investments, with 45 percent of the farms spending an average of $12,114 in 1986. Land improvement, building, and livestock investments were made by 13, 14, and 16 percent, respectively, of all Upstate New York farms.

Upstate farms had assets valued at nearly $452,000 on average (table 5). The average farm has a debt/asset ratio of 19 percent. Real estate dominates assets and debts, accounting for 58 and 65 percent, respectively,

Table 4. Capital investments for farms in Upstate New York, 1986

Item	Farms reporting	Average investment
	Percent	Dollars ($1,000)
Real estate	5	42
Land improvements	13	4
Buildings	14	11
Livestock	16	12
Machinery and equipment	45	12
Total	56	21

Source: 1987 Farm Management and Energy Survey.

Table 5. Summary of debts and assets by type of farm, Upstate New York, 1986

Farm type	Assets		Debts	
	Total	Farm real estate	Total	Farm real estate
	- - - Dollars ($1,000) - - -			
Cash crop	566	326	113	59
Dairy	427	245	90	58
General livestock	287	177	24	12
Grape	346	182	91	79
Horticulture	635	280	39	14
Poultry	614	372	71	30
Tree fruit	757	468	87	50
Vegetable	520	251	97	62
All farms	449	254	86	54

Source: 1987 Farm Management and Energy Survey.

of asset value and outstanding debt. Tree fruit and horticultural producers reported the largest amounts invested, with total assets valued at $757,000 and $635,000, respectively. Cash crop farms report $566,000 in total assets and the largest average debt of any farm type ($113,000).

Farms with Mapped Boundaries

The principal thrust of our research is to relate these economic features to New York's land base. As noted above, about one-quarter of our survey farms were mapped. The subsample of respondents that identified farm boundaries on photo-based soils maps operated somewhat larger and more profitable farms on average than typical farms of Upstate New York (table 6). The subsample operated an average of 501 acres of farmland, and reported a net cash farm income of $24,700, compared to an Upstate average of 388 acres and $19,800 net cash farm income. Investments made in 1985 and 1986, total assets, and total debts are larger on average for the sample of mapped farms. The size discrepancy may at first appear to reflect

Table 6. Size characteristics of Upstate New York farms and mapped farms, 1986

Item	Mapped farms	Upstate New York farms
	- - - Acres - - -	
Farmland operated	501	388
Cropland operated	356	246
	- - - Dollars - - -	
Net cash farm income	24,700	19,800
Farm investment, 1985	17,300	9,800
Farm investment, 1986	19,800	11,600
Total assets	566,000	449,000
Total debt	157,000	86,000

Source: 1987 Farm Management and Energy Survey.

some bias in the mapped farm data. However, this is merely the result of using the mapped farm data without weights based on the probability of a farm being sampled. The weights are important in making population estimates because the overall stratified random sample was designed to select a disproportionately large number of rare occurrence farms (e.g., large farms). Comparisons of unweighted data of the samples are much closer. The authors chose to avoid weighting the mapped sample farms because the sample was not designed to provide soil mapping unit acreage estimates for the target population. Thus, the mapped farms will represent slightly larger than average size farms.

Farm operators' estimates of farmland and cropland acreage were compared to the digitized estimates from the mapped areas (table 7). The average of the farmland and cropland estimates were reasonably close, from 1 percent for operated cropland to 12 percent for owned cropland. However, there were large discrepancies in acreage estimates on individual farms. Farm operators may have left out parcels, or may have misplaced boundaries on the soil maps. Another source of error for the digitized cropland

Table 7. Operator and mapped area estimates of farm acreage

Item	Survey response	Mapped area
	- - - Acres - - -	
Farmland owned	322	314
Farmland operated	501	462
Cropland owned	201	226
Cropland operated	356	353

Source: 1987 Farm Management and Energy Survey.

estimates was that most photos were dated -- vintages ranged from 1955 to 1978 -- and land use has changed in many areas during that time.

Soil Quality, Farm Income, and On-Farm Investment: An Illustrative Example

When operational, our system will permit new analysis of the interplay between New York's commercial agriculture and the land resource base. To illustrate, 91 farms from six counties were examined to determine the configuration of land operated in relation to soil quality. Acreage of soil mapping units for each farm were categorized into USDA-defined Land Capability Classes (table 8). Differences in the distributions of Land Capability Classes discriminate among soils according to degree of production limitation in crop use on each farm and are a common measure of soil quality (Klingebiel and Montgomery). Differences in resource quality, in turn, are thought to affect farm productivity and investment decisions. Under the USDA classification, class I soils are rated as the best for agriculture, with few restrictions for crop use. Class II, III, and IV soils have increasingly severe limitations for crop use; classes V and VI have severe limitations which usually restrict their use to pasture or woodland; classes VII and VIII have extreme limitations, restricting their

Table 8. Distribution of land in 91 farms by county and Land Capability Class

County	Land Capability Class I	II	III	IV	V	VI	VII-VIII
Broome	5	13	46	28	2	6	1
Cayuga	0	57	18	17	1	6	1
Chenango	2	29	34	12	3	9	11
Erie	1	36	52	7	2	1	1
Genesee	3	28	29	34	0	5	1
Madison	3	21	10	8	21	19	18
All	2	29	30	13	8	10	8

Source: 1987 Farm Management and Energy Survey.

use largely to woodland and wildlife use (U.S. Department of Agriculture, 1971).

A soil quality index was devised using a weighted average of the acreage falling in each Land Capability Class. An index value of 1 is calculated for a farm with 100 percent Class I soil, and an index value of 7 is calculated for a farm with all soils in Classes VII-VIII. Then we arranged the 91 farms according to this index and computed average farm size, net cash farm income, investment expenditures, and debt/asset ratios (table 9).

Interestingly, these preliminary calculations seem to contradict the conventional wisdom, and show that average net cash farm income is approximately the same on farms with the poorest soil resources as those with the best soil resources ($29,300 and $30,500, respectively). Further, farms with the poorest soils generate that income from fewer acres, 419 acres compared to a 461 acre average for farms with the best soils. Farms in the middle index group (index 2.75-3.75), have the lowest net cash farm income at $21,700, but are the largest farms on average. Farms with the lowest quality index have the highest debt/asset ratio with debts at 27 percent of total assets. Investment made by the middle soil quality group were the largest for both 1985 and 1986. The poor-soil farms invested the least with $10,200 in 1985 and $9,400 in 1986.

The data were also disaggregated by county SMSA designation (table 10). Farms situated in rural counties operated the largest acreage, were less profitable, but have recently made relatively large investments in the farm business when compared to farms in urban or urban fringe counties. Urban farms had the highest net cash farm income, $33,700, followed by those in urban fringe and rural counties, with $27,000 and $14,700, respectively. This follows the conventional wisdom that agricultural land is used more intensively in urban and urban fringe areas. This is also reflected in value of total assets per acre of farmland operated.[3] Farms in urban and urban fringe counties have similar values at $1170 and $1160 per acre. This contrasts with the farms in rural counties with an average value of $970 per acre. The value of total assets per acre of farmland owned is slightly different. Farms in urban counties were valued at $1770 per acre, as compared to $1560 per acre for farms in urban fringe and rural counties.

The soil quality index, based on Land Capability Classes, produced some interesting results. Differences in the index seem uncorrelated with other reported profitability, size, or productivity measures. Urban fringe farms with relatively poor soils compare favorably with urban farms in terms of acreage, net cash farm income, milk cows, farm investment, and total assets. These seemingly anomalous results will be refined as our research progresses, but may well point out the need to investigate whether

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[3] The value of land rented in is not included as part of total assets per acre of farmland operated calculations.

Table 9. Selected characteristics of 91 farms by soil quality index

Item	Soil Quality Index[a] 1-2.75	2.75-3.75	3.75+
Farmland operated (acres)	461	481	419
Cropland operated (acres)	381	312	258
Net cash farm income ($)	30,500	21,700	29,300
Farm investment, 1985 ($)	14,100	20,700	10,200
Farm investment, 1986 ($)	14,500	15,100	9,400
Total assets ($)	626,000	487,000	461,000
Total debt ($)	101,000	124,000	127,000
Debt/asset ratio	.16	.25	.27

[a] The Soil Quality Index is defined as the weighted average of ares of each land capability class.

$$\text{Soil Quality Index} = \frac{(\text{Class I}*1) + (\text{Class II}*2) + \ldots + (\text{Class VII}*7)}{\text{Class I} + \text{Class II} + \ldots + \text{Class VII}}$$

where a value of 1 would indicate a farm with all operated land of Class I soils, or an index of 7 would indicate a farm with all operated land of Class VII or VIII soils.

Source: 1987 Farm Management and Energy Survey.

Table 10. Selected characteristics of 91 farms in metropolitan and nonmetropolitan counties

	SMSA Urban	SMSA Urban fringe	Non-SMSA Rural
Farmland operated (acres)	436	417	528
Cropland operated (acres)	271	271	394
Gross receipts ($)	206,000	130,000	162,000
Net cash farm income ($)	33,700	27,000	14,700
Farm investment, 1985 ($)	14,500	11,000	23,400
Farm investment, 1986 ($)	13,700	13,600	11,800
Total assets ($)	509,000	483,000	514,000
Total debt ($)	84,000	138,000	149,000
Soil index (1-7)	3.0	4.6	3.2
Milk cows (number)	80	73	59

Source: 1987 Farm Management and Energy Survey.

the management practices or other economic factors often override or offset the effects of soil quality on farm profitability and productivity.

Concluding Comments

This paper deals with a continuing effort to develop a computer-resident land information system for commercial farms in New York. The system will be used for a variety of educational purposes, including applied research on relationships between land resources and the structure of the State's farm sector. To date, we have focused on techniques for integrating data from a probability-based sample survey, digitized soil maps, soil productivity indices, and published soil surveys. Further refinements are planned -- for example, the possibilities for overlays on photo-based tax parcel maps maintained by officials who administer New York's real property tax law. Also, there are prospects for developing the information needed to assess soil erodibility and generate estimates of average annual soil loss due to rainfall. These latter enhancements would allow more definitive analysis of the interplay between farming operations and surface water quality.

Preliminary results from our experiment with a computerized land information system appear to be promising. However, further efforts to design and implement such work on a more comprehensive scale depend almost entirely upon factors which are outside the control of the research analyst. Efforts of this sort are severely hampered by the availability of modern, photo-based soils information. Modern surveys have been published for only a fraction of all New York counties. It is also important for soils information to be digitized and rectified to facilitate comprehensive and cost-effective analysis.

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