A RESEARCH REPORT ON DEVELOPING A COMMUNITY LEVEL NATURAL RESOURCE INVENTORY SYSTEM

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CENTER FOR STUDIES IN FOOD SELF – SUFFICIENCY

PREFACE

The Center for Studies in Food Self-Sufficiency was formally instituted in the Fall of 1974 as a community-action/research project of the Vermont Institute of Community Involvement. The Center has begun a long-term effort into energy, food, man and environment relationships. During its first year, the focus of research has been on the use of energy in present agricultural production in Vermont and on a study of feasibility for increasing food self-sufficiency (local production to meet local needs) in Vermont. While the Center is currently working toward a plan for increasing Vermont's self-sufficiency and diversifying agriculture within the state, work is directed toward the development of a methodology for examination of similar questions anywhere in the world.

The energy crisis has clearly revealed that the national production/distribution system for all goods is based on incorrect assumptions concerning the finite nature of natural resources. One possible way to deal with resource related crises is the development of regional, ecologically sound, self-sufficient production/distribution models. It is our hope that this report, along with others to be released, will contribute to a discussion and the development of policy that better utilizes our natural resources in the production of food.

ACKNOWLEDGEMENTS

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Special thanks goes to Dr. Carl Reidel, Director of the Environmental Program at the University of Vermont, whose support and encouragement made the project possible. Wesley Ward of the Windham Regional Planning Commission and Michael Preziose of the Addison Regional Planning Commission were also supportive and helpful in the project's success.

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I. INTRODUCTION

Many people recognize the inevitability of growth and change and have looked for a means to exercise some control over the future of their town, region, and state. Land use planning is an attempt to influence growth and create some degree of citizen control. Despite a great deal of public controversy, by 1977 there was a system of 13 regional and 238 local planning commissions operating in Vermont. Often, one of the first activities of a planning commission is to establish an information base for determining physical, topographic, and socio-economic characteristics of the area. Existing data are collected and new data are generated. Unfortunately, many well intentioned planning commissions fail to take full advantage of the information available to them. Both paid and volunteer planners are conscious of the amount of data which they feel should be considered in developing any plan or policy, but are frustrated by the lack of knowledge of cost effective methods for integrating the data. Most methodologies for comprehensive rural planning are sophisticated transplanted urban planning techniques which are not appropriate to rural situations. The object of this paper is to report on a planning tool developed specifically for rural areas--an information system--and its application in two pilot Vermont towns.

The problem can be stated as follows: how can data be organized, stored, combined, and selectively retrieved so that it can be effectively and efficiently used in specific analyses the planning commission wishes to perform? A computer based resource inventory system, SEURAT, has been developed by the Center to address this problem. SEURAT is a basic map overlay system designed to do the following:

-overlay and store mapped information

-print maps of any individual category or combination of categories

-determine acreage of any category or combination of categories

It is an information manipulation tool which can be only as accurate as the least accurate information retrieved, and only effectively used by those who understand its limitations. By selectively combining and printing maps of different pieces of information, the system can save the planner many hours of light table and planimeter work. However, it must be kept in mind that the system cannot make decisions. The information which is not entered into the system (such as moral values, political feasibility, etc.) is probably more important to a decision than all the information which is entered into the system.

With these caveats clearly stated, we will list several example questions posed by regional or town planning commissions, for which SEURAT information maps were printed.

-How much land has gone out of agricultural production in the past 30 years, and what is the land presently used for?

-Where are our "prime" soils and what is the land use on these soils?

-How much of our present agricultural land is presently zoned for agriculture? How much of our present agricultural land is zoned for commercial/industrial/or high density residential use?

-How much of our present agricultural land would be zoned for agriculture under each of several proposed zoning ordinances?

The system can be most useful at the following stages of the planning process:

-reviewing trends

-retrieving and presenting information to be used in plan or policy development

-reviewing adequacy or suitability of plans, policies or ordinances which are in effect

-comparing adequacy or suitability of different proposals for new plans or ordinances

Overlay systems similar to SEURAT have been used in planning for at least 55 years. (1) The logic is simple--when decisions involve an analysis of two or more characteristics (such as soils, slope, and land use), maps of each characteristic are drawn to the same scale and overlaid. The viewer can then see where specific favorable or unfavorable combinations occur (such as flat areas with deep soils or areas with steep slopes and erodible soils).

This method of overlaying probably owes its fame to Iam McHarg whose overlay analysis technique has been demonstrated in Design with Nature.(2) The method is based on the ranking of natural and social characteristics in terms of value, cost or severity of impact. For example, in a highway study, critical physiographic factors are ranked according to the increase in construction cost which they would cause, and mapped so that the darker the tone, the higher the cost. Similarly, other factors such as wildlife, recreation, residential, historic, scenic, and forest values are mapped so that the lighter the tone, the lower the cost. Each factor map is produced as a transparency with three ranked categories. When several transparencies are overlaid, the resulting composite shows areas of highest social cost in dark colors, and areas of least cost in light colors.

This method is simple and easily understood. However, a composite map can become very difficult to interpret when the variables to be considered are so numerous that the entire map appears muddy brown. The consequent use of a spectrophotometer to detect differences detracts from the inherent simplicity and credibility of the method. In addition, the transparencies created tend to be useful in answering only one question and must be redrawn for additional analyses. For example, southern aspect may be least cost (light tone) for a solar building but highest cost (dark tone) for a forest or a ski slope.

The hand-drawn data file method, explained by Steinitz, Parker and Jordan,(3) solves some of these problems. While McHarg would print one transparency with three tones representing three categories of cost due to aspect, for example, the data file method would require three separate maps--one for each category of cost due to aspect. Each of these maps would then be reproduced in several colors so that northern aspect could be used in one analysis as least cost (green) and in another analysis as highest cost (red). In addition, putting two red transparencies of northern aspect into a composite overlay has the effect of weighting--the cost of northern aspect will now appear to be twice as high in the composite map.

Although this method is considerably more flexible than the previous overlay systems, redrawing and reclassification will often be necessary. For example, consider soil as the factor. At the present time, several definitions of "prime" agricultural soils have been proposed. Using the hand-drawn method, each new definition necessitates hand producing a new map.

Hand-drawn overlay maps have been used primarily to indicate areas of relative suitability. The mixture of tones and colors produces a pattern of light and dark which, when scrutinized, may suggest alternative solutions. The same overlay method could be even more useful if, in addition, a composite map could be produced which showed only the areas which met certain specified criteria, and if the acreage of areas meeting these criteria could be calculated. This would allow easier comparisons and tabulations.

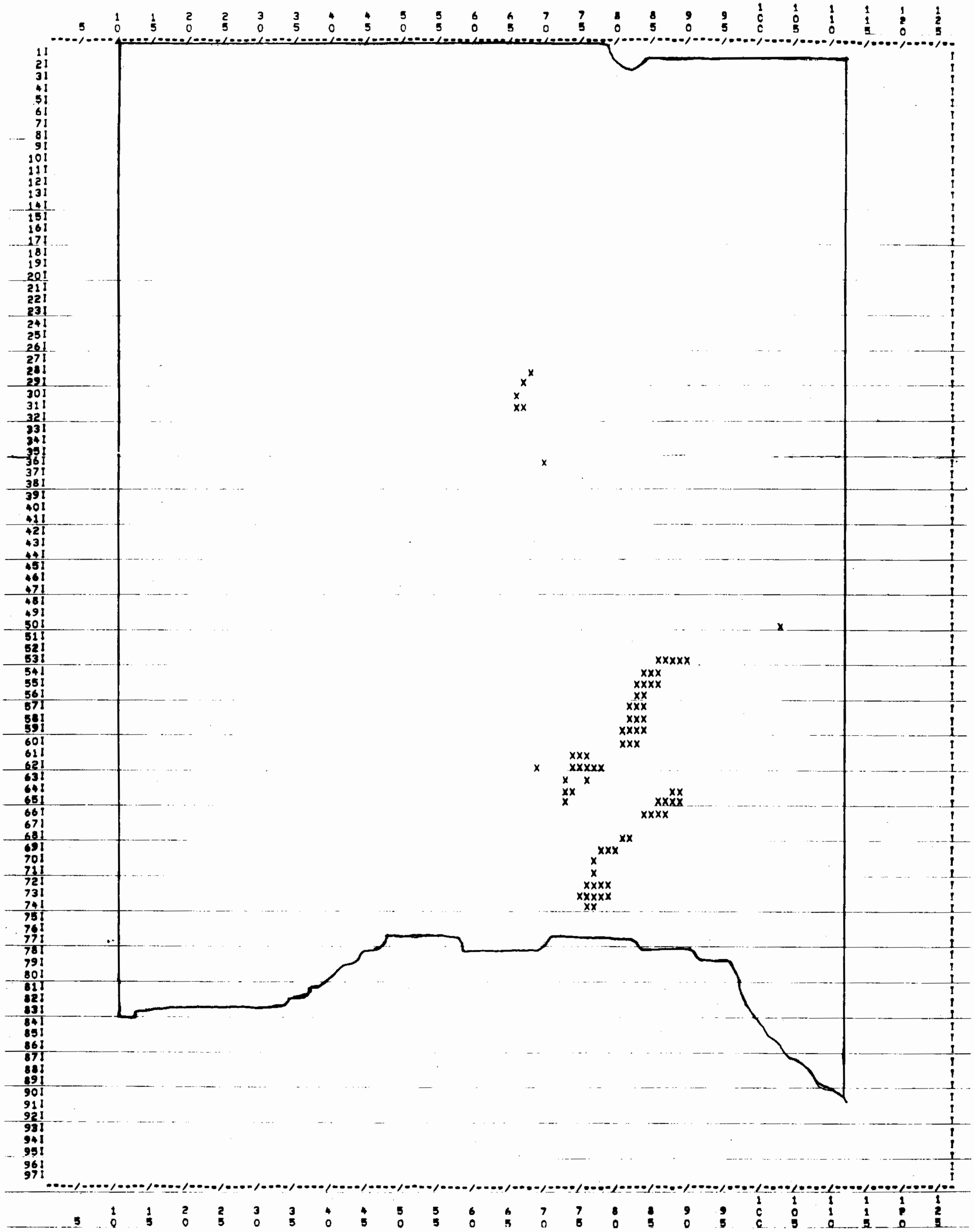
Use of a computer in the overlay process increases the flexibility of the method. Data are essentially stored by a data file method. That is, any factor category can be accessed independently of the others, and there can be many more than three categories without producing muddy maps. To use the prime agricultural soil example, once the basic soils map is entered into the file (whether by soil types, or individual characteristics such as depth to bedrock, etc.) the soil units can be aggregated according to any definition of "prime" without remapping. A different definition of "prime" requires only typing in different numbers to produce the new map.

Another advantage of the computer data file method is that the output can be adapted to the specific analysis needs. The map can be printed in different shades of grey to indicate relative suitability classes, as in the hand-drawn method, or a map can be printed showing only those areas which have prime agricultural soils which are currently in agricultural use. Thus, the user can specify the particular categories to be printed in order to reduce the amount of information on the map. (See figure 1)

In addition, the computer overlay system can count cells and calculate the area of each of the categories printed on the map. SEURAT merely adds flexibility, composite map editing, and counting capabilities to the commonly used overlay method.

FIGURE 1

Highest Potential* Agricultural Soils in Agricultural Use



*See Appendix.

II. REVIEW MAIN EFFORTS

A. Grid

There have been several grid mapping programs developed recently. Probably the most widely used and well known is GRID.(3) With this program, and with its many derivatives, a grid is overlaid on the input map, and data are manually coded and keypunched on a cell by cell basis. These programs were designed to be extremely flexible. Through the optional multiple use of subroutine FLEXIN, files can be manipulated in different ways before a map is created. However, this file flexibility exacts a toll of efficiency in data storage.

SYMAP (4) accepts entry of outline and data point information on a coordinate basis. A regular grid is laid over the outline internally. SYMAP has the capability of constructing isoline, proximal, or conformant maps. This is often useful if the data map is a continuous surface estimated by measurement of values at sample points. Subroutine FLEXIN is also available with this program for data manipulation.

Many grid programs were written to calculate and graphically display levels of data. For example, if census data were entered, a printout might show areas of highest population density as level 6 (darkest) and areas of lowest population density as level 1 (lightest). The extension of this same idea of value levels to a grid overlay program has necessitated a weighting provision in the program. PLANMAP III (5) and CONGRID (6) for example, allow the user to specify a weight for each variable and for each subvariable. The "scores" of the overlaid subvariables are then totaled for each grid cell, and divided into levels before the map is printed.

B. Intermediate Programs

COMLUP (7) uses a combination of grid cell and irregular polygon techniques. Data are entered in irregular polygons using a digitizer. Areas can be calculated as irregular polygons, thereby eliminating the area calculation error associated with a grid map. However, before data maps are overlaid and composite maps are printed, the information is changed internally to a grid system. Composite maps can be printed on either the line printer or on the plotter. Unfortunately, the plotter output is based on interpolation from grid cells, so the original accuracy is diminished.

The main advantages of this system over the previously mentioned grid systems are digitizer input, precise area calculations for single variables, and plotter output for acceptable appearance.

C. Irregular Polygon

An irregular polygon overlay program has many advantages. Many input maps (e.g. detailed soils map, vegetation map) contain irregularly shaped units, each considered to be homogeneous. On a polygon system these irregularly shaped units are traced, stored and overlaid as entered--making the area calculation and the composite maps more accurate. The resultant maps produced on a plotter are also more familiar looking than the line printer versions.

Irregular polygon storage could also resolve the sparse matrix storage problem of many grid programs. For example, although the variable "lakes" may occur in only 1% of the cells in the town, in many grid programs, space must be reserved for the remaining 99% of the cells to store "absence of lakes." The irregular polygon system, on the other hand, would store only the lakes.

Many of the irregular polygon overlay systems suffer from storage on an entity-by-entity basis. The symptoms are appearances of gaps and slivers. These occur because each area is entered completely and independently of its neighbors, and common boundaries are entered twice. Since digitizing equipment such as the data board or data tablet is more exact and consistent than the operator, the two versions of a common boundary often overlap or intertwine. Smoothing or editing programs have been written which are not completely satisfactory, as they are as likely to merge the banks of the river as they are to reconcile boundaries.

A detailed discussion of the different approaches to irregular polygon files, storage and overlaying is beyond the scope of this paper. However, we are convinced that INPOM, the chain file system presently being developed by the Harvard Laboratory of Computer Graphics, should solve the problems of gaps, slivers, and contiguity. The chain file consists of lists of coordinates representing boundary segments. Each list, or chain, contains two nodes and a string of intermediate points, the actual number of points depending on the complexity of the boundary. A "node" is defined as a junction point of two or more boundaries. Each chain has also the names of the polygons that it separates. Because the basis of the file is the chain, or section of a boundary, the common boundaries are truly common. Since each chain is stored with the adjacent polygons, determination of contiguity is no problem. Another list matches each polygon with its constituent chains so that the entity is not lost.

D. Choice of a System

Ideally, choice of a system should reflect your concept of space, or at least the planes of space which you plan to analyze. If you can see space made up of small units, uniform in size and shape, over which variable measurements can be averaged to represent the whole, then use the grid system. If you see space as made up of discrete irregularly shaped areas which are homogeneous for a single variable, then an irregular polygon overlay system is perfect. If you realize you cannot see space, but believe it to be continuous, lacking discrete boundaries and yet so infinitely divisible as to be indivisible, then no two dimensional overlay system exists to composite this space. However, if a choice must be made, the grid system gives the sense of a continuous surface, especially if viewed from a distance. Since a grid is an arbitrary division of space, it is not so great a conflict with the third concept presented above to determine the predominant soil type in each grid cell as it is to attempt to draw that line to separate soil type A from soil type B over a continuum.

There is a certain beauty in the inaccuracy of the grid system. Its very angularity and regular fragmentation forces a recognition that the printout is only a representation and a hint--not a perfect cartographic answer. A viewer must stand back, squint, think, and participate to make anything of the map. As in a pontillist painting, the finish detail, the final union of components, and the interpretation is done by the viewer. Hence, the naming of our program for George Seraut, French painter of the late 19th century.

Unfortunately, the choice of a system will probably have little to do with theory, and more to do with how and by whom the information will be used, and with cost, availability, labor and hardware. At the present time, grid overlay systems seem to be cheaper--not for storage necessarily, but for compositing and printing. Also, they do not usually require use of a digitizer or plotter.

E. Applications

Reports of applications of computer mapping are suddenly appearing in many journals dedicated to such diverse topics as recreation, civil engineering, soil science, cartography, public and private utilities, forestry, water resources, agriculture, ecology, botany, surveying, regional science, and urban and land use planning.

Typically, in planning, computer overlay mapping programs have been applied to suitability analyses. For example, different characteristics affecting suitability of a region for industry, such as soil erodibility, elevations, land use, and residential density, are overlaid and weighted. The weighted scores are then scaled into classes indicating relative suitability, and a map is printed showing different degrees of industrial suitability.

Suitability analyses are natural applications of the programs similar to GRID and SYMAP which automatically scale data values and print out levels. Common suitability analyses (8,9,10) include suitability for residential development, for urban development, and for recreation. Applications in forestry examine suitability of land for different management techniques. In soil science, interpretative maps are printed to show suitability, based on soil and slope characteristics, for wildlife, for forestry, for residential development requiring septic systems, for building, etc. (11)

The METLAND (8) project has developed criteria and composite maps showing agricultural productivity, wildlife productivity, ground water supply, sand and gravel supply, special resources, and environmental hazards. These composite maps were themselves composited into suitability maps for housing, industry, recreation, etc.

Besides looking at the characteristics of a town or region for general development, suitability analyses can also be very specific. For example, suitability maps for the town might be printed to suggest locations for a particular facility, such as a factory, sewage treatment plant, solid waste disposal area, or recreation area. Or, a particular site may have suitability analyses run to suggest the particular sub-areas which might best be used for the buildings, for the parking lot, for the gardens, etc.(12,13). In these cases the criteria and constraints would be very specific.

Computer overlay mapping has frequently been used to locate highways or utility lines.(12,13) The object here, as in location of most specific facilities, is to minimize cost, maximize utility, and minimize detrimental environmental impact. The best areas, which can be located through the mapping process, are those which are near needed materials, which do not necessitate relocation of households, which are on presently undeveloped land, which do not interfere with streams, lakes or other unique or fragile areas, which do not have steep slopes, which are on the best soils, etc. Then, areas which meet the criteria established in varying degrees are printed out in varying shades of grey.

The Center for Studies in Food Self-Sufficiency has applied computer overlay techniques to determination of whether certain uncommon crops might be grown locally, and, if so, where they might be most successful. Physical characteristics, including rainfall, elevation, length of growing season, drought incidence, mean temperature, soil type, slope and land use were overlaid, and matched up with the requirements of certain crops such as soybeans, sweet potatoes, and wetland rice.(14,15) The results were maps of crop suitability, suggesting areas where new crops might best be experimentally grown.

III. DESCRIPTION OF THE PROGRAM

A. Program Capabilities

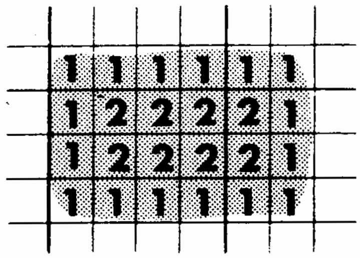
SEURAT is a grid overlay mapping program with the following basic capabilities:

1. Data entry is done through a digitizer, or data tablet; cell-by-cell keypunching is not necessary.
2. The file allows storage of up to forty variable maps.
3. The interactive programs are easy to use, regardless of experience.
4. The program searches and retrieves requested subvariables.
5. Maps of up to fifteen requested subvariables can be printed on the line printer.
6. Logical intermap compositing can combine subvariables of different variable maps to form a selective composite.
7. Subvariables can be reaggregated on a map to form more inclusive classes. For example, if soil type were entered, the types could be grouped and mapped in classes of erodibility, or of potential yield for alfalfa, etc.
8. Single or overprinted alphanumeric characters can be printed on maps as requested.

B. Entry

Data are entered into the computer file with a digitizer or data tablet, a magnetic table which, when drawn on with a pen-like sensor, can be used to send coordinates to the computer. The user indicates the subvariable to be entered, traces the outline of an area to be coded with the sensor, initiates a fill routine, and the program will automatically store the subvariable in all the cells within the boundary.

A clear grid overlay is used during digitization to allow the operator to determine which cells should be included in the area outline. For example, in the illustration below, only the cells marked '1' would be included in the outline. The cells marked '2' would be coded by the fill program.



Originally, the program was written so that no grid overlay was needed. The person entering data specified the minimum percentage of a cell area that needed to be filled with the subvariable. The program internally divided each grid cell into 15 smaller grid cells. The outline of a subvariable area was then entered via the digitizer and filled in by setting these small cells. The number of small cells set in each larger cell was compared to the percentage requirement, and the program determined whether or not the larger cell should be coded with the subvariable. Although convenient, this method was (computer) time consuming and expensive when compared with the manual labor alternative.

C. Storage

Each cell in the map is represented in the storage file by one, two, or three 32 bit words. The number of words used per cell is specified by the user depending on the total number of subvariables to be stored. A section of a word will be set to code each variable. The number of bits used to store any variable depends on the number of subvariables according to the following relationship:

$2^n - 1 \geq$ number of subvariables

where n = number of bits required for storage

For example, all 127 subvariables of the variable "soil type" can be stored in 7 bits of one 32 bit word.

For each row of the map, the storage file contains a word consisting of compacted x, y locations for the first cell, and a count of the number of cells in the row. This word is followed by one to three words per cell containing the variable information as explained above.

Each record contains 200 words, and the file is used by the program record by record.

The advantages of this system over traditional grid files (containing a record consisting of a location and all the subvariable codes for each cell) are mainly compaction and cost. The main disadvantage is inflexibility; it is more difficult to use data from other sources as input to this file, or to use this file as input to another program, than it would be using GRID, for example. Because of the file structure, overlaying is done using simple Boolean algebra.

D. Output

The program which directs the printing of a map is interactive, but may also be run in batch mode. The user specifies the title of the particular map being requested, the unit of measurement to be used in area calculation, (e.g. hectares, sq. kilometers), the different single subvariables or combinations of subvariables to be searched for, and the symbol or symbols to be printed for each.

The maps are printed on the line printer. The output includes the title of the mapping file, the title of the particular map, the grid cell border for orientation, the subvariable and subvariable combinations searched for, and the number of cells and area calculation associated with each symbol.

The output does not include frequency histograms or statistics other than area computations.

E. Updating

An entire information system can lose accuracy and credibility as fast as the real-life data or situation changes. Therefore, updating should be continual. SEURAT files can be updated as easily as they were created. The new is simply digitized over the old, and the transformation has taken its place. It is not necessary to redo the whole map, but only those areas which have changed.

F. Physical Limitations

The program, written in Fortran IV for implementation on a Xerox Sigma 6 computer, presently has the following limitations:

1. The maximum number of variables (not subvariables) which may be entered is 40.
2. The maximum number of subvariable combinations which may be searched for and printed on one map is 14.
3. A map stored in a single file and printed in one piece may not exceed 128x128 cells (16384). Larger maps must be sectioned.

G. Program Incapabilities

1. The program does not produce plotter output.
2. There is no direct variable weighting built into the program.
3. Interval or ratio data cannot be accepted for a single subvariable. Each subvariable must be dichotomous, so interval or ratio data must be broken into groups--each group being a separate subvariable. (See section IV,C)
4. The program does not interpolate or determine contour or proximal maps.
5. No composite maps are printed on the terminal screen. (Single variable maps may be printed on the screen of a graphics terminal).

IV. PROCESS

A. Choice of Variables

The purpose of analysis and availability of data are the most obvious influences in the decision of which variables to use. In our town planning projects, we used mainly existing mapped data. The variable maps included were:

detailed soils map

slope

roads

1974 land use

vegetation

flood plain

hydrology - streams and lakes

existing sewer lines

proposed sewer lines

ground water potential

power lines

zoning

public land

1942 agricultural land use

Other maps which we would have included in the analysis had they been available are: aspect, views, ownership, taxes, mental maps (16), detailed forest maps.

Ideally, an input map would require no modal chance. That is, the data would be collected in the field on a grid cell basis. This, of course, will probably only happen with new maps being specifically created for the computer mapping projects.

Several problems must be considered when dealing with existing maps. First, it is likely that the different input maps will not be drawn on the same base map. Therefore, there will be a discrepancy as to the location of the boundaries, rivers, houses, etc. This should be resolved before the maps are coded.

Second, different input maps will have different levels of detail and accuracy. While the maps can be entered and manipulated no matter what the level of detail, care must be taken in interpreting composite maps.

In addition, many available maps have been created for specific purposes which may make their use limited or unacceptable for other purposes. Maps which delineate areas according to residential suitability may be based on definitions of suitability which other people find unacceptable, or, maps showing agriculture potential may have been drawn with assumptions about existing crops or technology. The information entered into the system should be as value-free as possible, so that it can be used by different people, to compare different systems, based on different definitions and values. Values should be supplied by the users; they should not be built into the data base. Maps which are developed from a set of values can be put into the data file so that comparisons and scenarios can be run. In order to avoid misuse, if this is done, these value judgements should be made explicitly clear in any presentation of the results.

B. Choice of Cell Size

Basically, the cell size should be small enough so that important inventory detail is not lost, and large enough so that time spent in data entry and the cost of computer time are not prohibitive. Since different input maps will have different levels of detail, a cell size which is appropriate for one input map may be inappropriate for another. Also, the level of detail, in rural areas especially, may even vary in a single map between different locations. More detailed information is often collected for villages than for the rest of the town. This is due to a greater familiarity with the more populated areas, to the greater accessibility for field work in population centers, and also to a feeling that sparsely populated areas have less importance. In some instances, it may be advisable to map the village area separately and at a different scale, as many of the rural analyses may not apply to the village area, and since different analyses, which require different subvariable classes, may be preferable in the village.

To insure recognition of a subvariable area, the grid cell size should be 1/2 the size of the subvariable area. However, there is a danger in using an excessively small cell size. The resulting map printouts are often interpreted as having an accuracy equal to the cell size--despite the caveats printed in the legend. The small size often causes inaccuracy of the input maps (See section V for a discussion of this error). Also, the suggestion of accuracy of the small cell size often invites misuse of the system or challenge of the entire project because of the recognition of an error. To avoid this, it may be advisable to use a larger cell size and to code the more detailed information either according to percent classes, presence or absence, or number of occurrences (See section IV,C).

In addition to the level of detail on the input map, the size of the decision making or analysis unit should be considered in the choice of cell size. This could have to do with the size of real area or with proximity. In a regional study of agricultural viability, a one acre cell size may be illogical, even though detailed input maps are available. In this case, the decision to use an area for agriculture will not be made for each acre on an acre-by-acre basis, but rather for larger tracts of land. Similarly, an analysis of viability in our current agricultural system would be based on larger area units than individual acres. For example, an isolated mountain acre might have ideal combinations of slope, aspect, soil characteristics, but would not be considered to be a prime agricultural area because its isolation would make farming it uneconomical.

Additional considerations include flexibility and coordination with other projects. In some areas it may be important to tie the grid overlay to another geographic grid system which is in use. The final decision of grid cell size will depend on the planning scale (e.g. town, state, county);

on the accuracy of the inventory maps being stored in the system; on the analyses or decisions for which the information will be used; on the amount of money and labor one is willing to invest; and on coordination with other projects and agencies.

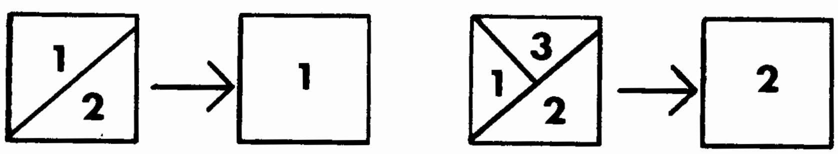
C. Types of Subvariable Coding

It is often assumed that use of a grid system means that subvariables will only be mapped if they occupy greater than 50% of the cell. This is clearly unsatisfactory for many types of spatial data, as it would necessitate an extremely small grid cell to map many variables of interest. Fortunately, several generalization, aggregation, and coding conventions may be used.

1. PREDOMINANT CHARACTERISTIC

This is the commonly used coding method. A cell is coded as subvariable A if subvariable A occupies greater than 50% of the area, or is the predominant subvariable if no subvariable occupies 50%. Soil and slope maps are typically entered this way.

variable : soil type   subvariables



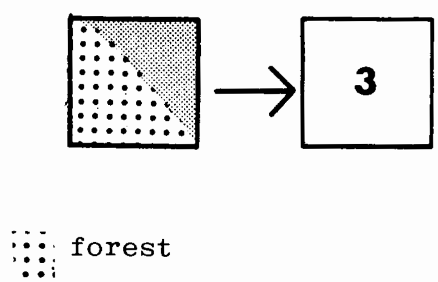
1
2
3

2. PERCENT CLASSES

When cells cover an area which is larger than the average homogeneous unit of a variable, it may be useful to use percent classes. For example, rather than coding a cell as "forest," you may want to determine the percentage of the cell in forest cover, and enter that variable in one of several subvariables which are actually percent classes.

variable : % of cell in forest cover   subvariables

1 = 0-25
2 = 26-50
3 = 51-75
4 = 76-100



3. PRESENCE OR ABSENCE

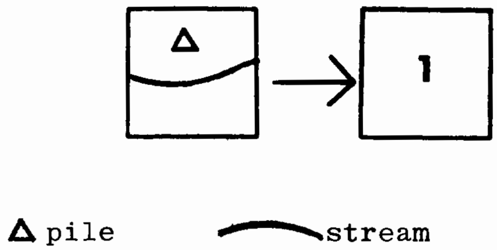
Many occurrences are important enough in an analysis to be coded, regardless of the amount of area they occupy. For example, in a study of non-point source pollution, we decided to include a variable "manure pile within 100 feet of a stream." This variable had two subvariables:

1=present, 0=absent. It could also have contained more subvariables, different size piles, or different distances from the river.

variable : manure pile within 100' of stream

subvariables

1 = present
0 = absent



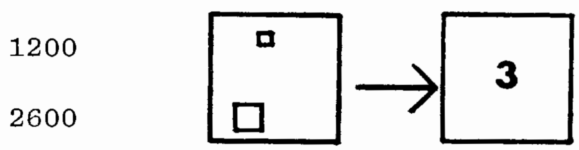
4. NUMBER OF OCCURRENCES

For several variables, it is more useful to have a count of the number of occurrences than it is to have an estimate of the total area they occupy. For example, we might want to know the number of houses, the number of employees, or the amount of electricity used in a particular area. The subvariables could either be the actual frequency or classes of frequencies.

variable : KWH electricity used/month

subvariables

1 = 0-1000
2 = 1000-2000
3 = 3000-4000
4 = over 4000



It is important to document the convention that is being used for each variable, so that users understand how to interpret the results. It may even be advisable to change the part of the program which totals area as the map is being printed. Although totaling of the number of cells will be correct, the conversion into hectares, acres, or square kilometers may be erroneous.

D. Methodology

(This discussion is very brief. Specific methodological instructions and suggestions are contained in the user's manual).*

A grid is drawn on mylar to lay over the input maps during coding or entry. Because our line printer prints 10 columns to the inch and 6 rows to the inch, the cell sides are in a ratio of 3 to 5. Registration marks are established on the grid and on the maps so that the cell position is fixed.

Since a data tablet digitizer is used to enter data, precoding is not necessary. However, we have found that for certain detailed maps (e.g. vegetative cover and soils) precoding in color speeds up terminal time which, for us, is limited. Simple maps (e.g. roads, floodplain, streams) are not precoded. The determination is made by the data tablet operator as to

* Available from the Center.

whether or not a cell should be coded with a subvariable.

Once all subvariables of a variable have been entered into the data file, a check is run. If the variable has been coded in a majority of the cells (as in soils, slope maps) we request a printout of the null category. For example, the variable slope was entered in 4 subvariables: 1=0-8% slope, 0=8-15% slope, 3=15-25% slope, and 4=over 25% slope. Since the most popular subvariable was the 8-15% slope, the first, third and fourth were entered, and all the remaining cells not coded as 1, 3, or 4, were coded as 0. 8-15% slope, in this case, would be the null category. Any cells which we had forgotten to code would show up in this category. The null category printout is then checked against the input maps and any errors are noted on the input map. Variables which do not occupy the whole area, (such as roads, or streams) are checked in their entirety.

Corrections and updates are made simply by entering the new value over the old one.

E. Error Analysis

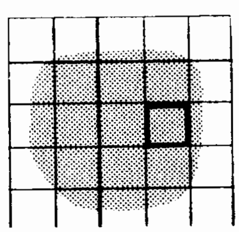
Before any information system is used, the sources of error must be recognized. Errors, just as easily as accurate data, are entered into the computer, overlaid, combined, and calculated and printed. Yet, the electronic aura of a computer printout often evokes one of two reactions from viewers: 1) crediting the printout with greater accuracy than that of the input maps, or 2) discrediting the computer and its system completely because the backyard of the selectman's house is coded as forest when everyone knows he has an acre garden.

The Center believes that the extent of the inaccuracy should be estimated and presented clearly to anyone using the system. It may seem that admitting all the mistakes possible in a computerized system may be admitting defeat before you begin. However, it may also help users, especially computer skeptics, to understand the process and to overcome a technological trepidation. This analysis will also discourage abuse and misuse of the system.

Errors can be introduced in each of the following ways:

1. INPUT MAPS

The original maps which are overlaid have different levels of accuracy. For example, a mapping unit in the Soil Conservation Service detailed soil survey contains 85% or more of the indicated soil type. Small areas of a soil type (2 acres or less) are not mapped. If your cell size were 1 hectare, your cell coding might be correct according to the map, but incorrect if checked in the field. Homogeneity of the mapping unit (and therefore divisibility) is assumed by the grid mapping system.

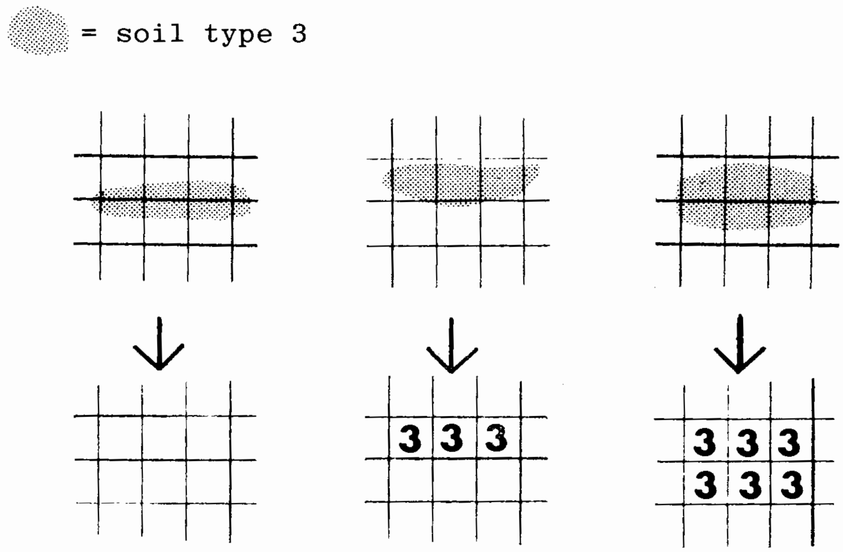


dark bordered cell would be mapped as type 4 but contain 90% type 5.

2. CODING

Coding data on a grid cell basis reduces the accuracy by (a) requiring an aggregation or modal change of data which has not been collected on a grid cell basis, and (b) requiring another step in which human error might occur.

(a) Since analyses often use existing maps, and since data are rarely collected on a grid cell basis, information must be converted to grid cells. Although this can be done in a variety of ways (See section IV,C), some distortion will usually occur. Compare, for example, each of the following sections of a detailed soils survey with the corresponding grid cell version.



Using the data file created for the town of Brattleboro, we attempted to investigate the extent of the distortion of area representation caused by conversion to a grid system. Since it is recognized that the misrepresentation occurs only at boundaries, small areas, 15 cells each, were analyzed.

Each grid cell in the study area is one hectare. The maps overlaid into the system are: soils, slope, vegetative cover, land use, roads, hydrology, and flood plain.

Twenty squares containing fifteen cells each were selected using coordinates read from a random number table. The computer maps for these blocks were checked, cell by cell, against each of the input maps. Within each 15 cell block, the mapped area of each subvariable was estimated using a dot grid. This dot grid estimate was subtracted from the computer rendition to obtain a difference in the amount of area coded as each subvariable.

The mean difference, as would be expected, is close to 0 (.032). The standard deviation is 1.6 hectares. For parcels between 0 and 15 cells (the average size area in the error check was 6.8 cells), we would expect 95% of the computer renditions of the area to be within 3.1 cells of the true area. This deviation can be explained by an examination of the variation in the computer codings in the illustration above. The average deviation (absolute value) of the computer totaled area from the dot grid estimated area is 1.2 cells.

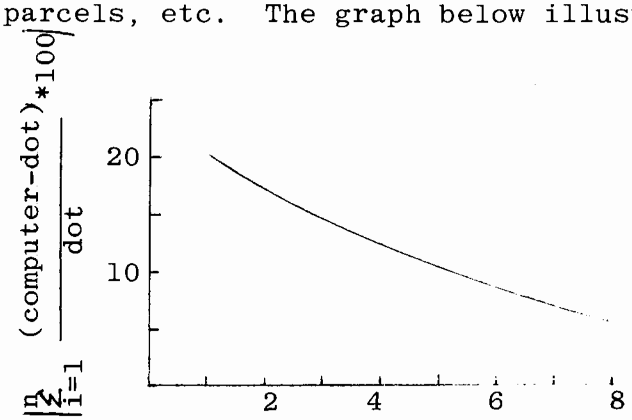
This area variation for small (1-15 cell) parcels indicates a potential abuse of the system; it should not be used to calculate the area of a specific parcel, as any estimate should have a ± 3.1 cell qualification attached.

However, the system is usually used to total area in the whole town that has a special characteristic or combination of characteristics. In this case, the accuracy of the estimate is much more acceptable. Summing the 116 parcels ranging from 0-15 cells in size used in the analysis, we find the dot grid estimated area to be 792.74 cells, while the computer totaled area is 789 cells--an error of 3.74 cells or 0.4%. It seems that, although grid systems may misrepresent the area of individual small parcels of a subvariable because of the way the grid may fall, on the average, by increasing the number of parcels in the equation

$$\sum_{i=1}^{n} \frac{(\text{computer area}) - (\text{dot grid area})}{\text{dot grid area}} * 100$$

the value will approach zero. In other words, overestimation of area will be balanced by underestimation of area.

To get an idea of the change in the percent of area that is over or underestimated by the grid cell method as the number of parcels which are summed increases, we looked at 9 parcels of each 8 subvariables. The parcels are entered into the table in random order. The percent error estimation was averaged for each of the eight first parcels, each of the eight second parcels, etc. The graph below illustrates the results.



We were also concerned there might be some consistent errors or biases. This might be due to the fact that certain subvariables occur only in small areas, (with a consistently high ratio of boundary to area), or only in large areas. For example, orchards, in Brattleboro, occupy only a few contiguous hectares, while mixed forests may cover 50 contiguous hectares. We decided to see whether there was any significant difference between the representation of area for small and for large parcels.

We divided the 116 subvariable areas contained in the 20 sample blocks into two groups: those subvariable areas greater than 5 hectares and those 5 hectares or less. We hypothesized that the mean difference between the grid cell area and the dot grid estimated area would be the same for each of the two groups.

Because the variance of the two groups can be considered to be equal (2.29 and 2.68 tested with a F test F(55,59)), a one-sided t test using pooled variance was used. The calculated t value was 1.75, and, at a 95% level of confidence, the hypothesis was rejected. The conclusion is that we are 95% sure that, on the average, the grid cell rendition of the area minus the dot grid estimate of the area, is greater for parcels less than 5 cells in area than for parcels greater than 5 cells but less than 15 cells. The area of smaller parcels tends to be overestimated, while the area of parcels between 5 and 15 cells tends to be underestimated.

It is possible that this bias is due only to our particular coders who are unconsciously unwilling to let small Vermont orchards slip through the mesh of the grid and into oblivion. However noble the cause, any bias should be checked and recognized before the data file is used.

Human error (b) is involved in the coding process in several ways. First, the determination must be made whether the cell should be coded with the subvariable or not. This is often done by a visual determination of whether or not the cell contains a specified percentage of the subvariable. We have found that a person checking the coding often disagrees with the determination originally made by the person coding the variable.

In addition, errors can be made in data translation, or in entering the coding into the computer file. During our investigation of errors, we tallied miscoded cells and came up with the following:

variable	% cells miscoded*
vegetation	2
land use	1
roads	0
hydrology - streams and lakes	0
flood plain	0
soils	0
slope	2.7
average 1%	

*cells were counted as miscoded if the coding was not the same as the checker's coding. In several cases, this was explained by a difference in opinion between the coder and the checker as to whether the subvariable occupied greater than or less than 50% of the cell.

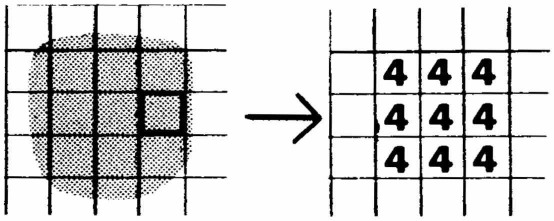
3. DATA TABLET DEMAGNETIZATION

The data tablet must be demagnetized periodically. If this is not done frequently, or if it is done improperly, erroneous lines are drawn during the digitization process, and cells are miscoded.

4. OVERLAY PROCESS

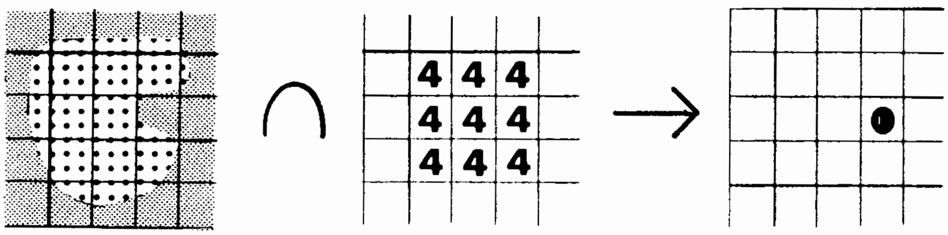
An overlay process will overlay inaccuracies of the original maps just as it will overlay the accurate information. In addition, the overlay process itself will produce a few composite oddities. The frequency of inaccuracies and oddities depends on the levels of accuracy of the input maps, and the size of the grid cell.

For example, consider the coding of soil types A and B as discussed in section IV,E,1.



dark bordered cell would be mapped as type 4 but contain 90% type 5.

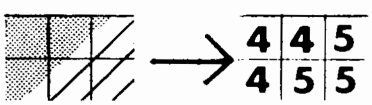
Assume that it is very rare to find soil type 4, which has very low agricultural potential, used for agriculture. However, overlaying a land use map (shown below), with a greater degree of detail, might produce a composite map indicating that there is one cell in which agriculture is being practiced on soil type 4. Actually, since farmers rarely ignore physical characteristics, the agriculture is occurring only on the small pocket of soil type 5 contained within the area mapped as type 4.

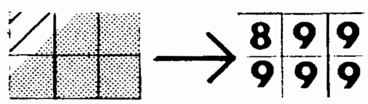


land use
agriculture
forest

composite map showing agriculture on soil type 4

Or, the grid overlay process itself might cause similar oddities. In the following example, we are again interested in the co-occurrence of soil 4 and agricultural land.

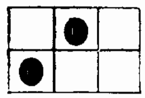




soil 4
soil 5

forest 8
agriculture 9

The composite map indicates that there are 2 cells of this co-occurrence which would make you wonder about traditional wisdom. Actually, though, only 10% of the total area in the two cells has this co-occurrence.



composite based on coded grid cells

agriculture on soil type 4

actual ground composite

agriculture on soil type 4

V. APPLICATIONS

A. Introduction

The Center chose two towns for the pilot study of its computer mapping method--Brattleboro and Middlebury. Brattleboro (population 12,239), in the southeast part of the state, contains a small urban area along the Connecticut river in the eastern portion, and fairly mountainous terrain in the western portion. Only about 15% of the land is used for agriculture. Middlebury, (population 6,532), on the other hand, is a more agricultural town in the Champlain Valley with about 50% of the land in agricultural use.

In each town, we worked closely with the appropriate Regional Planning Commission and, later, with the town planning commission. The maps included in the overlaid data base, the questions asked, and the analyses performed in the two towns, varied depending on the needs perceived by the staffs and members of the planning commissions. The input maps included in the analyses and their sources are listed in Table 1.

A one hectare grid cell was used in both towns. Brattleboro, which has an area of 20544 acres, or 8317 hectares, was entered in one piece in this program. Middlebury, which has an area of 25280 acres or 10230 hectares, was divided into two sections to be entered because of the shape of the town.

B. Residential Development

Probably the most commonly asked questions concerned future residential development. Planning commission members would like to have an indication of where residential development is most likely to take place naturally, and to where, with different zoning or planning techniques, it might suitably be directed.

In the town of Brattleboro, criteria were established based on physical characteristics of the soils, slope, and water table, to determine which areas had critical limitations, serious limitations, moderate limitations, slight limitations or no limitations for residential development (Appendix A). The criteria were based on an analysis of limiting factors on design, construction, operation and maintenance of site improvements according to current state standards and conventional engineering practice. These categories of limitations were first established for residential development requiring on-site septic systems. The results were as follows:

Table 1

Variables Used in Pilot Towns

Variable	Source of Data
BRATTLEBORO	
Roads	WRPC from Vermont Highway Department
Slope	WRPC from USGS
Land Use	WRPC from air photos
Flood Plain	WRPC
Hydrology - streams and lakes	WRPC
Soils	WRPC
Vegetative Cover	WRPC from air photos
MIDDLEBURY	
Soil	SCS detailed soil survey
Flood Plain	Flood Insurance Study
Existing Sewers	Wright Engineering
Proposed Sewers	Wright Engineering
Roads	Vermont DOT
Ground Water Potential	USGS and Vermont Department of Water Resources
1975 Land Use	Center for Studies in Food Self-Sufficiency from air photos
Agricultural Land Use in 1942	Center for Studies in Food Self-Sufficiency from air photos
Power Lines	Central Vermont Public Service
Zoning	Middlebury Zoning Ordinance
Water Lines	ACRPC
Tax Stabilized Land	ACRPC
Public Land	ACRPC

Limitations for Development Using On-Site Subsurface Sewage Disposal*

Limitation	Hectares	
Critical	4813	
Serious	1825	
Moderate	662	1551
Slight or No	889	

*detailed list of criteria included in Appendix A.

As a comparison, criteria for limitations for development requiring alternative waste disposal systems were developed,* and a map was run showing the results.

Limitations for Development Using Alternative Waste Disposal Systems*

Limitation	Hectares	
Critical	2312	
Serious	2757	
Moderate	1481	3120
Slight or No	1639	

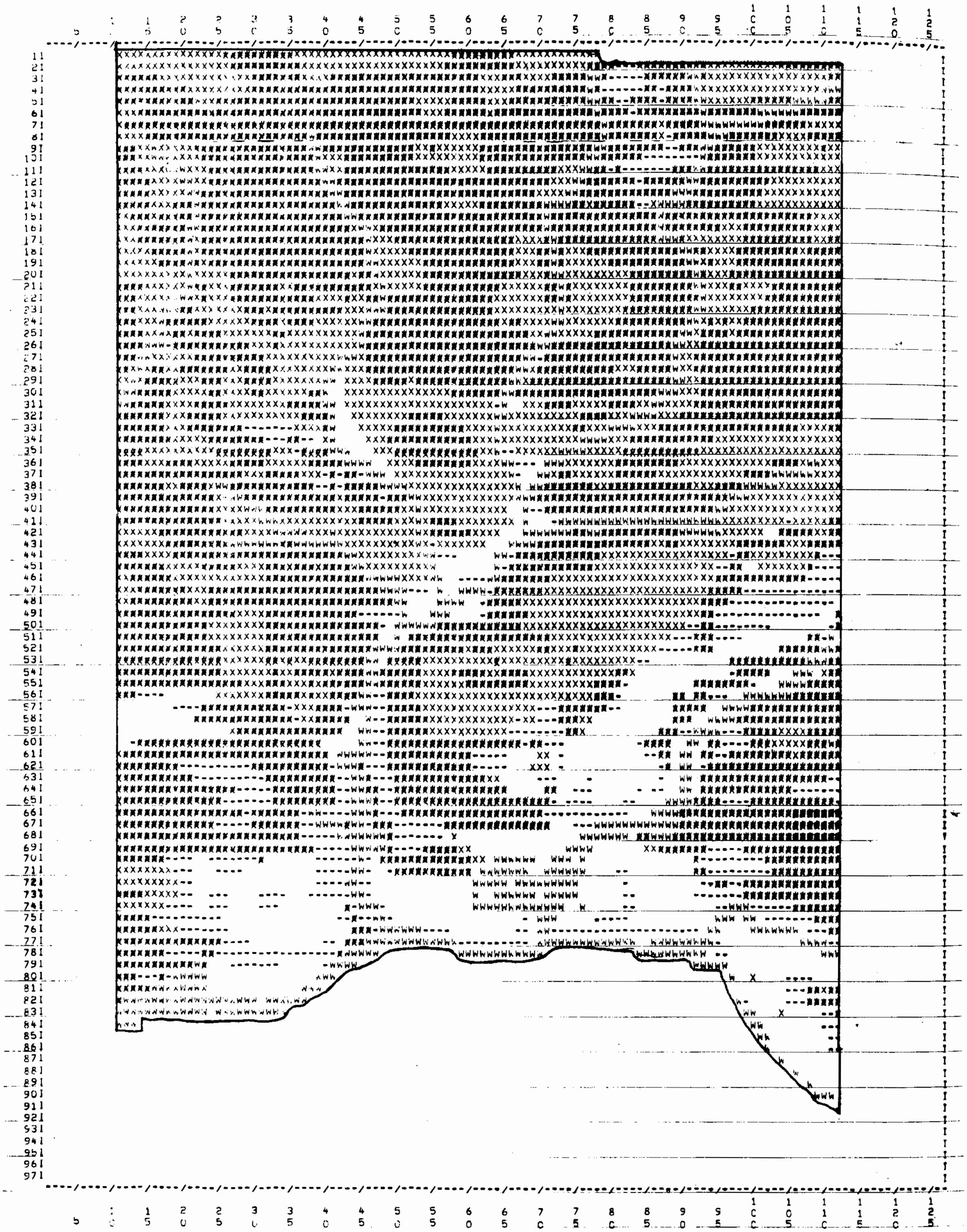
A comparison of the totals from the two maps shows to what extent alternatives to traditional septic systems might open up new areas for suitable residential development; 1568 more hectares are potentially developable using alternative waste disposal systems* than would be developable using only septic systems. The two maps (figures 2, 3) show where the residential development might best take place, based on the effect of physical characteristics of the land on design, construction, operation and maintenance of homes.

To carry the analysis further, the conflict between the potentially developable land (that with moderate, slight, or no limitation to residential development) and agricultural land was examined. The table below summarizes the results of several maps.

*Alternative waste disposal means that no leach field is required. It might include composting systems, or sewer and water lines. Full criteria are included in Appendix A.

FIGURE 2

Limitations for Development Requiring On-Site Subsurface Sewage Disposal

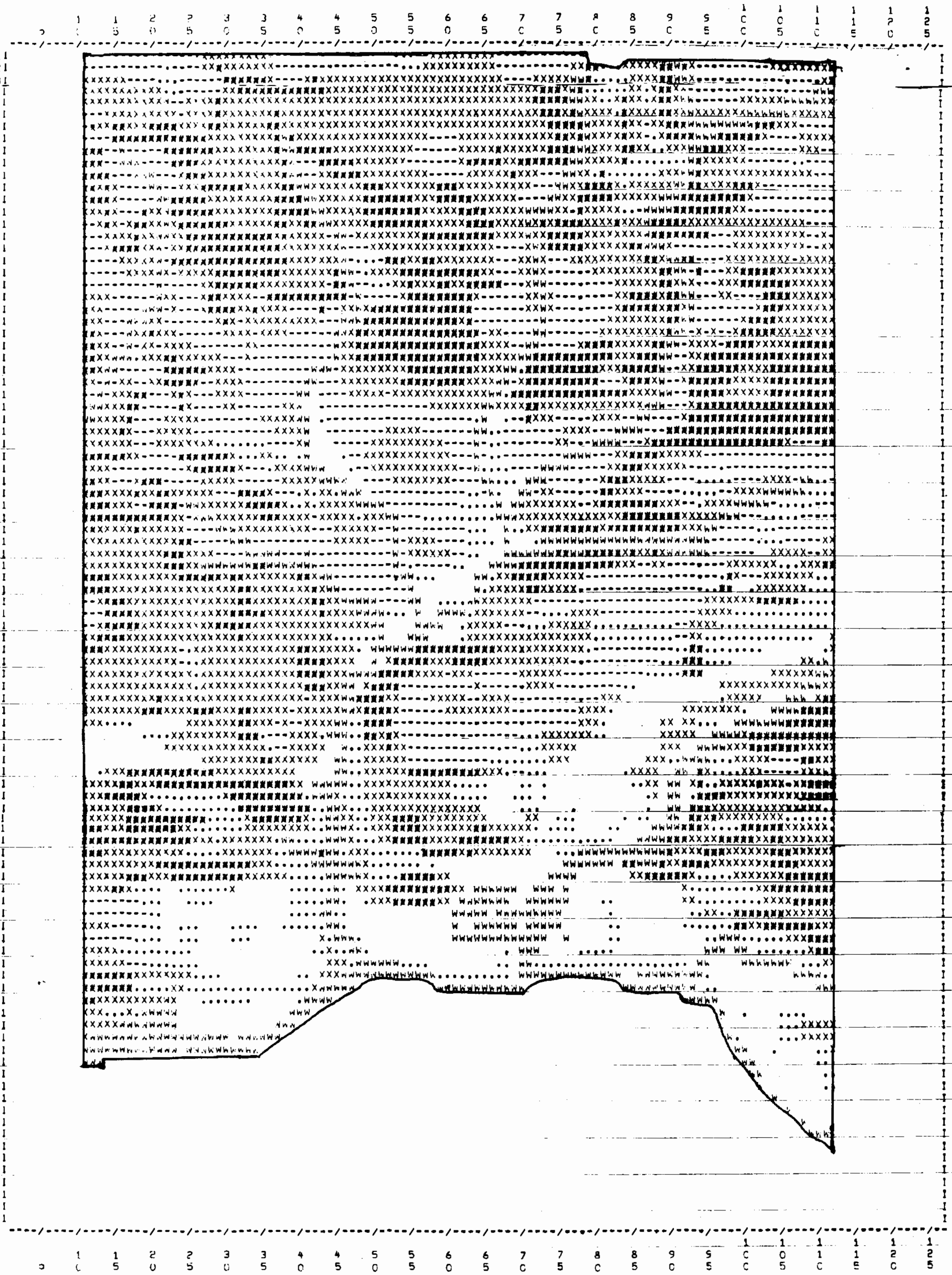


KEY: ✱ = severe limitations X = serious limitations

W = rivers, streams – = slight limitations

FIGURE 3

Limitations for Development With Alternative Waste Disposal Systems



KEY: ✱ = severe limitations   X = serious limitations

W = rivers, streams   - = moderate limitations

	Hectares Suitable for Development Requiring;	
	ON-SITE SEPTIC	ALTERNATIVE WASTE DISPOSAL
1) Total agricultural land=1040		
2) Total potentially developable land	1551	3120
3) Total hectares in agriculture also potentially developable (intersection 1 and 2)	249	469
4) Total (3) as percent of all agricultural land (1)	24%	45%
5) Total (3) as a percent of all potentially developable land (2)	16%	15%
6) Amount of land potentially developable, excluding agricultural land	1302	2651

At least 24% of the existing agricultural land is suitable for residential development.* By reserving agricultural land for agricultural use, that is, by subtracting that land from the potentially developable land, the amount of land potentially developable for residential use requiring septic systems drops from 1551 hectares to 1302 hectares--a decrease of about 16%. On the other hand, subtracting existing agricultural land from the amount of land potentially developable for residential use requiring alternative waste disposal leaves the town with 2651 hectares. About twice as much non-agricultural land would be suitable for development if alternative waste disposal methods rather than traditional septic systems were employed. (Compare figures 4 and 5).

Unfortunately, this analysis may be somewhat futuristic, as alternative waste disposal systems, including disposal of grey water, have yet to be perfected in Vermont.

Middlebury has been interested in another set of questions. As this paper is being written, the Addison County Regional Planning Commission is beginning to look at residential development in relation to zoning plans in Middlebury. First, areas potentially developable for residential use are being determined using criteria (based on physical factors) which are similar to those developed in Brattleboro. Second, a map of these potentially developable areas is overlaid with a present land use map and different zoning plans, to show how much of the presently developed land and potentially developed land is included in each zoning category. The preliminary results will give a comparison between various proposed zoning plans and will allow the Commission to answer questions such as:

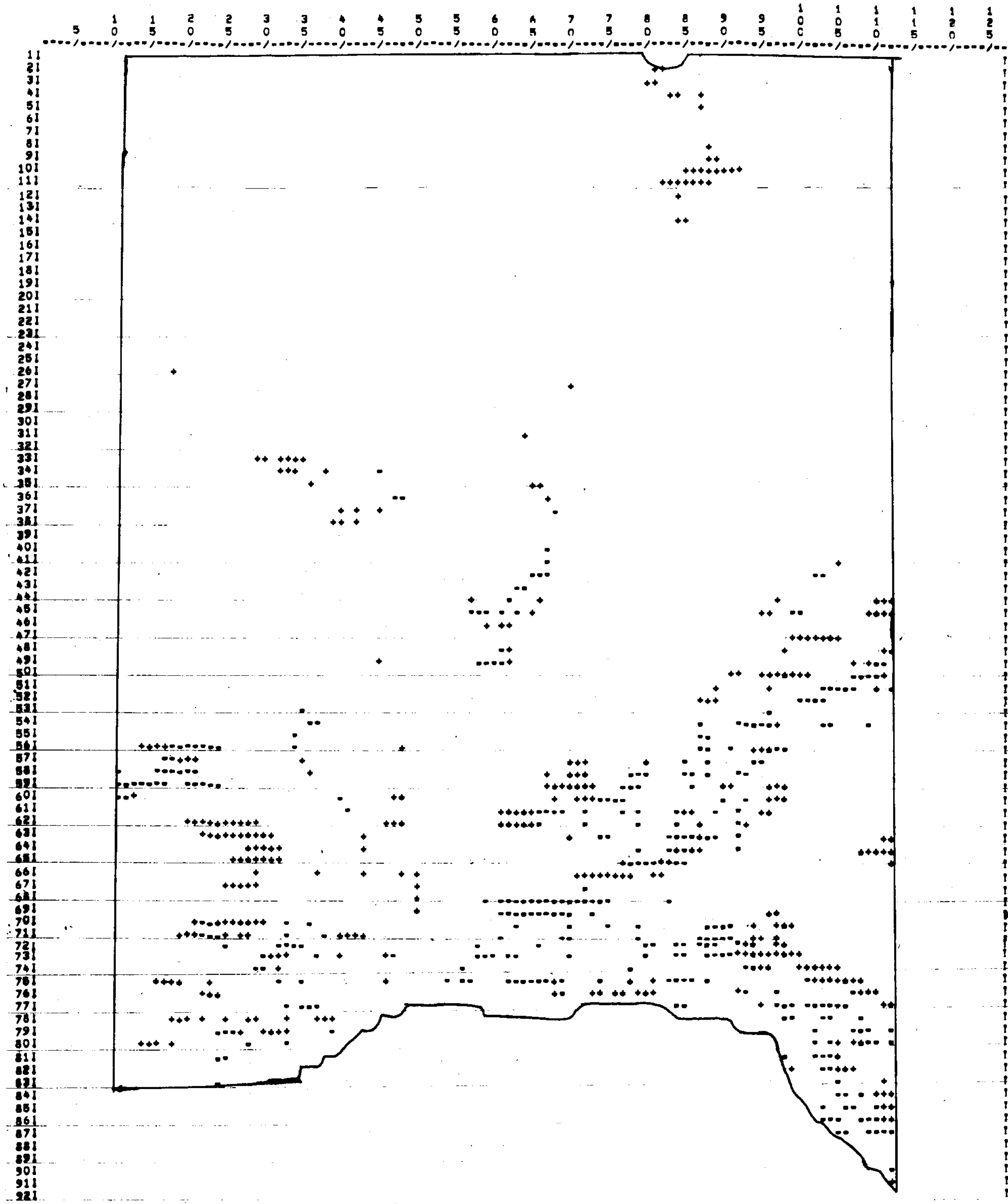
1) How are existing agricultural, forest, residential, commerical areas zoned under each plan?

*no, slight, or moderate limitations, see Appendix A for criteria.

FIGURE 4

Land Suitable for Development Requiring On-Site Subsurface Sewage Disposal

Land in Residential, Commercial, Industrial, Public, or Agricultural Use Excluded

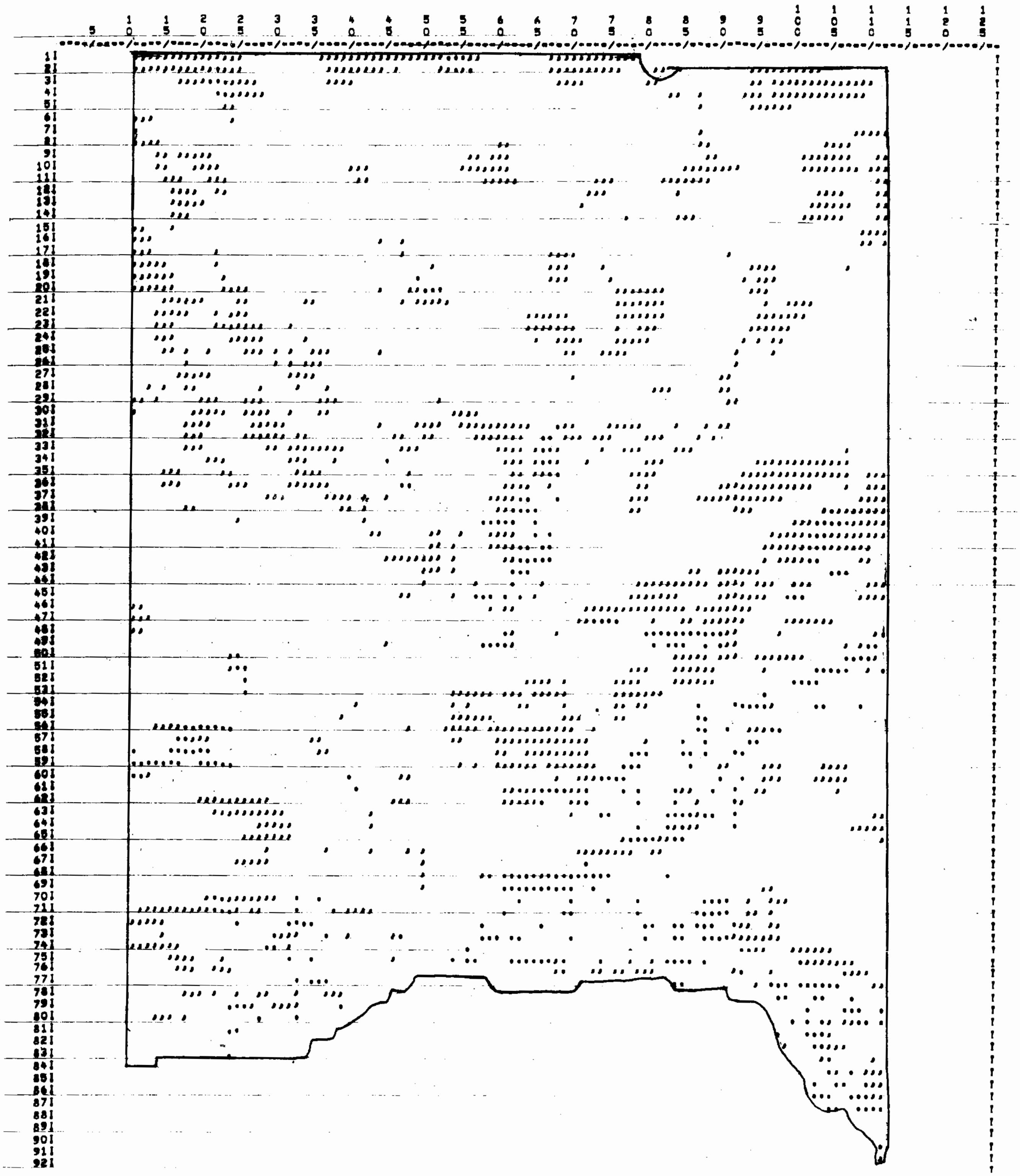


Key: - slight or no limitations for development
\+ moderate limitations for development

FIGURE 5

Land Suitable for Development With Alternative Waste Disposal Systems

Land in Residential, Commercial, Industrial, Public, or Agricultural Use Excluded



Key: · slight or no limitations for development
, moderate limitations for development

2) How are "prime" agricultural, forestry, or other resource areas zoned under each plan?

3) How are the potentially suitable new residential areas zoned under each plan?

They have found, for example, that the existing zoning ordinance zones 51% of all existing agricultural land in "Low Density Agriculture," and 25% in medium or high density residential, commercial or industrial categories. Of the Highest Quality Agricultural Soils (SCS National Definition, see Appendix B) in the town, 29% are zoned in the low density agriculture category.

Then, to look at the future suitability of the existing town zoning plan, the potentially developable land can be "filled up" with houses, subject to constraints of physical, topographic limitations, existing land use, and zoning density. Each housing unit can then be multiplied by a projected average number of people per household to determine an estimate of the maximum population capacity of the zoning plan.

This analysis could then be carried further to estimate the amount of land that will remain in agriculture and its yield, the amount of energy required by the buildings, industries, and commercial establishments, the amount of water that will be needed by the maximum population in each of several zoning plans. The information would be used by planning commission members to draw up alternative zoning plans, and to compare the results--looking for a suitable balance between forest land, agricultural land, and developed land.

Of course, this method has many shortcomings. It does not consider the effect of issuing variances to the zoning ordinance; it assumes an average household size while we may find different patterns emerging; it does not account for large landownerships; we do not know how future technology will affect our energy consumption, etc. However, it may be useful in alerting the planning commission to inconsistencies or problems in their zoning ordinance in time to avert unwanted patterns of growth.

C. Agricultural Land

Vermont citizens are increasingly concerned with the future of agriculture in the state. Even those not directly involved in farming value the rural-pastoral quality of the state, and there is a direct relationship between the quality of the land and tourism. However, agricultural land is constantly going out of production. In 1880, 4,882,588 acres in Vermont were in farms. In 1970, there were 1,915,520 acres in farms--or only 39.3% of the 1880 total (15). Citizens are looking for ways to understand and to change these trends without leading the town to bankruptcy in order to preserve something quaint. There is an underlying belief that maintaining viable agriculture is more than historic preservation; farms are the backbone of rural areas and they foster an ecologically sound and healthy life for citizens.

The argument has been advanced that, on the national level, the land going out of agricultural production is the least productive land.(17,18,19) This argument is based on statistics which show an 11% decline in the amount of land used for agriculture in the northeast from 1944 to 1969, while agriculture in the corn belt increased by 2%. The conclusion drawn is that "the net effect has been to increase average cropland productivity as well as to return much erosion-prone cropland in the East to its natural state." (17, p.15)

While this type of analysis might be encouraging to statisticians predicting national food production, it is distressing to those who believe that some sort of agriculture in the Northeast should continue, and that the apparent national shift to farming the more productive land may not hold in the Northeast.

Using data collected for the town of Middlebury, Vermont, we tested the hypothesis that a greater proportion of less productive land than of prime agricultural land has gone out of agricultural use during a given time period. Two different definitions of prime agricultural land based on physical land capability as determined by the SCS detailed soil survey were used in the analysis to represent the most productive land. The time period examined was the 32 years from 1942 to 1974. A 1942 map of agricultural land was drawn from air photos and compared to a 1974 land use map and the detailed soils map.

Although essentially an agricultural town, Middlebury has experienced population growth well above the State average. In 1940 the town population was 3175 and by 1970 it was 6532--an increase of 106%. This increase is much greater than that of Addison County as a whole (35%) and compares with the 90% population increase in Chittenden County, the most populous county in Vermont.(20)

Figure 6 shows all land which was in agricultural use in 1942 and its present use. Between 1942 and 1974, the amount of land in agriculture decreased by 22%. If the hypothesis that marginal lands had a greater probability of going out of agricultural use were true, a similar map showing present uses of prime agricultural soils which had been used for agriculture in 1942 would show that less than 22% of these prime soils had gone out of production by 1974.

To test this, we used each of two sets of criteria to determine which land is the most productive. The first is being formulated as a proposed Act 250 (21) definition of 'prime' agriculture. The Soil Conservation Service is developing these criteria for Vermont use only. About 68% of all land farmed in the town in 1942 meets the criteria for 'prime' according to this definition (VT).*

Figure 7 shows the prime agricultural land (VT) which was used for agriculture in 1942. Of this prime land, 21% had gone out of agriculture by 1974. There is no significant difference between the proportion of prime agricultural land (VT) that has gone out of production (21%) and the proportion of all agricultural land that has gone out of production (22%).

The second definition of prime agricultural land is a national definition which encompasses very few of Middlebury's soils. Only 254 hectares (or 4%) of all Middlebury land in agricultural use in 1942 meet the criteria for this national definition of 'prime' (Figure 8). These are called 'highest quality soils' (US) in Vermont and form a subset of 'prime soils' under the Vermont definition (VT). Of these 254 hectares of highest quality agricultural land (US), 22% were converted to non-agricultural uses between 1942 and 1974. This compares to the 22% of all agricultural land, 21% of prime land (VT), and 24% of land that is not prime by the Vermont definition (US), that has gone out of agricultural use during the same time period.

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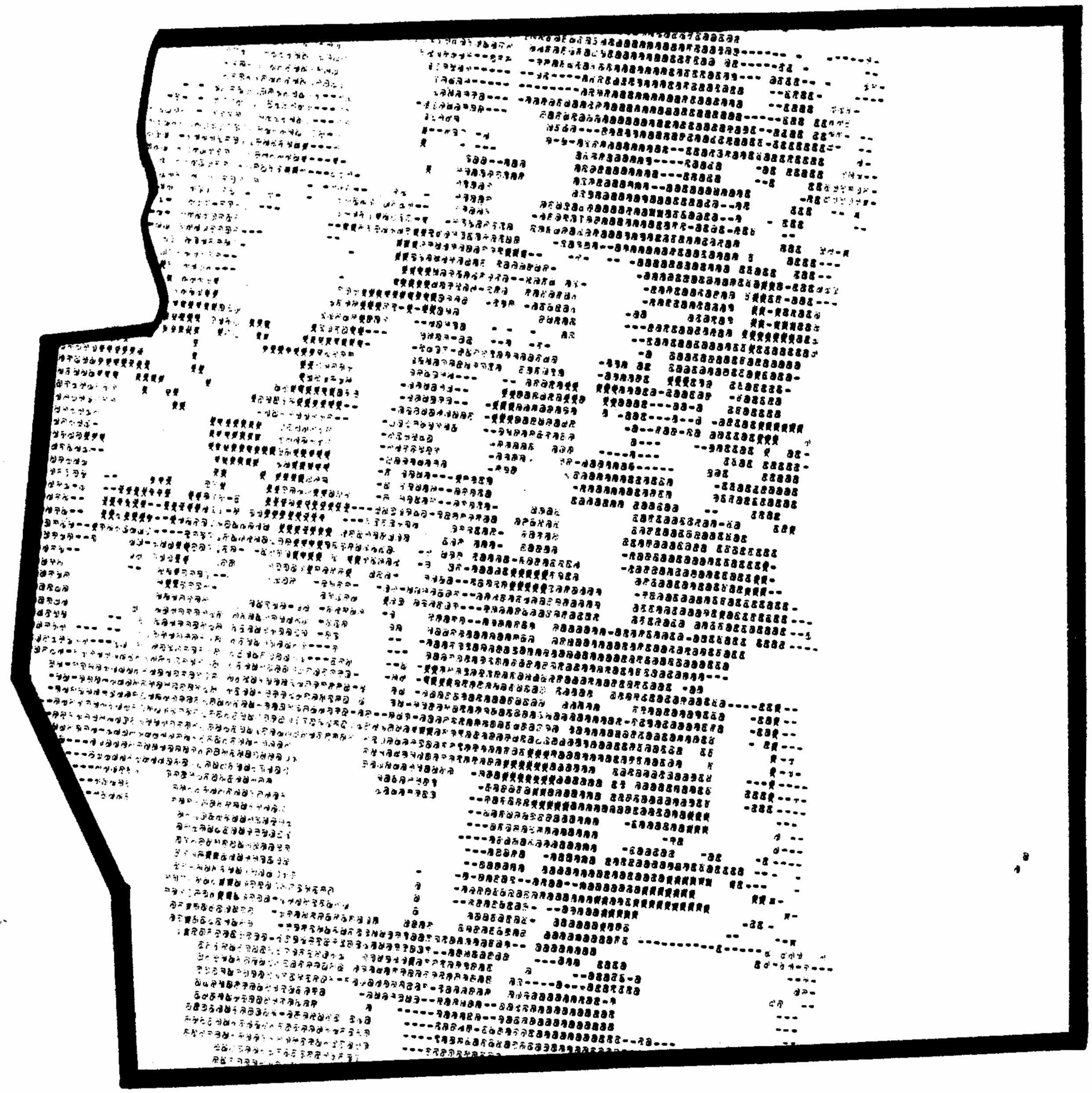
*From here on in this paper, (VT) refers to the proposed Vermont definition of "prime," (US) refers to the national SCS definition of "prime," called "highest quality" in Vermont.

FIGURE 6

1974 Use of Land Which Was Farmed in 1942



Scale:

one character = one hectare

Key:

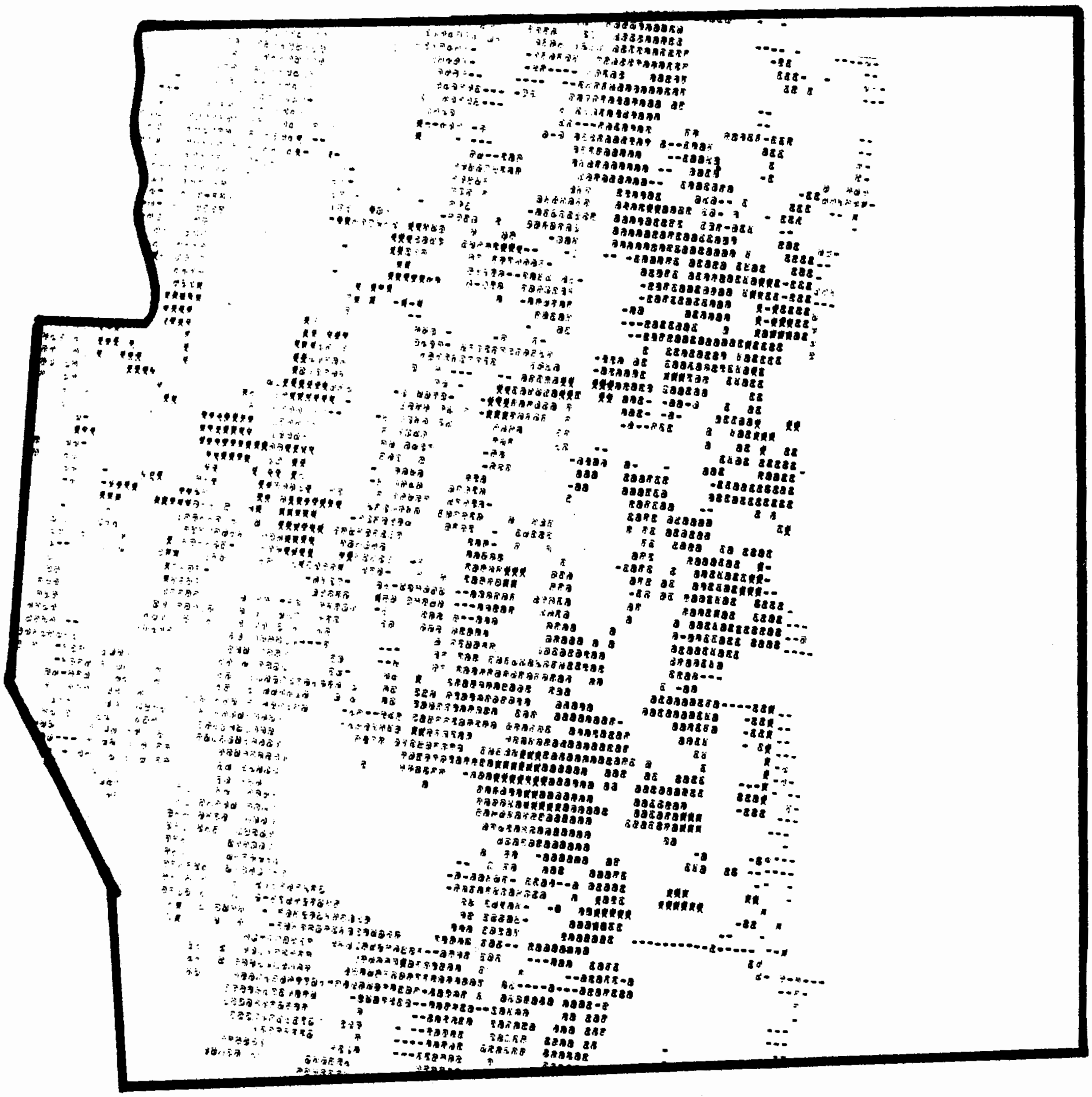
@ Agriculture

\- Forest

¥ Commercial/Residential/Industrial

FIGURE 7

1974 Use of 'Prime' (1) Land Which Was Farmed in 1942



Scale:

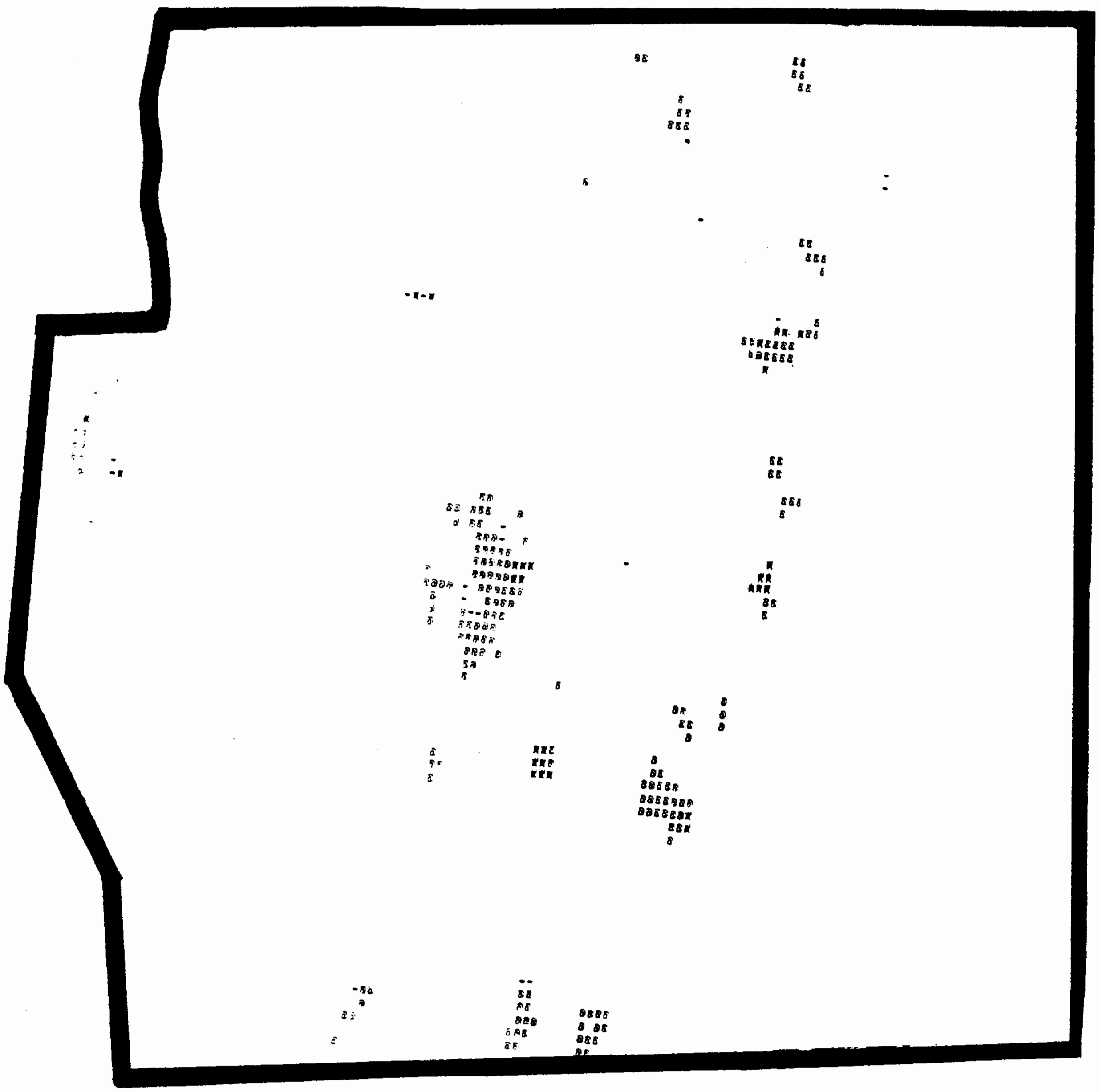
one character = one hectare

Key:

@	Agriculture
-	Forest
¥	Commercial/Residential/ Industrial

FIGURE 8

1972 Use of 'Highest Quality' (2) Land Which Was Farmed in 1942



Scale:
one character = one hectare

Key: @ Agriculture
– Forest
¥ Commerical/Residential/Industrial

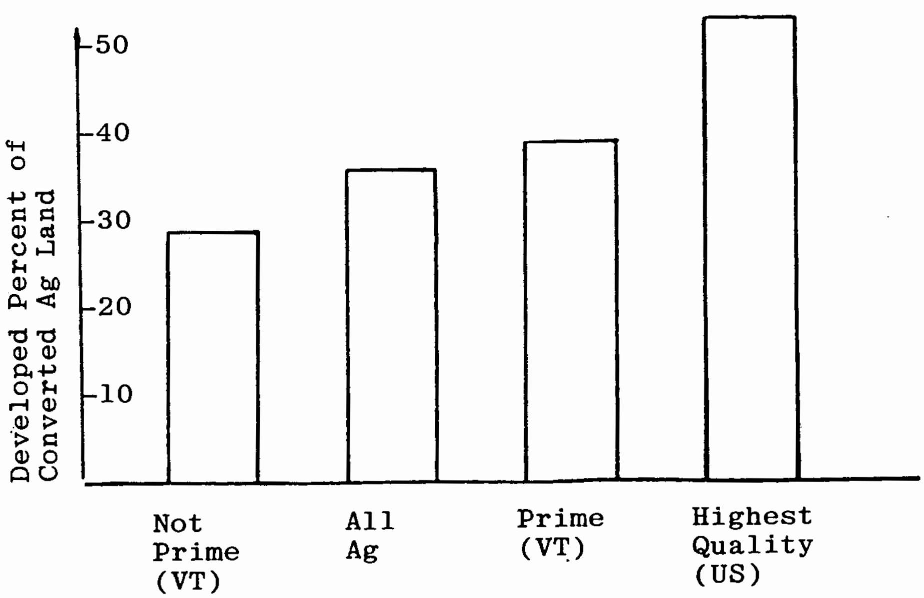
Since there is virtually no difference between these percentages, we must accept an alternative hypothesis which states that there is no significant difference between the probability of not prime (VT), all agricultural, prime (VT), and highest quality (US) land going out of agricultural production between 1942 and 1974.

A possible explanation of this is that, although farming may be more productive on the better soils, the pressure of development and therefore the opportunity cost is greatest on the most productive agricultural soils, as these soils are often superior for building. That is, the incentive to keep prime soils in agricultural use caused by their higher productivity may be balanced by the incentive to sell caused by their value if sold for development. If this theory were valid, fields on highest quality soils (US) which had gone out of agricultural production, would be more likely to be used for development than would fields on not-prime soils. The hypothesis we tested was: Of the land converted from agricultural to other uses between 1942 and 1974, a higher proportion of "highest quality" (US) land than of "not-prime" land (VT) was used for residential-commercial-industrial development.

This hypothesis was tested by comparing a 1974 land use map with maps of the land that has gone out of agricultural use in each of the different soils capability categories, to determine the 1974 uses of converted agricultural land.

FIGURE 9

Presently Developed Land as a Percent of All Land Converted From Ag Use (1942-1974) in Each of 4 Capability Categories



A trend which supports the hypothesis is indicated by the results graphed in figure 9. Only 29% of the non-prime (VT) land which has gone out of production has been used for development. The proportion of converted land which is developed seems to increase as the agricultural productivity potential of the soil increases, so that 53% of the highest quality land (US) no longer used for agriculture is now developed. (How much of the remaining percentage is being held for development speculation is, of course, unknown).

Although all agricultural soils, regardless of their capability for crop production, have an equal probability of going out of agricultural use, the above calculations indicate that the higher the agricultural potential of the land that goes out of agriculture, the higher the probability that it will be converted to development. This lends support to the theory that pressure of development is greater on the prime agricultural soils than on the lower quality soils.

This analysis raises several planning questions:

1. Since it does not appear that the least productive agricultural land is being removed from agricultural use, should steps be taken to change the trends so that prime land is preserved in agriculture?

2. Would prohibiting commercial-industrial-residential development on prime agricultural soils reverse this trend? One argument is that the market will separate more successful farms from failing farms. However, as the USDA recognizes, "the traditional market system may not always be sufficient in providing for the wise use of our lands."(17, p.5) Viable local economies can rely on several main production or income producing bases. The market itself can push one of these bases out of existence, and not because it is not viable. It may be that local public policy is needed to support a viable farm economy.

3. If any action is taken to reserve prime land for agricultural use, what criteria should be used to identify this prime land?

Should the major determinant be only the physical capability of the land to produce crops, or simply the fact that it is presently in agricultural use, or the developmental pressures on the land? Obviously, the latter point brings up a whole series of economic concerns and questions which require further analysis.

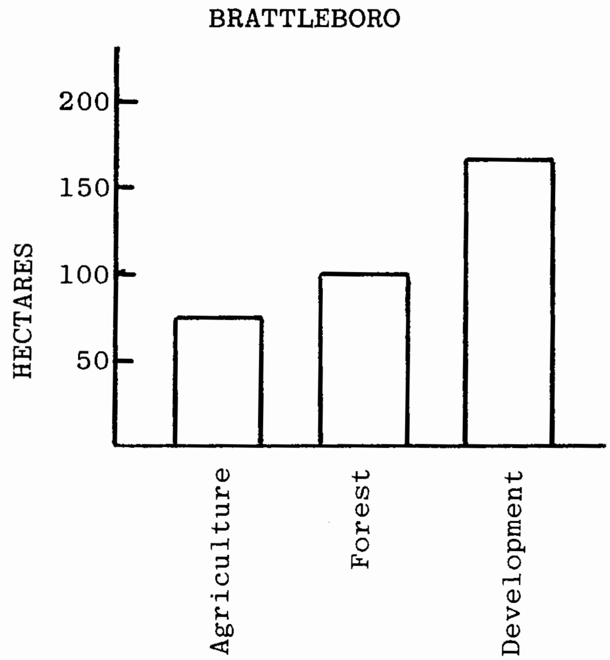
Looking at physical capability in Middlebury, our calculations show that the correlation between prime soils (VT) by the Vermont definition and the land presently used in agriculture is not high (.63 using a sign test). Of the prime land (VT), 56% is in agricultural use, and 69% of the existing agricultural land is prime (VT). The correlation between highest quality (US) soils and existing farmland is even lower (.58).

The town of Brattleboro has, at this time, a reconnaissance soil survey rather than a detailed soils map, so their maps and calculations will not be as accurate as those in Middlebury. However, the graph (figure 10) showing the current use of the soils with the highest agricultural potential (Appendix E) indicates that twice as much of this land was developed (includes single, double, multi-family mobile home park, hotel-motel, commercial, and industrial) as was farmed (includes crop, pasture, and orchard land).

Looking at a map showing the soil potential of land presently in agricultural use, they found that 63% of present farmland is in the category of lowest potential, while only 6% was in the category of highest potential. This is summarized in the table on the following page.

FIGURE 10

Uses of Prime Agricultural Land



Development includes: single, double, multi-family residential, mobile home park, motel-hotel, commercial and industrial.

Agricultural Potential of Soils Used For Agriculture

BRATTLEBORO

	Class I	Class II	Class III	Low Potential
Total ag. land	6%	3%	28%	63%
Crop	7%	4%	25%	64%
Pasture	5%	2%	26%	67%
Orchard	0%	0%	47%	51%

Numbers in table represent column headings as percent of row headings

The simplest answer to the question of determining which land should be reserved for agriculture is to reserve all land which is presently in agricultural use. However, if we assume that some farmland will be converted to other uses in the future, then we must determine which subset of "all land" we wish to preserve for agricultural uses. This subset might represent either our "most likely to succeed" farmland, or our potentiall most productive land based on physical characteristics. If we consider our "most likely to succeed" farmland, a definition of prime land should probably contain criteria relating to variables such as size of ownership and other quantifiable surrogates for economic viability.

Land which is potentially most productive could be represented by the intersection of the Vermont definition of prime soils (VT) and the existing agricultural land. This would exclude areas with prime soils which are presently in non-agricultural uses, and also exclude areas which are in agricultural use but which do not have prime soils. In Middlebury, then, under this definition prime agricultural land would include 30% of the total land in the town, and 69% of the present agricultural land.

VI. CONCLUSION

The ability to control and shape the environment exists most powerfully at the local level. Local people are the most intimately involved with environmental and land use issues. They are the ones who must live most directly with the consequences of planning decisions.

Therefore, it makes good sense that local people should have access to planning tools and inventory systems such as the ones described in this report. As we have stated, there is no 'best' system, only a best system for a particular community's needs and resources. State and regional planning groups have a major role to play in aiding communities select, set-up, and maintain computerized or non-computerized inventory systems which fit the individual community.

This project has been an attempt to show, in an exploratory fashion, what some of the capabilities and outcomes can be for Vermont communities which use computer techniques for natural resource inventory systems.

It has been a continuation of the Center for Studies in Food Self-Sufficiency's effort to carry out projects in the community--projects in which the community itself can directly participate and from which it can benefit.

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APPENDIX A

Key for Physical Limitations for Development Map:

<u>Development Requiring On-Site Subsurface Sewage Disposal</u>

(Based on an analysis of limiting factors on design, construction, operation, and maintenance of site improvements according to current state standards and conventional engineering practice).

CRITICAL FACTORS:

15% or greater slopes
excessively wet soils
water
10-15% slope plus seasonal high water table
10-15% slope plus 0'-4' depth to bedrock

SERIOUS FACTORS:

seasonal high water table
10-15% slope plus hardpan
10-15% slope plus 4'-8' depth to bedrock
4'-8' depth to bedrock plus seasonal high water table or hardpan

MODERATE FACTORS:

10-15% slope
fragipan
4'-8' depth to bedrock

APPENDIX A
(continued)

Key for Physical Limitations for Development Map:

Low-Impact Development With Alternative Waste Disposal Systems

(Based on an analysis of limiting factors on the design, construction, operation, and maintenance of limited site improvements according to standards and procedures to minimize cost and alteration to the existing topography).

CRITICAL FACTORS:

25% slope
water
10-25% slope plus excessively wet
15-25% slope plus 0'-4' depth to bedrock

SERIOUS FACTORS:

15-25% slope
excessively wet
0'-4' depth to bedrock
10-15% slope plus 0'-4' depth to bedrock

MODERATE FACTORS:

10-15% slope plus seasonally wet
10-15% slope plus fragipan

SLIGHT LIMITATIONS:

4'-8' depth to bedrock
fragipan
seasonally wet
10-15% slope

APPENDIX B

from SOIL CONSERVATION SERVICE

Soil Potential for Agriculture in Vermont

The soils and land of Vermont have been classified into four categories with respect to their potential for agriculture. The four categories are Highest, Good, Low, and Limited.

The soils are rated on their relative ability to support crops that are commonly grown in Vermont. The Highest and Good categories comprise those soils with the highest potential productivity and the least limitations for farming. The Highest category coincides with the national definition of "Prime Farmland" in the Land Inventory and Monitoring program as administered by the Soil Conservation Service.

The definitions of each category follows:

Highest Potential

Soils in this category qualify for Prime Farmland as defined in the National Land Inventory and Monitoring program. They have high potential for sustained agriculture and have little or no limitations for a wide variety of crops adapted to Vermont's climate. They have the following attributes:

1. Soil temperature and growing season are favorable.
2. Soil moisture is adequate to sustain crops throughout the growing season.
3. Water moves readily through the soil, and hardpans or other restrictive layers are absent.
4. Stones comprise less than 10 percent of the surface.
5. The soils are not frequently flooded and have no water table within 1.5 feet of the surface during the growing season.
6. The soils are not frequently flooded and have no water table within 1.5 feet of the surface during the growing season.
7. Slope is favorable and soils are not subject to erosion.
8. Soils are deep and rock outcrops are not present in sufficient amount to hinder use.

APPENDIX C

from SOIL CONSERVATION SERVICE

Good Potential

Soils in this category are in land capability classes II and III according to the National Land Capability Classification system. This system was developed by the USDA Soil Conservation Service. Soils in class II and III that qualify for the "Highest Category" are excluded from this category. Soils in this category have good potential for growing crops, but one or more limitations will restrict the choice of crops and require more intensive management than for soils in the Highest category. The limitations result from one or more of the following:

1. Excess slope and an erosion hazard.
2. Excess wetness or slow permeability.
3. A flooding hazard.
4. Shallow or moderate depths to bedrock, hardpan, or other layers that limit the rooting zone.
5. Moderately low available soil moisture.

*The Vermont definition of prime used in this paper includes the SCS definitions of Highest Potential and Good Potential as indicated in these Appendices.

APPENDIX D

Summary Table:

Changes in Use of Agricultural Land Between 1942 and 1975

	All Agricultural Land	Prime (1) Vermont	Prime (2) Highest Quality	Not Prime (1) Vermont
1942	5754	3910 (68%)	254 (4%)	1844 (31%)
1975	4481	3084 (69%)	199 (4%)	1397 (31%)
Change	1273	826	55	447
Change as % of 1975 amount	22%	21%	22%	24%
Resident./ Commercial/ Industrial as % of change	36%	39%	53%	29%
Forest as % of change	48%	50%	19%	45%

Measured in hectares (2.47 acres)

APPENDIX E

Brattleboro Soils: Agricultural Potential

Soil Type	Slope
HIGHEST POTENTIAL	
Unadilla	0-8
Scio	0-8
Merrimac	0-8
Raynham	0-8
Colrain	0-8
Stowe	0-8
Ondawa	0-8
Woodbridge	0-8
Peru	0-8
CLASS II	
Tunbridge/Woodstock	0-8
CLASS III	
Unadilla	8-15
Scio	8-15
Merrimac	8-15
Windsor	0-8
Deerfield	0-8
Tunbridge/Woodstock	8-15
Stowe	8-15
Woodbridge	8-15
Woodstock	0-8

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