An Internet-Based Integrated Resource Management System (IRMS)

First Quarter Report, Year 2
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1. Project Objectives and Tasks

The goal of this research project is to develop a user friendly Internet-based decision support system (DSS) that addresses total resource management by integrating ecological and economic models with a geographic information system (GIS). Specifically, research is proposed to develop and implement an integrated resource management system (IRMS). This DSS is designed to assist natural resource-based agencies in developing management plans. For example, IRMS will be used by MDNR Soil and Water Conservation Program to prioritize Special Land Area Treatment – Agricultural Non-Point Source (SALT-AGNPS) projects. IRMS will also be used as screening tool for identifying costs and benefits of potential SALT-AGNPS projects.

Specific objectives of the proposed project are as follows:

1. Develop an Internet-based Integrated Resource Management System (IRMS) that addresses changes in land use and/or its management practices by integrating economic and environmental simulation models.

2. Develop feedback loops with IRMS end users and conduct three workshops for selected agency field staff.

2. Research Approach

IRMS will have three components: an Internet-based geographic information system (GIS) building upon ArcView Internet Map Server, a graphical user interface (GUI), and a modeling system. The GUI includes the menus that allow a user to select parameters and evaluation criteria needed to run IRMS. It will be developed using Java, JavaScript, HTML Form components and ArcView Avenue programming languages. The interface enables the decision maker to manipulate land use/management practices, execute the models, and view results within the GIS.

The GIS layers to be incorporated in IRMS include: soils, land use, digital orthophoto quadrangles (DOQs), hypsography, and hydrography. Depending on the data needs of the models, other layers may also be digitized with IRMS. Digitization of these layers should require a modest effort given scanning technologies, object character recognition software and other software algorithms. Although some of these layers do not currently exist statewide, the intent of this research is to have the appropriate tools in place before the layers do become available.

The modeling system includes the Cost and Return Estimator (CARE) model and four habitat models. CARE is a crop budget generator which can be used with individual stockholders in conservation planning or as a tool for economic evaluation in watershed planning. The first habitat model has been developed by Wes Burger, Mississippi State University (see Habitat Model to Predict Landscape Use of Northern Bobwhite in Missouri). Subsequent models will be incorporated onto the tool as they are developed by Burger and

others. The purpose of integrating the habitat models is to streamline and automate the process of constructing habitat suitability surfaces for large-scale habitat assessment.

3. Work Schedule

IRMS is a three-year project extending from October 1, 1998 to September 28, 2001. The table below lists the proposed timelines for IRMS:

Tasks	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4		Q2	Q3	Q4	Q1	Q2	Q3	Q4
Consult with agencies on assigning field staff to project and establish formal feedback loops	X											
Develop prototype IRMS by integrating CARE model	X	X	X	X								
Develop prototype of habitat models (CARE still under development)				X		X	X					
Complete integration of CARE model						X						
Complete integration of habitat models								X				
Activate feedback loops		X	X	X	X	X	X	X	X	X	X	
Conduct workshops								X		X		X
Prepare quarterly reports to funding agencies, collaborators and specified field staff	X	X	X	X		X	X	X	X	X	X	X
Meeting with funding agencies, collaborators, model developers and field staff regarding direction of project				X				X			X	
Prepare on-line users manual				X			X				X	
Prepare final report/distribute final version of IRMS												X

4. Quarterly Progress

Integration of Socio-economic Model

The Cost and Return Estimator Model (CARE) was the originally proposed economic model for the project. The CARE is a farm budget generator, developed by USDA Soil Conservation Services (SCS) from 1985 to 1994, and primarily used as a field office or farm PC tool. Based on an extensive research and evaluation of economic models taken at the beginning of this project, the profits and costs model (ProCosts) was chosen to replace the CARE model. The reasons were twofold: (1) ProCosts is a profit and cost analysis program that handles crop budgeting, livestock budgeting, and conservation practices. It is developed by the Natural Resource Conservation Services (NRCS) to phase out CARE. (2) In addition to the standalone version, a web-based ProCosts version would be

implemented with efficient database design to accommodate simultaneous access of multiple users. The model seemed to fit well with objectives and applications of IRMS project. However, the release of the ProCosts model was postponed for various reasons. As the first year of this project went by, the release of the web-based ProCosts version was still not foreseeable in the near future.

In lieu of the situation, a project managers' meeting was called on November 23rd of 1999. Attendees of the meeting are: Dean Martin (MDNR), Eric Kurzejeski (MDC), Chris Fulcher (CARES) and Yan Barnett (CARES). It was agreed that a different model or approach should be used in order to complete the project in time. The possibility of using CARE model was discussed. However, we all agreed that it would not be a good substitute since CARE is currently being phased out. At the time of the completion of IRMS project, CARE model will be very likely out-of-date and no longer supported by NRCS. Other economic models did not seem to fit with this project well (see model reviews in First Quarter Report, Year 1). The conclusion of the meeting was to provide U.S. demographic and Socio-economic data online. An amendment to the project contract was added to formalize this change.

The integration of demographic and socio-economic database was an attempt to link environmental issues with human factor. The database would be a useful source for answering questions such as the population composition in a watershed in terms of farmers and non-farmers, and etc. In addition to the database, several analytic tools will be developed for the users to look at the trends over time and more.

CARES will investigate the appropriate census attributes to be included in this project. The U.S. census data are reported or summarized in census block level or census blockgroup level. A census tract is the upper level unit composed of several blockgroups. The demographic and socio-economic data will be presented at the tract level for this project. Other appropriate aggregation level of the data such as zip code areas and watershed areas will be investigated.

A prototype for visualizing Missouri demographic and socio-economic data is in progress. Currently, the general population data from U.S. 1990 Census are served on the Internet (see Figure 1). This includes: (1) total population, (2) female population, (3) rural population, (3) persons on farm, (4) persons in family, (5) persons living alone, and (6) persons in group quarters. The data are presented in census tracts and zip code areas. The user can visualize the data for whole state or for a certain county. Figure 2 shows the state-wide total population in tracts. The user can find out the actual population for any census tract by using the Identify tool and clicking on the tract polygon.
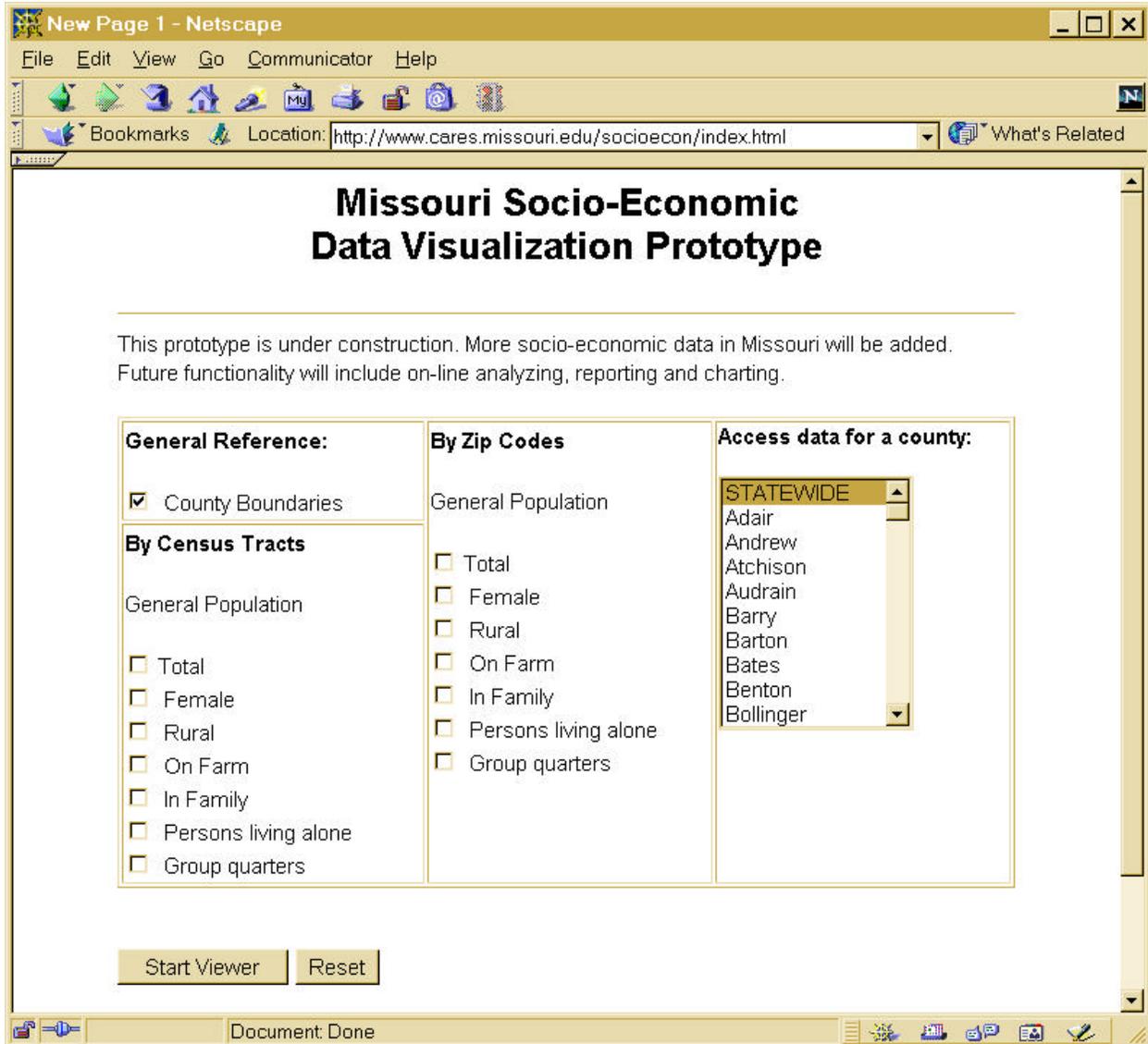
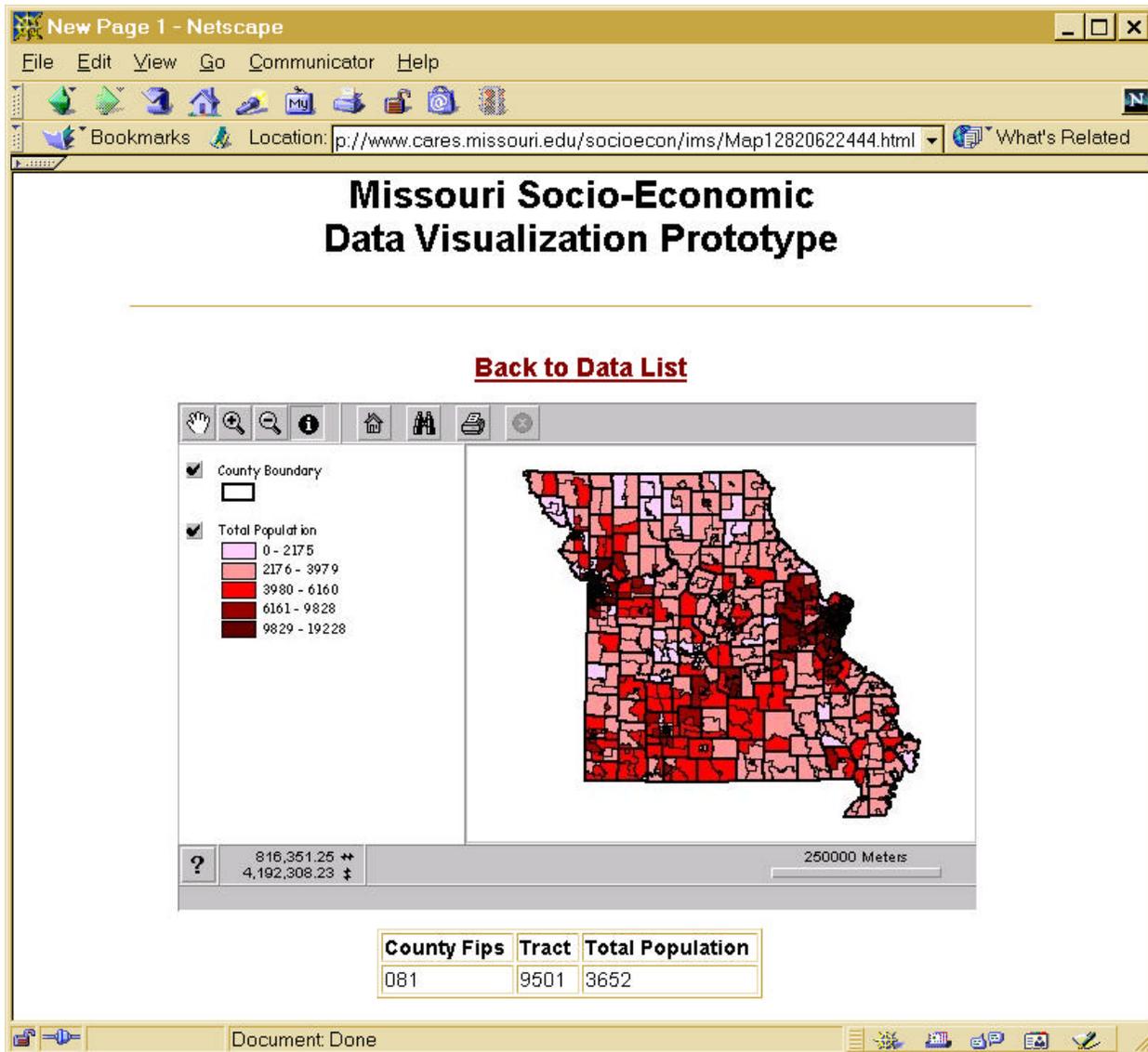Figure 1. A prototype for Missouri Demographic and Socio-economic data visualization.

Figure 2. Viewing Missouri state-wide total population by census tracts on the Web.

Develop prototype of habitat models

The first meeting with Dr. Wes Burger on the habitat models finally took place on November 22nd, 1999. Dr. Burger is funded through MDC to develop the habitat models to be integrated in the project. Chris Fulcher and Yan Barnett of CARES were present in the meeting. Eric Kurzejeski and two other ecologists from MDC also participated the discussion. Chris and Yan demonstrated the current CARES Internet map serving and decision supporting capability. Dr. Burger described the habitat models to predict landscape use of northern Bobwhite in Missouri.

1. Habitat Model I - Winter Habitat Model

The winter habitat model accounts for three landscape variables: (1) landscape shape index of row crops - RC_LSI, (2) edge density of woody patches - WD_ED, and (3) edge density of CRP fields - CP_ED. These three variables are calculated through the following equations:

$$RC\_LSI = TE_{RC} / (2 * \sqrt{(\pi * A_{RC})}) \tag{1}$$

$$WD\_ED = TE_{WD} / A_{WD} \tag{2}$$

$$CP\_ED = TE_{CP} / A_{CP} \tag{3}$$

where TE_{RC} = total edge length of row crops, A_{RC} = total areas of row crops, TE_{WD} = total edge length of woody patches, A_{WD} = total areas of woody patches, TE_{CP} = total edge length of CRP fields, and A_{CP} = total areas of CRP fields.

The habitat suitability of a location is determined by the landscapes within the bird's home range from the location. The average home range size for bobwhites is 345 meters. Thus, by generating a 345-meter buffer area of any given location and calculating the three landscape variables of the buffer area, we can obtain a Y value for the location:

$$Y = 3.18 * RC\_LSI + 0.05 * WD\_ED + 0.06 * CP\_ED \tag{4}$$

The habitat suitability of the location is then calculated by converting the Y value through an equation, which will be provided by Dr. Burger.

The critical data for this study is the landuse coverage. The accuracy of the landuse delineation determines the reliability of the habitat suitability surface generated. Currently, several NRCS county field offices in Missouri are developing county landuse inventory database based on 1-m resolution digital orthophotos (DOQQ). Among the counties completed, the Callaway county landuse inventory is the most comprehensive one. Callaway county was 100 percent inventoried, including all crop fields and non-crop fields.

The Callaway county landuse coverage was obtained from the county field office in Fulton. This landuse coverage will be used as the base layer for habitat suitability evaluation. A

Web-based graphic user interface will enable the user to modify field boundaries or add new features such as grass waterway to generate alternative habitat suitability.

The 6300-acre Harrison Branch watershed located in northeastern Callaway County was used as test area. The landuse categories were reclassified into four types: row crops, woody patches, CRP, and others (Figure 3).
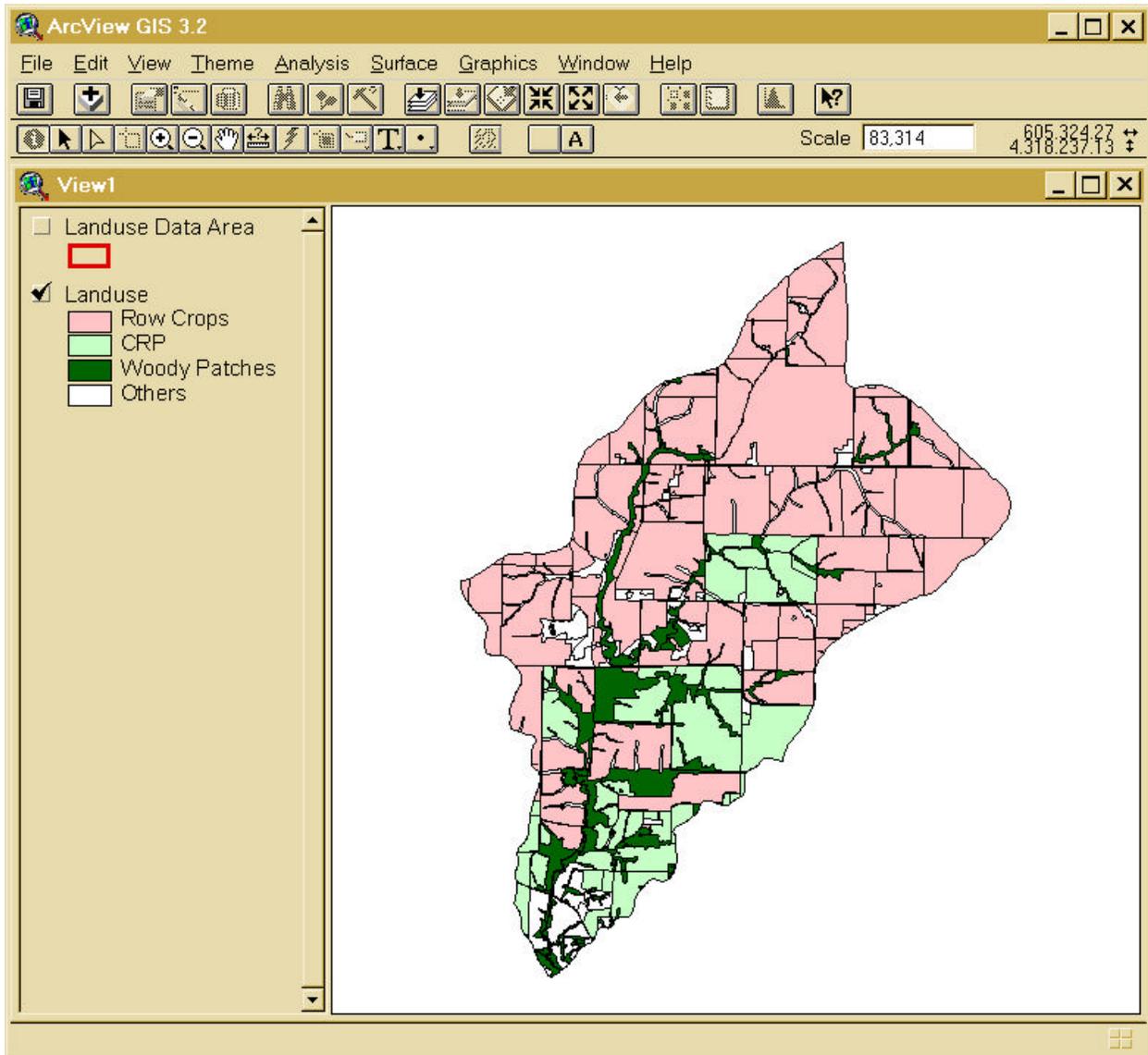

Figure 3. Harrison Branch watershed landuse.

When the user defines an area for habitat suitability evaluation, a grid layer of the area is generated to map the suitability surface. For each cell in the grid, a 345-meter circular buffer is created to calculate the three landscape variables. Furthermore, the Y value for

the cell is derived from the landscape variables. A smaller cell size will result in a finer resolution habitat suitability surface but requires more intensive and longer computing.

Based on a number of testing using different cell sizes and study areas, the average time for calculating suitability for each cell is approximately 0.04 second. Table 1 gives a glance of computing times needed for a 10, 100, and 500-acre study area respectively using 10, 30, and 50-meter cell sizes on a 550 MHZ processor computer.

Table 1. Approximate computing time for various cell sizes and study areas.

Study Area	Cell Size (m)	Total Cells	Computing Time
10 acres	10	405	16.2 sec
	30	45	1.8 sec
	50	17	0.7 sec
100 acres	10	4047	2 min 42 sec
	30	450	18 sec
	50	162	6.5 sec
500 acres	10	20235	13 min 30 sec
	30	2249	1 min 30 sec
	50	810	32.4 sec

A Web-based program requiring long processing time is very undesirable. The appropriate cell size for calculating the suitability surface is to be investigated. Figure 4 shows the Y surface of the Harrison Branch watershed using 50-meter cell size. A higher Y value indicates a better habitat suitability. Notice that the Y surface can only be generated for the areas with complete landuse coverage within the 345-meter buffer zone, as defined by the data layer 'Landuse Data Area'.
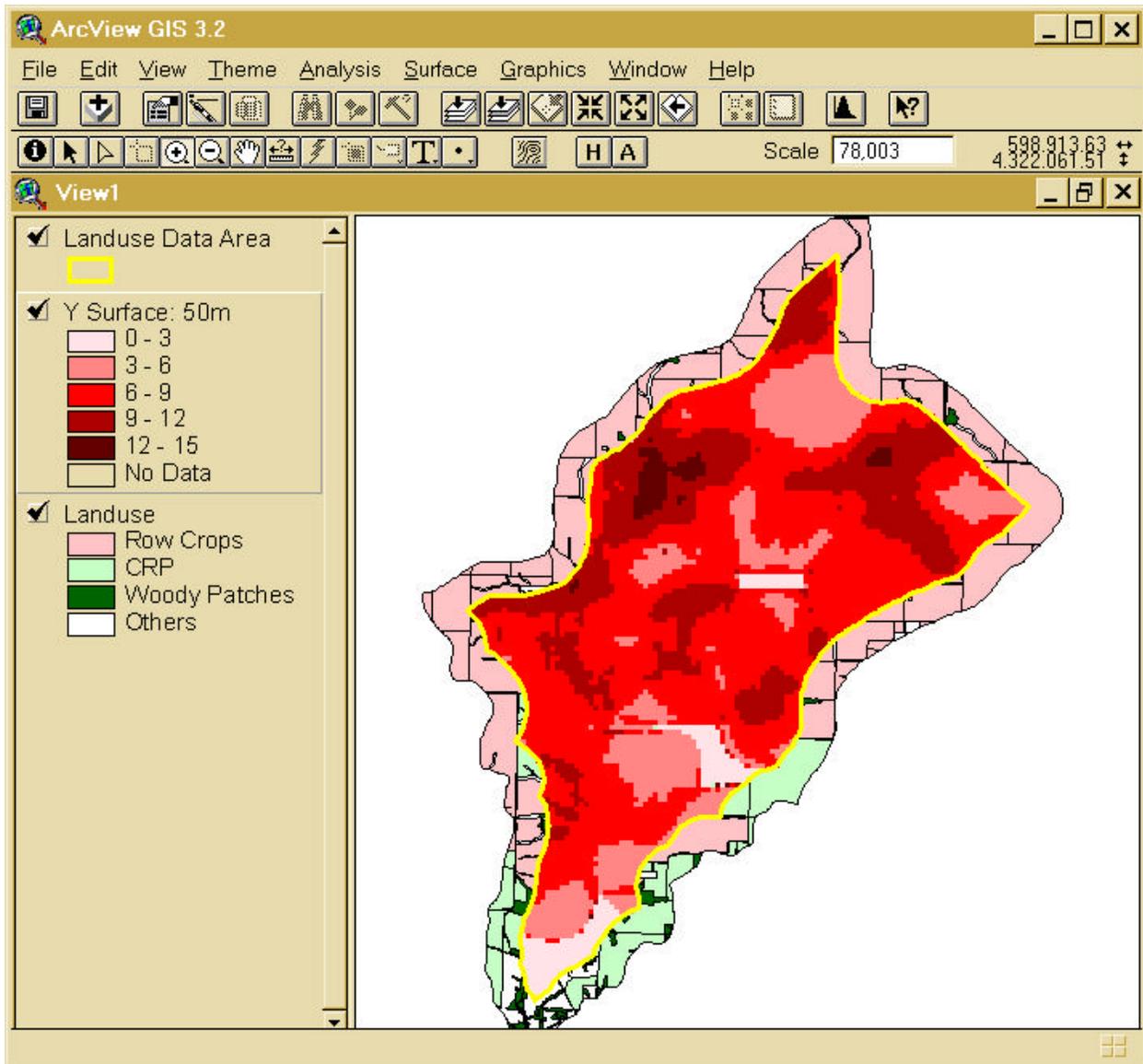
Figure 4. Y surface of the Harrison Branch watershed

Dr. Burger will provide the equation for converting Y value to habitat suitability. The NRCS county landuse inventory categories were also sent to Dr. Burger for regrouping into categories suitable for the habitat models. The Web-based interface is being developed for online modeling.

2. Habitat Model II - Summer Habitat Model

The summer habitat model uses the same approach as the winter model except it accounts for six landscape variables. The model is currently still under the development. The overall habitat suitability of a location will combine the results from the winter model and summer model.