An Internet-Based Integrated Resource Management System (IRMS)

Second Quarter Report, Year II
1/1/2000 – 3/31/2000

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Missouri Department of Natural Resources
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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 proposed modeling system initially included the Cost and Return Estimator (CARE) model and habitat models. 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 has been postponed for various reasons and was not foreseeable in the near future.

In lieu of the situation, the project contract was amended to use a different model or approach in order to complete the project in time. Therefore, U.S. demographic and Socio-economic data were to be integrated for public access online. 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.

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	Q1		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~~	~~X~~		-	-	-	-	-	-
~~Develop prototype of habitat models (CARE still under development)~~	-	-	-	~~X~~	~~X~~		~~X~~	-	-	-	-	-
~~Complete integration of CARE model~~	-	-	-	-	-		-	-	-	-	-	-
**Develop prototype IRMS by integrating demographic and socio-economic database*					*X*		*X*	*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	X	X	X	X	X		X	X	X	X	X	X

and specified field staff												
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

* See the Amendment in the First Quarter Report, Year II, submitted on December 31, 1999.

4. Quarterly Progress

Integration of Demographic and Socio-economic Data

A web-based prototype to visualize demographic and socio-economic data was initiated last quarter. The prototype allowed the user to select and view general population including sex, race, rural population, people on farm, living alone, and living in group quarters (Figure 1).

The prototype provided function for people to view selected demographic data on the Internet. However, it is currently disjoint with environmental and other databases. In the meantime, CARES houses several internet map servers for different projects and databases, such as CARES Watershed Information Clearinghouse, Missouri Digital Soil Survey Mapping, and Saline County Database. Several reference datasets and base maps such highways, incorporated areas and digital orthophotos are repeated for every map server. But it is difficult to overlay data layers across map servers, e.g. watersheds and soils. As more and more datasets are put on the Internet, it is essential to have a user-friendly interface to access data across projects and the map servers.

To meet this demand, we are currently redesigning the websites and consolidating the existing disjoint map servers. This will provide one entry point for all the datasets for any location in Missouri. The demographic and socio-economic datasets will be part of the system. We believe that would truly provide both state agencies and the public an Integrated Resource Management System. The new setup is to be completed by June of 2000.

In the meantime, more datasets from 1990 census are being processed including housing and income information. We are also working towards certain level of web-based integration with databases at the Office of Social and Economic Data Analysis (OSEDA) web server.

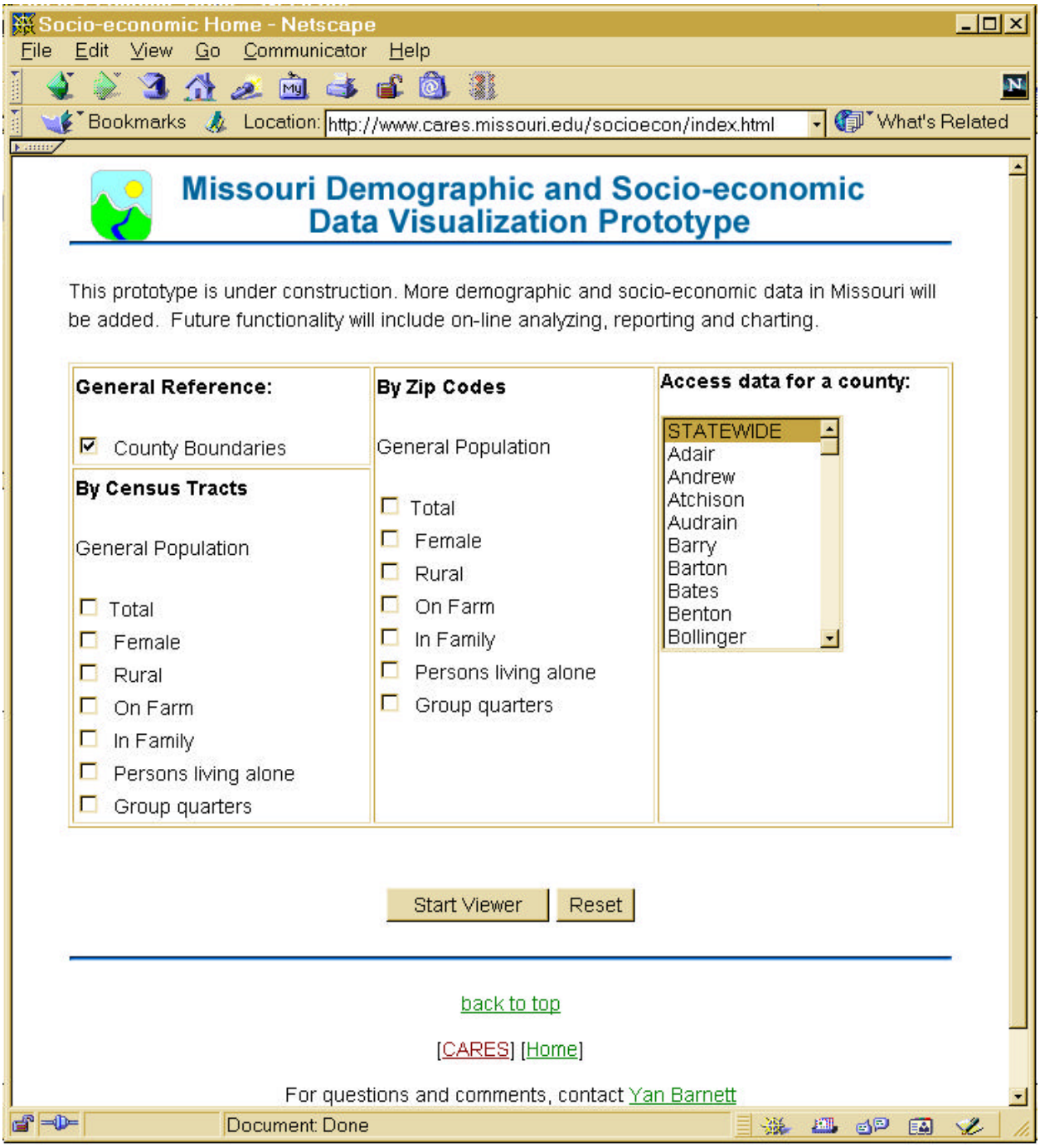

Figure 1. Demographic and Socio-economic data visualization prototype

Develop prototype of habitat models

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:

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

$$WD\_ED = TE_{WD} / A_{WD} \quad (2)$$

$$CP\_ED = TE_{CP} / A_{CP} \quad (3)$$

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:

$$Y = 3.18 * RC\_LSI + 0.05 * WD\_ED + 0.06 * CP\_ED \quad (4)$$

The Y value is converted to habitat suitability index (HSI) through equation (5):

$$HSI = EXP(Y) / (1 + EXP(Y)) \quad (5)$$

The resulting habitat suitability index is a probability value ranging from 0 to 1.

The Callaway county landuse inventory was used as the base land cover data for habitat modeling. The NRCS land cover/use classification was aggregated into habitat classification for calculating landscape variables (Table 1).

Table 1. Habitat classification aggregation from NRCS land cover/use classification

NRCS Land Cover/Use Classification			Habitat Classification
Level I	**Level II**	**Level III**	
Cropland	Row and Close Grown Crops	CRP	CRP
			Rowcrop
	Horticultural Crops	Orchards	Rowcrop
			Rowcrop
	Hayland and Pasture		Pasture/hay
	Hayland		Pasture/hay
	Farmsteads		
	CRP		CRP
	Other Cropland	CRP	CRP
			Rowcrop

Grassland	Hayland and pasture	CRP	CRP
			Pasture/hay
	Prairie		Pasture/hay
	Grass		Pasture/hay
	Grass-forbs-legume mix		Pasture/hay
	Waterway		Pasture/hay
	Warm Season		Pasture/hay
Forest Land	Deciduous	CRP	CRP
			Woody
	Evergreen	CRP	CRP
			Woody
	Mixed Deciduous/Evergreen	CRP	CRP
			Woody
Other Farm Land	Farmsteads		
	Livestock Facilities - Confine		
	Livestock Facilities - Open		
	Reclaimed Borrow Areas		
	Conservation Practices		
	Other Land in Farms		
Rural Transportation	Interstate Highways		
	Paved Primary Federal/State		
	Grave Roads		
	Dirt Roads		
	Field Roads		
	Driveways		
	Other Paved Roads		
	Other Roads		
	Railroads		
Urban and Built-up Land	Less Than Ten Acres		
	Ten Acres and Larger		
Water	Perennial Stream		
	Water Body 40 Acres or Larger		
	Water Body Less Than 40 Acres	CRP	CRP
Wetlands	WRP		
Woody Non-Forest	Brush	CRP	CRP
	Brush		Woody
	Evergreen		Woody
	Treeline		Woody
Barren Land	Brush		
	Mud Flats		
	Quarries and Gravel		
	River Wash		
	Sand		
	Stripmines and Borrow Pits		
	Stremmines, Quarries, Gravel		
	Other Barren Land		

A web-based prototype interface for habitat modeling was developed. Figure 2 shows the interface when the user starts the modeling program. The menu shows data layers of Counties, Land Cover, and Digital Orthophotos. The Counties data layer serves as a reference map showing county boundaries. The Land Cover data layer is the NRCS county

land cover/use inventory dataset. It is the base land cover/use data for habitat modeling. Digital Orthophotos are provided for generating user-delineated alternative land cover/use. The land cover digitizing interface had been developed in the Fourth Quarter, Year I, and will be integrated with the habitat modeling interface.

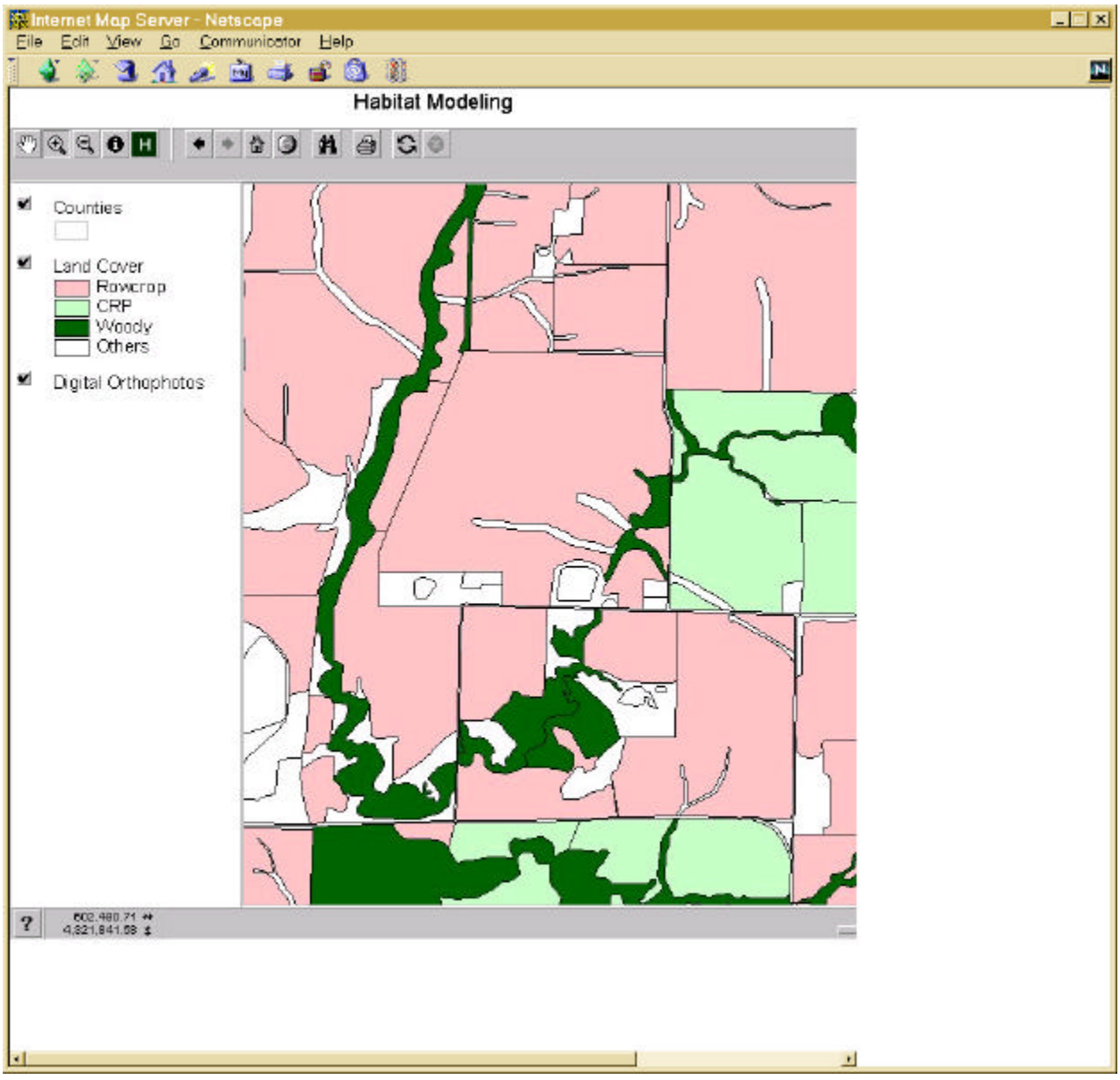

Figure 2. The web-based prototype interface of habitat modeling

The prototype interface has a number of tools and buttons for map zooming in/out, panning and other visualization activities. A customized tool is added for habitat modeling (H). When the user click the Habitat tool, he can draw a polygon on the map to define his study area (Figure 3). A pop-up menu lets the user select the land cover data layer and grid cell size for habitat modeling. The options for grid cell sizes are 50 meters, 40 meters, 30

meters, 20 meters and 10 meters. Once the user completes the selection, and click the OK button. The web server calculates the habitat suitability surface and draws the result on the browser window (Figure 4).

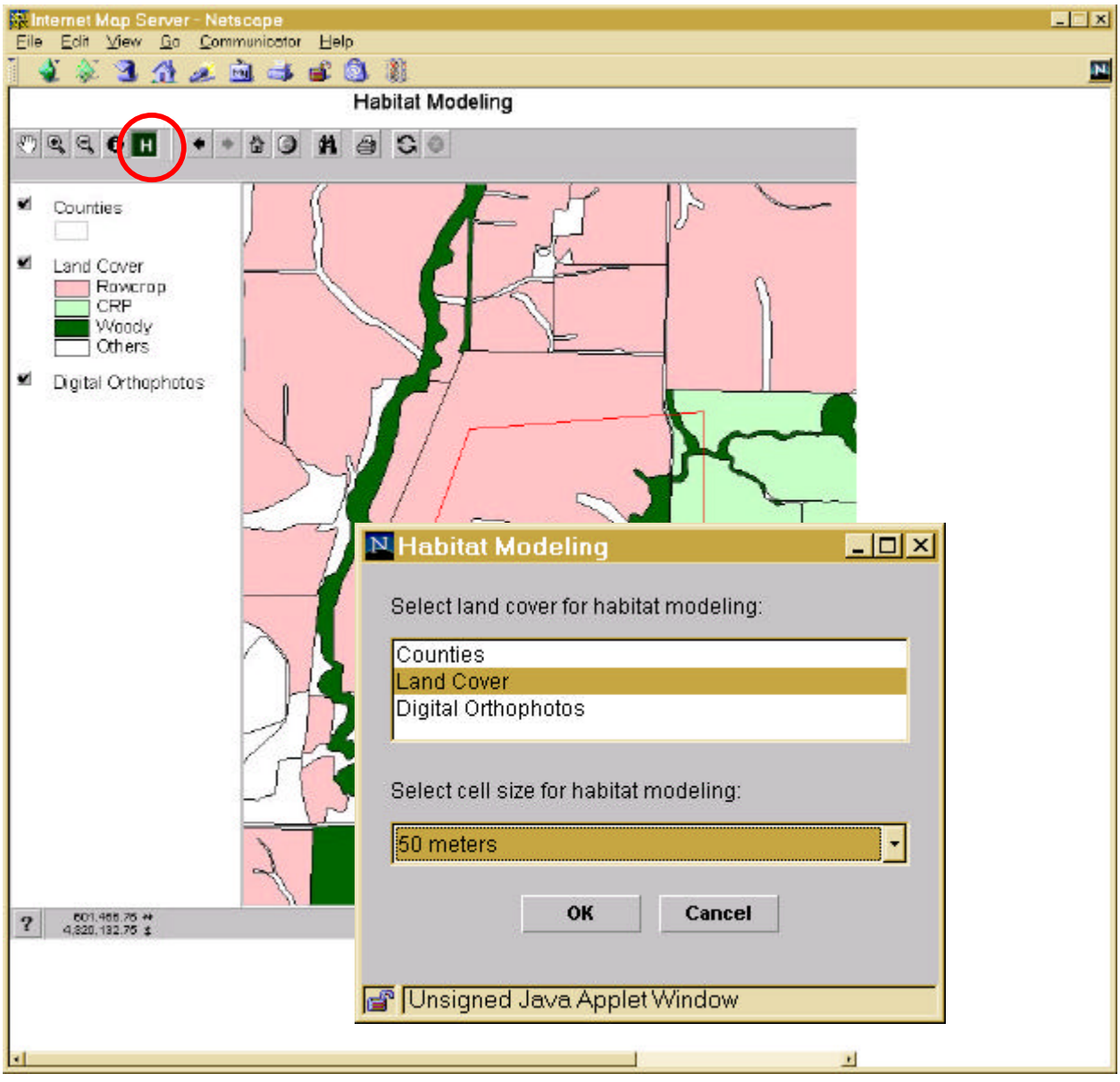

Figure 3. Use habitat model tool to define a study area and select land cover data layer and grid cell size

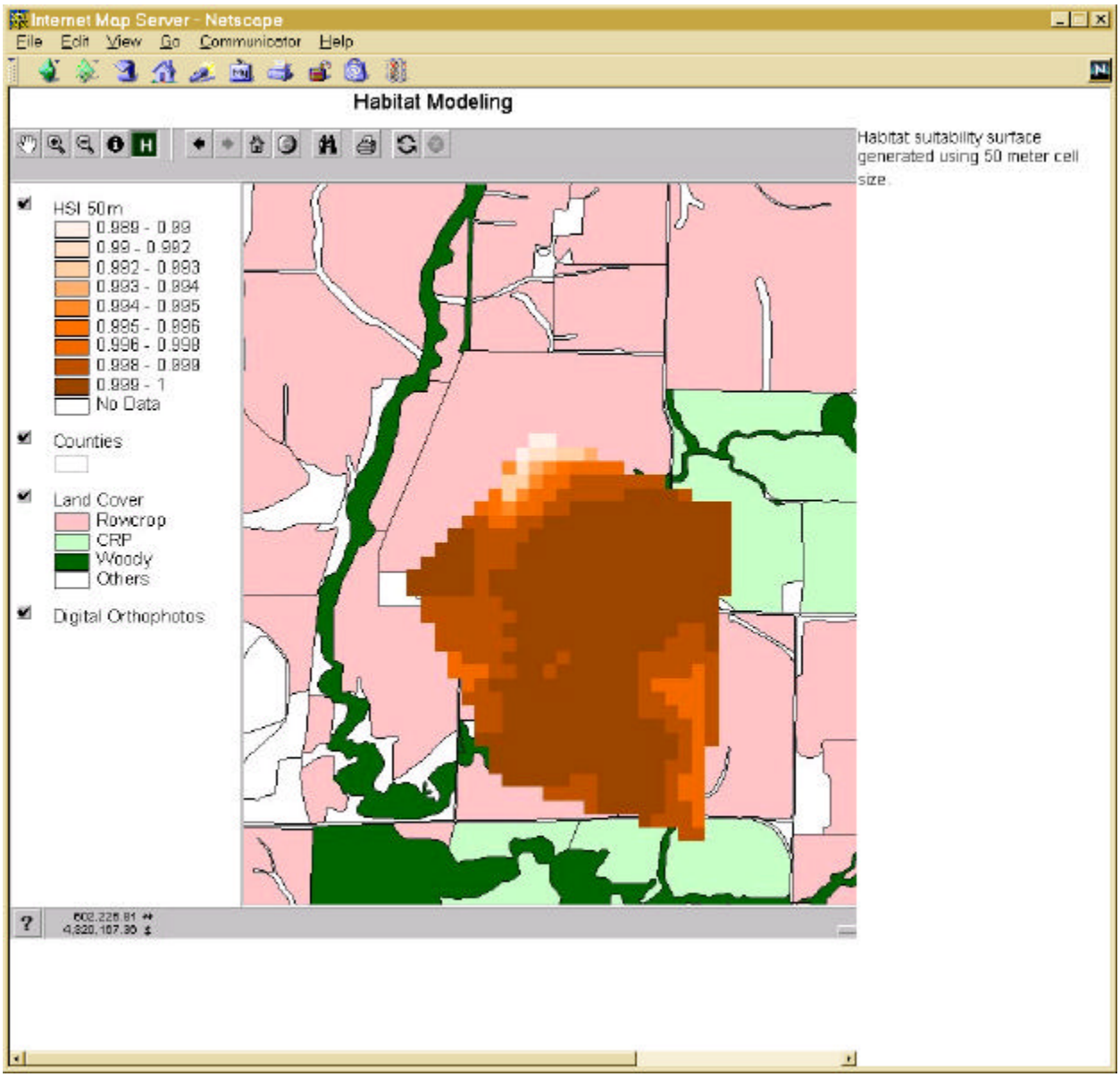

Figure 4. Habitat suitability surface for the desired area

The prototype interface is still very primitive, since the attention has been mainly on the function rather than the look so far. However, with all the pieces in place, a user-friendly and integrated interface will be developed.

The Callaway county land cover/use inventory data layer was used as base land cover. It covers 100 percent of the lands in the county. As the land cover/user inventory for other counties are being completed by NRCS/FSA, it was hoped to serve as a good base land cover data for habitat modeling in Missouri. However, NRCS/FSA is currently only delineating lands enrolled in programs to speed up the inventory. It no longer includes the

lands used for grass waterways, forests and others. The dataset will not be suitable for habitat modeling. An alternative base land cover data will need to be chosen.

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.