# An Internet-Based Integrated Resource Management System (IRMS)

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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 (DOQQs), 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 and Quarterly Progress

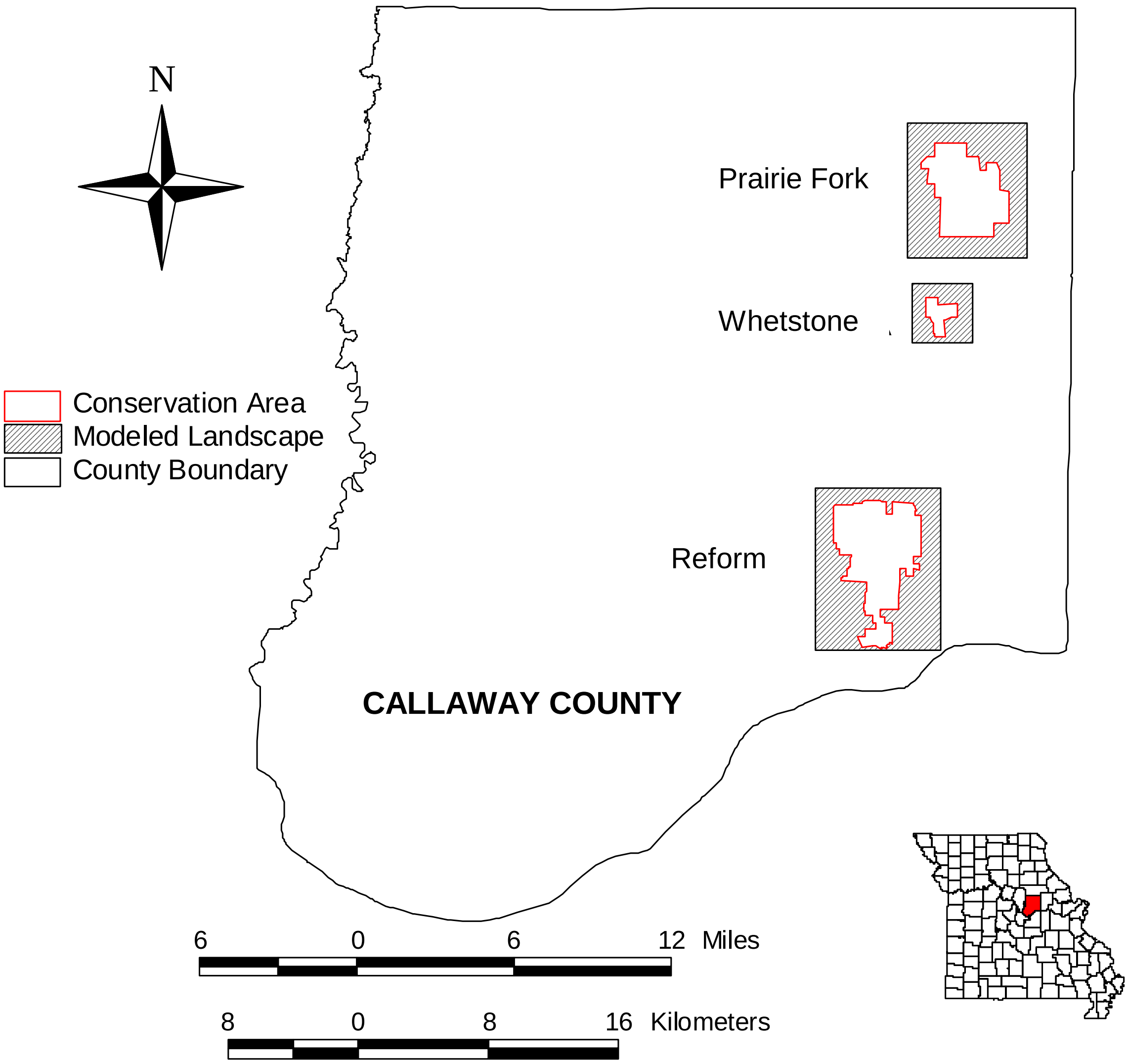
The Integrated Resource Management System is a three-year project extending from October 1, 1998 to September 28, 2001.

During this quarter, we collaborated with D. Todd Farrand, Food and Policy Research Institute (FAPRI) on an preliminary study on "The Effect of Scale on Habitat Modeling - Quantitative Assessment of Fish and Wildlife Habitat" (unpublished paper by Farrand). Further collaborated study on the subject for a published paper using other datasets is planned for this fall.

Todd used IRMS project's online analysis tool for initial testing. In order to generate results based on a large number of scenarios, a standalone interface was more suitable. So we provided Todd with the land cover inventory dataset of Callaway county based on 1-m resolution digital aerial photographs. In addition, an interface based on ArcView GIS software to run on a desktop computer was prepared for the study. The study results are reported below.

1) <u>The effect of varying the resolution of the underlying data by running the model on 1-m and 30-m land cover data</u>

Two land cover datasets based on 1-m and 30-m resolution images were used for this study. The 1-m resolution dataset was digitized from 1992 digital orthophoto quadrangles (DOQQs) by NRCS Callaway County field office. The 30-m resolution dataset was developed by Missouri Resource Assessment Partnership (MoRAP) from 1992-1993 LANDSAT TM data. Relative habitat suitability was calculated for landscapes encompassing 3 conservation areas with the county: Prairie Forks, Reform, and Whetstone. Habitat suitability maps for each area were generated at 16 different model resolutions on each landscape for a total of 96 model runs.




Map source: The Effect of Scale on Habitat Modeling, unpublished paper by D. T. Farrand.

For each conservation area, land use composition differed between the 1-m and 30-m landscapes, with the 1-m data tending to contain more non-habitat and woody vegetation than the 30-m data. For Prairie Forks and Whetstone conservation areas, the model classified significantly more area as highly suitable and significantly less as unsuitable for the 30-m data than for the 1-m data as determined by a t-test. For Whetstone area, the marginally and moderately suitable classes also had significantly fewer cells for the 30-m data. For Reform conservation area, the 1-m landscape had significantly more highly suitable habitat and significantly less moderately suitable habitat than the 30-m landscape, but actual difference was small.

Edge was artificially boosted in the 30-m landscapes due to the raster to vector conversion necessary to run the model as programmed. This was not considered crucial because it was expected that the greater proportion of non-habitat in the 1-m landscapes would result in a patchier, more fragmented landscape, and therefore better represent actual conditions. The 30-m landscapes had significantly higher proportion of quail locations classified in highly suitable habitat for Prairie Forks and Whetstone conservation areas. Whether or not this is simply due to the significantly higher proportions of highly suitable habitat in the 30-m landscapes is not known.

Although 1-m data appears to have higher resolution, it may not yield more accurate information about quail habitat with this model than the more widely available 30-m data. Given that the 1-m data yielded lower quantities of highly suitable habitat and higher quantities of unsuitable habitat, this data may at least yield a conservative estimate of relative habitat quality. However, the cost of producing such 1-m data sets across quail range in Missouri is prohibitive, and would not be justified for this purpose alone unless further analysis shows that it indeed provides superior information.

*Project implication: Currently, land cover data based on 1-m resolution DOQQs are only available for limited number of counties in Missouri. Based on this study result, the 30-m resolution dataset will be used for the web-based habit modeling tool.*

2) <u>The effect of varying the resolution of the analysis grid from 30 m to 611 m</u>

Varying the analysis grid affected the resolution of the output maps. The analysis grid was set at 12 resolutions or cell sizes: 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 432, and 611 m. The area of these cells corresponds to: <1, 1, 2, 4, 6, 9, 12, 15, 20, 24, 50, and 100% of Burger's average home range size (38 ha), respectively. For this part of the study, the analysis window was held constant at 38 ha (i.e., a radius of 345 m); the way the model was originally programmed.

The results indicated that varying the analysis grid resolution had little effect on the number of locations assigned to each suitability class within a landscape, with the 30-m data consistently capturing a larger proportion of locations on all conservation areas. The mean proportion of locations in each class was statistically different between the 1-m and 30-m resolution for the highly suitable and unsuitable classes on Prairie Forks and Whetstone conservation areas. These differences typically involved a shift from unsuitable to either marginally or moderately suitable, or a change from marginally or moderately suitable to highly suitable, between the 1-m and 30-m landscapes. Locations in habitat classified as unsuitable tended to be in areas heavily dominated by either woods or row crops. Areas classified as marginally or moderately suitable typically had much smaller extents than the extreme suitability classes, and, perhaps consequently, encompassed fewer quail locations. Reform conservation area had a slightly more locations classified in highly suitable habitat and fewer classified in moderately suitable habitat for the 1-m landscape relative to the 30-m landscape. No location was classified lower than moderately suitable on either Reform conservation area landscape.

This suggests that broad-brush maps may be sufficient for planning purposes, saving time and requiring less processing power.

*Project implication: Based on this study, therefore, large analysis grids will be used for the web-based habitat modeling tool given current internet bandwidth limitation.*

3) <u>The effect of varying the model resolution (analysis window) between 12.5% and 100% of the average home range</u>

Varying the analysis window determined the size of the area used to calculate the habitat suitability index score of the grid cell. The analysis window was set at 5 resolutions or radii: 122, 173, 244, 299, and 345 m, or 12.5, 25, 50, 75, and 100% of the average home range size. For this part of the study, the analysis grid was held at 210 m to keep the grid size smaller than the analysis window yet allow for the fastest processing.

The study results indicated that varying the analysis window had a significant impact on habitat classification by the model. As the analysis window became smaller, the proportional area classified as highly suitable was greatly reduced. Corresponding increases in the proportion of unsuitable habitat were observed, while the intermediate suitability classes tended to hold steady or increase slightly down to 50% after which they too declined. Although the 30-m resolution landscapes tended to predict more highly suitable habitat at larger windows (50 – 100%), the 1-m data predicted more in the smaller windows (<50%). Similarly, the size of the analysis window impacted the proportion of locations falling within the highly suitable habitat class, with fewer locations captured as the analysis window was reduced. No clear relationships were observed between landscapes or study areas.

For both habitat classification and location classification, reducing the size of the window reduced the proportion of highly suitable habitat and the agreement between habitat classification and quail locations (assuming quail were located in optimal habitat). The model performed very poorly below 244 m (50% of the home range) suggesting a threshold may exist between 25 and 50%. The area of the 50% analysis window was approximately 19 ha (47 acres). Although Burger's average home range size was generated empirically, the habitats in his study area may have represented sub-optimal habitat. Evaluating landscapes using his model at full resolution (i.e., 38 ha window) may overestimate habitat suitability. Further investigation will be needed to determine the optimal analysis window.

*Project implication: Burger's home range size will still be used unless further research indicated a better optimal value.*