UNIT 52 - RESOURCE MANAGEMENT APPLICATIONS

UNIT 52 - RESOURCE MANAGEMENT APPLICATIONS

Compiled with assistance from John Bossler, Ohio State University

The slide set contains twelve slides (#41 to 52) to illustrate this unit. As in many of these practical applications, widely accessible documentation is not available.

UNIT 52 - RESOURCE MANAGEMENT APPLICATIONS

Compiled with assistance from John Bossler, Ohio State University

A. INTRODUCTION

- resource inventory and management was one of the earliest uses of GIS
  - these applications dominated sales by vendors in the early 1980s

- many systems installed by state and federal governments and resource industries, particularly forestry, oil and gas

- most successful resource applications:
  - forestry - timber inventory, watershed management, development of infrastructure (roads), forest regeneration
  - agriculture - studies of agricultural pollution, inventories of land capability, productivity studies
  - land use - planning use of land, zoning, evaluating impacts
  - wildlife - management of habitat, evaluation of impact

- less successful
  - subsurface resources - requires 3D approach, technology is predominantly 2D
  - oceans - requires 3D, problems are time-dependent, lack of suitable data sources
  - water resources - good for integration over watersheds, but 2D approaches are not ideal for linear surface watercourses or 3D groundwater

Characteristics of applications

- layers:
  - typically requires many coverages of an area - resources and relevant management factors are multi- dimensional
  - mixture of data models - raster and vector
  - with vector model, heavy use of polygons to represent homogeneous areas

- scale:
  - varied but uncommon above 1:10,000

- data quality:
  - many layers are result of interpretation, classification
  - quality is variable, often unevaluated

Functionality

- simple map analysis:
  - overlay, measurement of area, buffer zone generation, calculation of viewshed

- modeling:
  - many include the use of external models based on multiple variables obtained from different layers
    - e.g. models to simulate drainage basin runoff, fire spread

Adoption

- most forest management agencies by mid 1980s

- most resource management agencies by late 1980s

Organizations

- numerous conferences sponsored by federal and state agencies

- no major organization clearly devoted to GIS applications in resource management
  - discipline-based organizations focus applications, e.g. forestry, ecology

B. EXAMPLE - BIG DARBY CREEK PROJECT

- demonstrates an application of GIS to natural resource management
  - illustrates the role of a GIS in linking with an existing analytical package
    - GIS provides data input, storage, output and some analytic capabilities
    - existing package provides specialized modeling, interfaced with the GIS

- funded by Nature Conservancy, NASA, Ohio EPA, Ohio Department of Natural Resources

- 2 year project

- combines a GIS (ERDAS) with a nonpoint source pollution model (AGNPS)
  - additional software was developed to link the two existing packages

- goal to provide a low-cost, user-friendly system and database to support land use planning and management for the basin

- purpose of this project is to evaluate effects of changes in management practice
  - model with GIS provides capability to evaluate "what-if" scenarios - observe and quantify effects of changes
  - role of model is to simulate effects of natural processes, e.g. if x changes by an amount a, what is the corresponding effect on y?
  - model is only useful if it predicts such effects accurately

- an additional role of the GIS in this case is to integrate spatially
  - if changes are made in certain parts of a drainage basin, GIS can be used to integrate results of changes over the whole basin and give user the total

Big Darby Creek characteristics

Watershed
  - contains 370,000 acres (580 mi2, 1,500 km2) in central Ohio
  - includes parts of 7 counties

State Scenic River
  - one of the region's last remaining free flowing streams
    - not dammed for flood control or water supply
  - over 60 of 100 Ohio freshwater fish species
  - "exceptional water quality" (Ohio Environmental Protection Agency)

Heritage elements
  - 107 "heritage element" occurrences
    - heritage elements are rare plant and animal species, champion trees

protected by state and federal laws

Sediment production
- however, is "highest sediment yielding watershed in Ohio" (Soil Conservation Service)
- percentages of land use - 71% cropland, 9% forest, 9% pasture, 9% fallow, 1% urban

Typical management questions
- what would be the water quality effects of a 10 m conservation easement along the river?
- which soil types or fields are contributing the most siltation to the river and should be targeted for some kind of conservation action?
- which combination of crop/field management practices yields the most benefit to water quality?
- effective management requires quick and accurate answers to these and other questions

AGNPS - Agricultural Nonpoint Source Pollution Model

- developed by US Department of Agriculture
- simulates impact of agricultural land use on water quality
- calculates for watershed as a whole, or for 40 acre units, the erosion and siltation and the nitrogen, phosphorus and chemical-oxygen demand generated by a storm
- results provided in tabular form

The GIS

- low cost, microcomputer-based
- uses the GIS module marketed by ERDAS
  - ERDAS product is normally associated with image processing thus these capabilities are also available
- provides:
  - easy data entry and manipulation
  - flexible graphics for output
  - report generation

GIS-Model Link

- GIS provides data entry and manipulation interface for the AGNPS program
- once the database has been created by the GIS it is reformatted and fed to the AGNPS model by a simple series of user commands

after the model tabulates the results, output is fed back to the GIS to be displayed in map form

C. DATABASE

- 21 variables required by AGNPS were entered through GIS

  overhead - Variables used in AGNPS model

- include:
  - current management practices obtained by survey of 200 farmers
  - soil type, slope from Soil Conservation Service surveys
  - land cover from remote sensing (Thematic Mapper)

- 40 acre raster cells, 400 m on each side
  - 210 rows and 148 columns

Slides

slide 41 - Regional setting

slide 42 - Landsat scene

- Columbus is light blue area in lower right, Darby Creek watershed is centered on greenish area to left of Columbus
- note proximity to major metropolitan area, population 1.4 million

slide 43 - surface hydrology
- 1 = Big Darby, 2 = Little Darby, 3 = major streams

slide 44 - photograph of Big Darby Creek

slide 45 - land use

- 1 = cropland, 2 = fallow, 3 = pasture, 4 = forest, 6 = urban, 7 = water
- note 88% of watershed is in agricultural use, only 9% is forest and 1% developed

slide 46 - photograph of cropland in the watershed

- another layer identifies slope
  - 50% of watershed is &LT2% slope, only 3% has slope >12%
  - note that estimation of slope depends on size of raster cells
    - the mean slope in a cell 400 m by 400 m is not the same as the maximum slope
    - definition of slope used is unclear

- despite low slopes, much of basin has high soil erodibility according to SCS's rating system

28% of basin qualifies for SCS Conservation Reserve Program (CRP)
- evidence of critical need for soil conservation practices

slide 47 - distribution of CRP soils
- clustered in areas of higher slopes and along watercourses

slide 48 - the 107 Heritage Element occurrences in the watershed
- identifies rare plant and animal species and "champion" trees protected by state and federal laws
- large number of occurrences indicates watershed's ecological diversity and significance

slide 49 - subwatersheds
- subsequent results will be for subwatershed 1 in northern extremity

D. SAMPLE RESULTS

slide 50 - nitrogen levels predicted by AGNPS model using data from GIS and displayed by GIS

1. (upper left) historical baseline - complete forest cover, virtually no erosion

2. (lower left) assuming complete compliance with CRP for eligible soils (28% of basin)

- low levels of erosion, only in limited areas

3. (upper right) current conditions - red indicates extremely high soil erosion
- several areas of very high erosion

4. (lower right) assumes implementation of a conservation easement on both sides of river, with forest cover
- erosion is reduced within the easement, but not outside
- number of raster cells in lowest category of erosion is increased from 459 under current conditions to 531

Management strategies tested

overhead - Management strategies tested

- conservation easements of various widths on both sides of river
- use of no-till or conservation tillage practices on critical areas
- conversion of critical areas to non-agricultural (forested) use
- various combinations of the above, determined by likely acceptability to local farmers and government agencies

Example of output

- given limited resources for erosion abatement, where should effort be concentrated?
- model can identify areas where greatest reduction in erosion rate can occur for given change in management practice

  slide 51 - critical areas for sediment reduction

  - shows where change in management practice will produce greatest reduction
    - 12% reduction in sediment yield can be achieved by changing management of these cells
    - these are only 3% of area

E. ASSESSMENT OF SYSTEM

- user-friendly GIS provides easy display of results, colorful graphics, standardized reports, easy input of data

  slide 52 - specialized linkage required between GIS and erosion model (AGNPS)

  - such linkages will become unnecessary if data transfer formats can be standardized

- about 30 minutes required to test a scenario fully and obtain results
- system runs on readily available PC hardware under DOS
  - system is comparatively portable and could be used for decision support in local planning meetings

EXAM AND DISCUSSION QUESTIONS

1. What types of standards would be useful in interfacing packages such as AGNPS and ERDAS? Who should develop them and how should they be promulgated?

2. Discuss the role of spatial resolution in the Big Darby Creek study and its effects on the results. What arguments might have been used to justify a 40 acre cell?

3. Why was a raster data model used in this study rather than a vector data model?

4. The results quoted in this unit were based on counts of raster cells. Discuss the issue of accuracy in the Big Darby Creek study, and its implications for implementation of the study's results.

Last Updated: August 30, 1997.