RESOURCE NOTES

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The Spatial Terrain Analysis Resource Toolset (START)

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Most of the existing automated terrain analysis tools are not arranged into any sort of classes and categories but are available haphazardly as commands on various GIS systems or as software available outside of commercial GIS systems because of its specialized nature. In some cases, the terrain tools are not completely finalized and they require further software work to cleanly interface with systems like ARC/INFO. To make sense of these tools we have systematized them into four major groups based on traditional divisions in geomorphology. These include tools for hillslope analysis, catchment analysis, and drainage pattern analysis, as well as physical process modeling tools that simulate the effects of terrain morphology on various physical ecosystem processes.

All the tools we are presenting here use DEMs as their only required data source, with exceptions that will be noted. They work primarily in Unix, but it should also be possible to compile the software to work on PCs. You should look at the following list as an early look at capabilities of which most could be made available soon depending on your expressed interest. We also hope to be able to accept a few project locations where we could run the models and develop elevation derivative data bases and related products. If you email, call, or send in a response indicating your interest in the toolset and their products, you will automatically become an informal customer for the project, part of a potential user group, and will be kept advised on our progress and access to the software. We should remind you that in some cases we still will need to get into a mutual arrangement with another agency before we can distribute their software at BLM.

Hillslope Analysis Tools

- **Slope gradient analysis** — calculates slope gradients in degrees or percent based of Digital Elevation Model (DEM) data. This data aids in evaluation of soil erosion and landslide potential, in identification of potential soil types along slope profiles, and other applications mostly hydrologic and geomorphic in nature. Available as an ARC GRID function.
- **Slope length analysis** — calculates length of each flowpath on the terrain from any point to a nearest local elevation maximum identified from DEM data. A flowpath can be compared to complex cross section of the slope, or slope profile, made along the steepest path on the slope. Therefore, slope length can be useful in locating a soil type on a hillslope. Slope length is also useful particularly in erosion and sediment yield calculations. Available as an ARC GRID function.
- **Slope aspect analysis** — calculates the orientation of a slope facet in degrees from the northern direction from DEM data, mainly useful to solar irradiation calculations. Available as an ARC GRID function.
- **Planimetric curvature analysis** — calculates the curvature of slope that is parallel to the elevation contours which can be used to help identify divergent or convergent flow areas on the landscape: convergent flow generally indicates higher erosion and transport potential, while the divergent flow indicates lower potential. Available as an ARC GRID function.
- **Profile curvature analysis** — calculates the curvature perpendicular to the elevation contours from DEMs which indicates whether any particular point on the hillslope profile is in an area of convex or concave curvature. This indicates whether the area is more likely to be erosive or depositional. Available as an ARC GRID function.
- **Neighborhood or focal curvature analysis** — recently developed at NARSC, this capability permits averaging of negative and positive slopes over neighborhoods of various sizes and shapes and is useful in visualization of specific and general hillslope curvature patterns in map view. Available as an AML and C software that imitates an ARC command.
- **Fourth-order-of-relief analysis** — this set of methods divides the landscape into the categories of: convex areas which include crests of convexities and convex slopes; flat areas (neighborhood curvature=0) which include sloping flats (curvature=0, slope>0) and horizontal flats (curvature=0, slope=0); and concave areas which include concave slopes, open basins or valleys, enclosed basins or depressions, and troughs of concavities. The fourth-order-of-relief analysis permits map representation of hillslope morphology in great detail and at various levels of generalization making it easier to identify hillslope patterns and slope types (e.g. head slope, nose slope, foot slope, etc.)

Drainage pattern analysis tools:

- Flowpath delineation based on topographic relief aids the identification of flow patterns across landscape with relief (STREAMNETWORK.AML);
- Stream order analysis (Strahler and Shreve methods) permits situating of stream reaches and related catchments in the context of a hierarchical framework: aids in multi-scale analysis and in relating our units to national hydrologic unit frameworks;
- Analysis of accumulation of water flow along flow paths throughout the entire landscape permits delineation of drainage patterns and aids evaluation of water accumulation in streams: can be understood as representing catchment area for any point on the landscape;
- Other drainage network analysis tools, such as tools for modeling cumulative effect of runoff across a connected network of watersheds, are currently being studied and will be discussed more closely in future resource notes.

Watershed analysis tools:

- ***Delineation of catchments based on:***
  - Natural divides in the terrain
  - User-specified catchment outlets (MAKESHEDS.AML, SEEDSHEDMODEL.AML)
  - Location of stream junctions (REACHSHEDMODEL.AML)
- ***Watershed order analysis*** - based on stream order analysis using Strahler and Shreve methods.
- ***Basin morphometric parameters*** - BASINSOFT is an encrypted AML tool that has been made possible by some excellent software development work performed by our colleagues at the USGS based on century of developments in quantitative geomorphometry. Basin morphometric parameters not only describe the shape of catchments in a variety of way,s but many of them have hydrologic significance and can be related to surface water processes occurring in the catchment. Although the software is available only at the USGS (we have a test version of it), we can perform the basin morphometric analysis with their help. A partial list of basin geomorphometric variables that can be calculated with this software includes methods to measure average basin slope, shape factor, basin rotundity, stream density, relative relief, constant of channel maintenance, ruggedness number, and more.

Automated physical process models:

These models are available in the Terrain Analysis for Environmental Sciences (TAPES) software developed primarily based on work by the late Dr. Ion Moore and continued by Dr. John Gallant at the Centre for Resource and Environmental Studies in Australia and Dr. John Wilson from University of Southern California and Montana State University. The software is a set of programs that works both on grids and contour data to model influence of terrain on various environmental processes.

- **Calculation of solar irradiation and temperature** based on topography is helpful in evaluation of the geographic distribution of solar energy input into the landscape;
- **Calculation of wetness index, soil wetness, and evapotranspiration** based on solar irradiation calculations and products of other available modules;
- **Calculation of dynamic wetness index** which accounts for limited time available for water to drain from upslope areas;
- **Spectral analysis of DEM surface**s to determine their fractal dimension and, therefore, surface roughness.
- **Calculation of potential soil erosion index** based on several terrain variables.

This software represents about 20 years of dedicated research effort and is available as a public domain access with some limitations. The models can provide estimates of the results of various environmental processes based on DEMs and auxilliary data such a solar radiation file, vegetation, and soil data. Preparation of these additional data inputs is relatively easy to accomplish based on existing data sources. If there is enough interest in this software, it is currently available as C and FORTRAN source code which we can compile for the AIX machines at the BLM for use as contributed resource analysis software that interfaces with the ARC/INFO GIS and generates ARC/INFO data.

At NARSC, we the see the function of translating research into practical management as a common responsibility of all the scientists at the BLM, but we also realize that our various duties might not give us time to get acquainted with the latest tools. The START project is the beginning of our contribution to making access to these tools easier. For further information on it and on related efforts contact:

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