United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

General
Technical Report
PNW-GTR-397
April 1997

UTOOLS: Microcomputer Software for Spatial Analysis and Landscape Visualization

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Abstract

Ager, Alan A.; McGaughey, Robert J. 1997. UTOOLS: microcomputer software for spatial analysis and landscape visualization. Gen. Tech. Rep. PNW-GTR-397. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 15 p.

UTOOLS is a collection of programs designed to integrate various spatial data in a way that allows versatile spatial analysis and visualization. The programs were designed for watershed-scale assessments in which a wide array of resource data must be integrated, analyzed, and interpreted. UTOOLS software combines raster, attribute, and vector data into "spatial databases" in which each record represents a square pixel of fixed area, and each field in the database represents a map layer, theme, or attribute. UTOOLS includes several common GIS functions, such as procedures for calculating buffers, slope, aspect, patch size, convexity, and measures of topographic diversity. The UVIEW program provides rapid two- and three-dimensional images of digital elevation models, attribute data, and vegetation patterns at watershed scales. UTOOLS programs fulfill the routine analytical needs of resource professionals at low cost and without the expense and training required by many other spatial analysis and visualization systems.

Keywords: Geographic information system, wildlife habitat relations, landscape visualization, landscape ecology, ecosystem management, ecosystem planning, watershed analysis, habitat analysis, spatial analysis, spatial databases, visualization software.

Contents

Introduction

The management of natural resources on National Forests has undergone a rapid transformation in response to growing concerns over ecosystem sustainability. Special attention is being focused on the viability of aquatic and terrestrial populations adversely affected by human-caused disturbances (FEMAT 1993). The assessment of such disturbances on habitats and dependent species is a complex task that requires several analysis tools, including geographic information and decision support systems, simulation and deterministic models, and appropriate data links. Although not confined to aquatic and terrestrial biology, the shortage of suitable analytical tools has been especially acute in these fields in which new analysis procedures have been adopted that consider several species and geographic scales, and include spatial components like buffers, corridors, and home ranges. The advent of ecosystem analysis, in which species interdependencies are considered along with individual needs, has further intensified the problem. These analytical needs require improved spatial analysis tools and data visualization that are designed to work within the operational environment of Federal land management agencies. Specifically, these tools must be usable by resource specialists, not exceed budgeted costs, be able to access diverse data sources and formats, and address specific needs of resource specialists as they relate to land management planning.

The UTOOLS software evolved from the demands of resource specialists within the Forest Service for efficient spatial analysis and landscape visualization tools to address complex land management issues (Ager and McGaughey 1996). UTOOLS is a system of 22 public domain programs that, when coupled with Paradox[1] database software, provides a simple geographic analysis “toolbox” that meets the analytical needs of resource specialists (see appendix for information about software mentioned in the text). Recently, these programs and their documentation have been widely distributed and applied within the Forest Service because of their ease of operation and tailoring to specific resource issues facing specialists within the Agency. UTOOLS has supported analysis of many fire salvage and watershed projects, forestwide timber analysis for the Forest Ecosystem Management Analysis Team report (FEMAT 1993) and even law enforcement activities. In this paper, we outline the capabilities of UTOOLS, and discuss several applications that focus on aquatic and wildlife habitat assessments and research.

Overview of UTOOLS Software

UTOOLS was designed to address ecosystem analysis problems in which many data themes must be examined simultaneously. Analyzing ecosystems requires integrating many facets of natural systems; UTOOLS reorganizes spatial data to meet that need. Specifically, UTOOLS programs combine raster, vector, and attribute data into “spatial databases” in which each record represents a square pixel of fixed area, and each field in the database represents a map layer or map attribute (fig. 1). The spatial databases are stored in Paradox, where they can be analyzed via several avenues (fig. 1), or visualized with UVIEW.

The overall advantage of the spatial data structure is that it eliminates the need for complex links between raster or vector map themes and attribute data. The accuracy of much of the analysis does not require vector data. The error introduced by converting a vector map to a raster map is, at the most, one-half the pixel size. Complex geographic information system (GIS) operations, such as overlays and unions, are thus reduced to

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

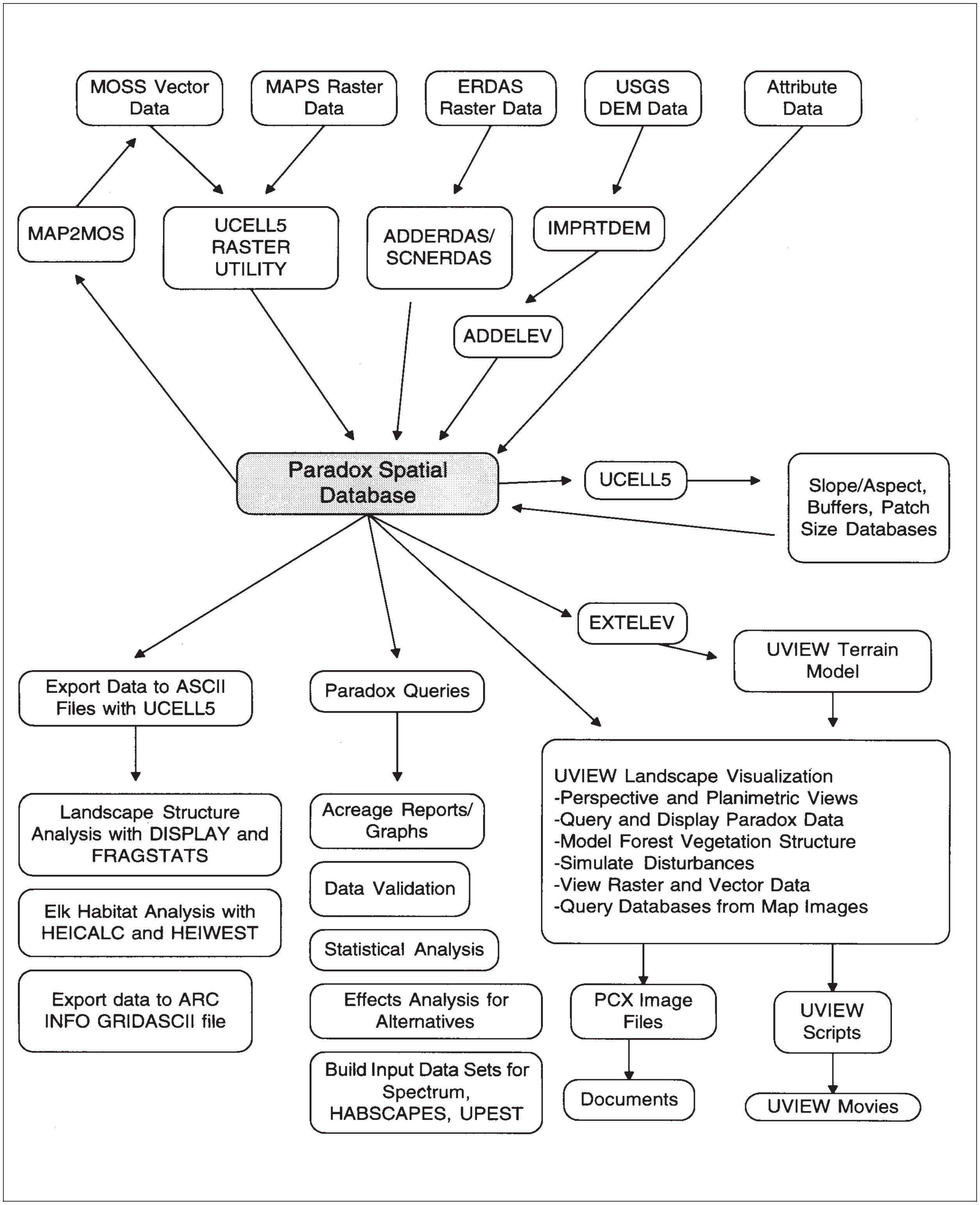


Figure 1—Overview of UTOOLS programs and data links.

simple Paradox queries. Many habitat and other resource analysis problems involve repetitive querying of several layers and attributes, comparison and cross validation of data assembled from many sources, simulating effects of management activities, or designing the spatial layout of habitat reserves. Solutions to many of these ecological problems cannot be derived from optimization software, but rather require exploration of many alternate solutions. Thus, iterative spatial analyses that integrate many kinds of data are characteristic of habitat and other ecosystem component investigations. When data structures are combined into a UTOOLS Paradox database, querying is more efficient and analysis is simplified. Furthermore, a robust system of data links to other software extends the functionality of UTOOLS and the Paradox spatial databases to encompass several spatial analysis tools.

Capabilities of UTOOLS Software

The analysis and visualization capabilities in UTOOLS were designed to accommodate the demands of resource specialists. This design required both spatial algorithms within UTOOLS software and data links to a growing number of programs commonly used by resource specialists for specific analysis (for example, FRAGSTATS, McGarigal 1993, McGarigal and Marks 1995; HEICALC, Hitchcock and Ager 1992; HEIWEST, Ager and Hitchcock 1992; and DISPLAY, Flather and others 1992, McNeil and Flather 1992). These data links also required the ability to convert data in UTOOLS databases for export as either raster or vector data to ARC/INFO data layers. The utility of UTOOLS also has been extended by the development of applications that have built on UTOOLS software to support other analyses (for example, Mellen and others 1995b).

Much of the analytical function in UTOOLS is provided by the Paradox query system, which is attractive for users because of its intuitive design and simplicity. Paradox queries of spatial databases can achieve several of the most common GIS functions, including all types of overlays and attribute links. The interactive query system is extended by a scripting capability in which one or more query operations can be saved in ASCII files for later replay. This feature dramatically simplifies the development and application of complex rule bases, like those that involve mathematical operations or many combinations of layers and their attributes. The Paradox-integrated programming language, ObjectPAL™, and the Borland database engine for Pascal and C provide additional avenues to develop custom, stand-alone database applications that interface with Paradox spatial databases. One of the more useful commercial applications of this type is Parastat, which provides various statistical analyses such as data exploration, multiple regression, and analysis of variance.

The demand for several spatial operations led to the creation in UTOOLS of UCELL5, a DOS-protected mode program compiled in Borland Pascal 7.0. UCELL5 reads from and writes to spatial databases, and performs selected spatial operations frequently used in environmental assessments. These include routines to calculate buffers, slope and aspect (Skidmore 1989), discrete patches, landscape convexity (Kvamme 1988), landscape diversity, bilinear interpolation, and many other spatial operations.

The UVIEW Program

Data visualization is a powerful tool in ecosystem management as a method to portray forest conditions and simulate alternative management plans (Heasley 1990; Orland and others 1990, 1992). In its most advanced form, data visualization tools can be used to generate photorealistic images of forested landscapes by using U.S. Geological Survey (USGS) elevation and stand structure data, providing a powerful method to explore forest policy issues. Few of these tools exist, however, and virtually none have been available to resource specialists in Federal land management agencies.

State-of-the-art visualization tools are integrated into UTOOLS via the UVIEW program. UVIEW builds two- and three-dimensional images of attribute data stored in UTOOLS Paradox spatial databases, vegetation patterns at landscape scales, and digital terrain models (DTMs; an organized data set describing the ground surface and consisting of a regularly spaced grid of elevations). UVIEW evolved from terrain-viewing software developed for the PLANS system (McGaughey 1991) and the Vantage Point visualization system (Fridley and others 1991). The UVIEW program combines the capabilities of a relational database with a simple terrain-viewing system to provide a flexible analysis and display tool. The images produced by UVIEW provide a readily understood visualization depicting spatial analysis results and existing or desired landscape conditions.

UVIEW provides a flexible system for viewing a digital terrain model. Four parameters control the appearance of perspective views: the head or eye location; focus or target location; camera lens focal length (15 to 400 millimeters), and the vertical exaggeration (1.0 to 4.0). UVIEW allows users to specify exact coordinates for the head and focus locations or interactively select a head and focus location while viewing a simple perspective representation of the DTM.

Terrain models can be viewed by using various methods and resolutions, including coarse and fine resolution profiles; coarse and fine resolution grid; solid surface representations with hidden surface removal; and lighted, shaded solid surface representations with hidden surface removal. Users typically use the wire frame representations for positioning and exploration of the terrain surface. They use the solid surface representations to display attribute data from the Paradox spatial database and simulated vegetation. Computer systems equipped with a VESA-compatible graphics adapter capable of displaying 256 colors in at least 640 by 480 pixel resolution can display lighted, solid surface representations. These rendered images add realism to a scene by simulating a light source and computing various shades of color depending on the orientation of a DTM cell. UVIEW uses a gray-scale gradient for bare ground and 12 additional colors for attribute display.

Attributes in Paradox spatial databases are draped on landscape views by using an interactive query system that supports various query operators, including string pattern matching, numeric comparisons, and Boolean operators. UVIEW can display query results in both perspective and planimetric views. The planimetric view of the DTM includes contour lines generated from the DTM with a user-specified contour interval. Polygon and vector data files also can be displayed in planimetric view.

UVIEW supports a versatile script language to automate data visualization. Scripts can be used to generate sequences of images to illustrate a landscape from different viewpoints, or show changes in vegetation in response to alternative management scenarios. The VIEWPCX utility can display single images or sequences of images to provide animation capabilities. The UV360FLT and FLY are utilities that can be used to define viewing parameters for constructing “virtual flights” over landscapes.

UVIEW can model vegetation patterns to simulate existing or desired landscape conditions (fig. 2). The primary goal in vegetation modeling is to simulate overall landscape texture and pattern rather than specific, detailed vegetation structure. UVIEW uses two methods to model vegetation pattern. The first method uses estimates of canopy closure from a Paradox spatial database to generate tree cover for each pixel. The second uses vegetation codes in one Paradox spatial database and structure definitions for each possible vegetation code in another Paradox database. The canopy-closure method represents differences in stand densities well but does not represent differences in stand composition and structure. UVIEW displays all values of canopy closure by using the same type and size of plant; only the density of plants differs (fig. 2). In contrast, vegetation modeling based on structure definitions represents both stand density and stand composition. Stand structure definitions consist of layer descriptions, with each layer in a vegetation type described by the type of plant, plant stem diameter, plant height, plant crown diameter, plant live crown ratio, a factor describing the variability of the size parameters, and the number of plants per unit area (normally acres or hectares). UVIEW represents various plant types ranging from grass to mature, healthy conifer and hardwood trees. Vegetation structure descriptions can consist of up to 36 layers; however, practical descriptions contain only two to three layers.

Example Applications of UTOOLS

Analysis of Landscape Structure

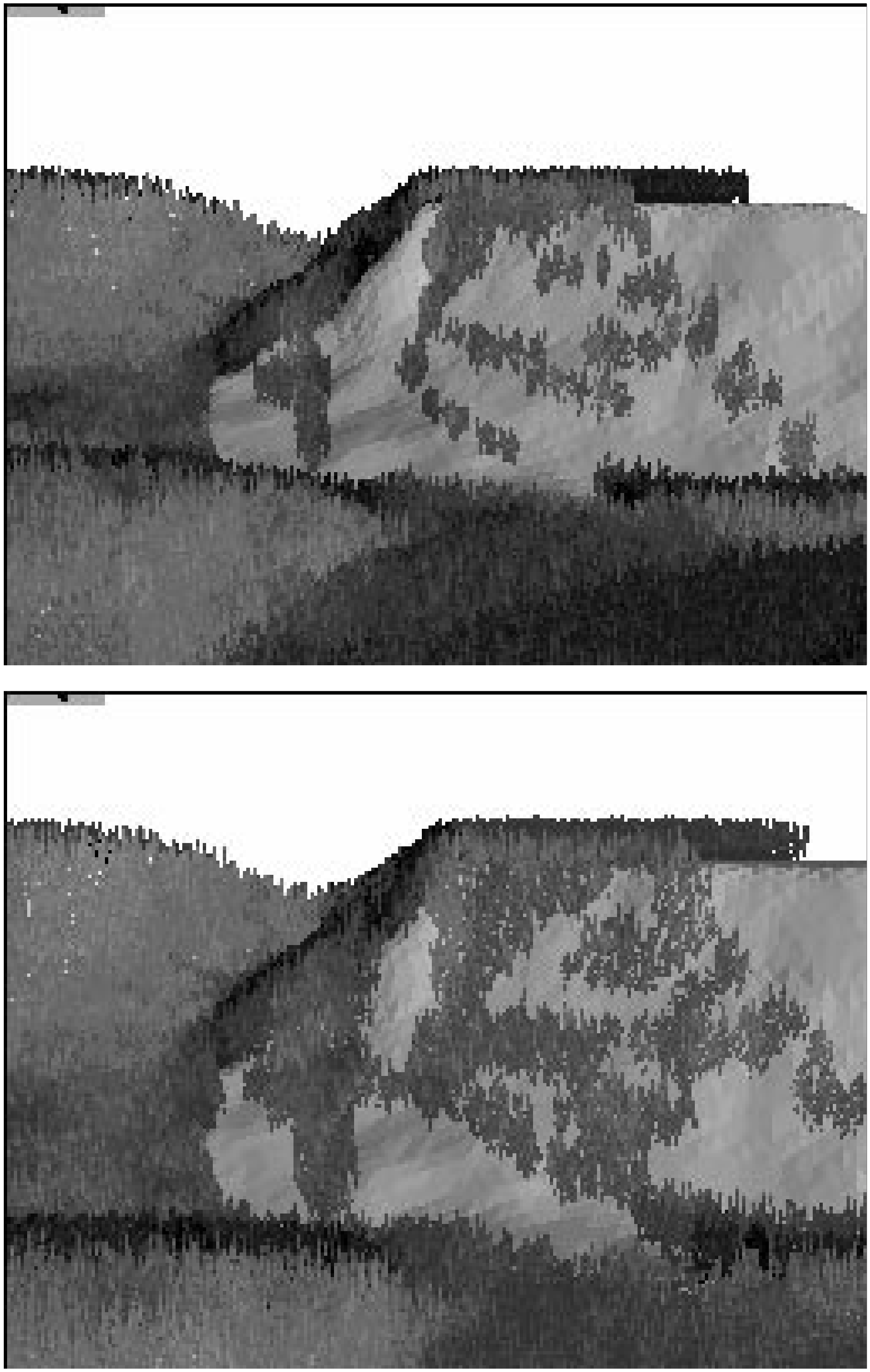
UTOOLS programs used in conjunction with Paradox, FRAGSTATS (McGarigal and Marks 1995), and DISPLAY (McNeil and Flather 1992) provide a simple and efficient set of tools for quantifying and visualizing landscape structure. Landscape structure affects many ecological characteristics, and many metrics have been developed to measure pattern, texture, grain, and other spatial characteristics of landscape patches (for example, see O'Neill and others 1988, Turner and Gardner 1991). The calculation of landscape metrics for large landscapes has been vastly simplified with programs like FRAGSTATS and DISPLAY. UTOOLS further enhances the utility of these programs by providing a simple means to convert various landscape data to Paradox spatial databases where they can be manipulated and subsequently exported to ASCII files formatted for DISPLAY and FRAGSTATS. Changes in landscape structure resulting from management or natural disturbances can easily be represented by using Paradox queries on a spatial database and data export features in UCELL5 that format Paradox data for input into DISPLAY or FRAGSTATS.

Analysis of Vertebrate Habitat Relations With HABSCAPES

A system called HABSCAPES (Mellen and others 1995a, 1995b) was developed by the Mount Hood National Forest to examine wildlife populations in a community context on large landscapes. HABSCAPES uses Paradox spatial databases created with UTOOLS programs. Output from HABSCAPES is a spatial database mapped with UVIEW. The goal of this system is to predict occurrence of all terrestrial vertebrate and aquatic amphibian species relative to landscape pattern for large geographic areas. Species are grouped into life-history guilds based on expected responses of species to the amounts and distributions of habitat across the landscape (for example Brown 1985, Thomas 1979). Habitat configurations are measured in terms of home range, patch size, patch-configuration use, and stand-level habitat preference. The procedure links databases of wildlife habitat relations and life-history characteristics to a UTOOLS vegetation database by using FORTRAN programs and Paradox scripts. Several UTOOLS programs are used in the HABSCAPES analysis to develop and synthesize the vegetation database as well as display the results. Although HABSCAPES was developed as a Forest-level analysis tool, it is now widely applied for watershed analyses and Adaptive Management Areas by both west- and east-side National Forests in the Pacific Northwest (Region 6).

Forage Allocation Models

UTOOLS software has proven useful for building the land strata for linear programming models (Johnson and others 1986) and spatially displaying the outputs. For instance, Johnson and others (1996) describe a prototype stocking allocation tool to guide the allocation of forage resources to cattle *(Bos taurus)*, mule deer *(Odocoileus hemionus)*, and elk *(Cervus elaphus)* in the Blue Mountains. This linear programming model

A
B


C

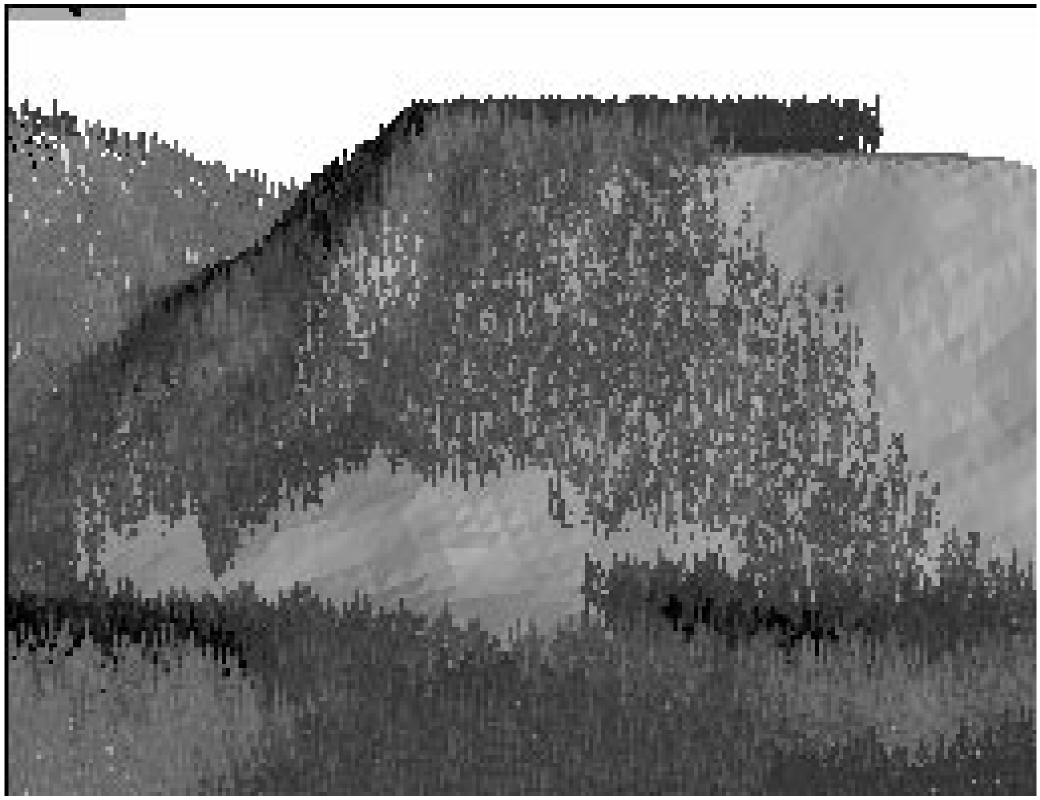


Figure 2—UVIEW can depict vegetation patterns by using canopy-closure estimates for each pixel in the spatial database. Images shown are heavy harvest with aggregated retention (**A**), light harvest with aggregated retention (**B**), and harvest with dispersed retention (**C**). (Data and images were produced by the students of FE 444, winter quarter 1995, College of Forest Resources, University of Washington.)

appraises forage consumption by elk, mule deer, and cattle over seven monthly time periods (April 1 to October 31), by using spatially and temporally explicit information on habitat preferences, forage production, and forage quality, as well as species-specific metabolic relations for weight gain and loss. Animal distributions are predicted based on their responses to environmental variables, including seasonal estimates of the quantity and quality of forage produced in various habitat types. This model was built from various data themes that describe topography, forage production, distance to features like water and roads, and many other layers. The data are assembled in a UTOOLS spatial database, and land strata (analysis areas) for the linear programming model are synthesized with Paradox queries. Model outputs for forage use and other variables are linked, by using the model identifiers, to the spatial input database, where they are summarized and mapped with UVIEW (fig. 3). By using the habitat identifiers in the spatial database, forage use is linked back to the spatial database and is displayed visually (fig. 3).

Assessment of Elk Habitat in Western Oregon and the Blue Mountains

Thomas and others (1988) developed a habitat effectiveness index (HEI) to measure elk habitat quality for winter ranges in the Blue Mountains of eastern Oregon. A similar model was developed for elk habitat in western Oregon (Wisdom and others 1986). The models evaluate four habitat components: the size and spacing of cover and forage areas; the density of roads traveled by motorized vehicles; the quantity and quality of forage; and the quality of cover. Although research to validate these models continues (Wisdom and Rowland, in prep.), HEI models are widely applied in measuring and monitoring elk habitat (Edge and others 1990). Nearly all National Forests in the Pacific

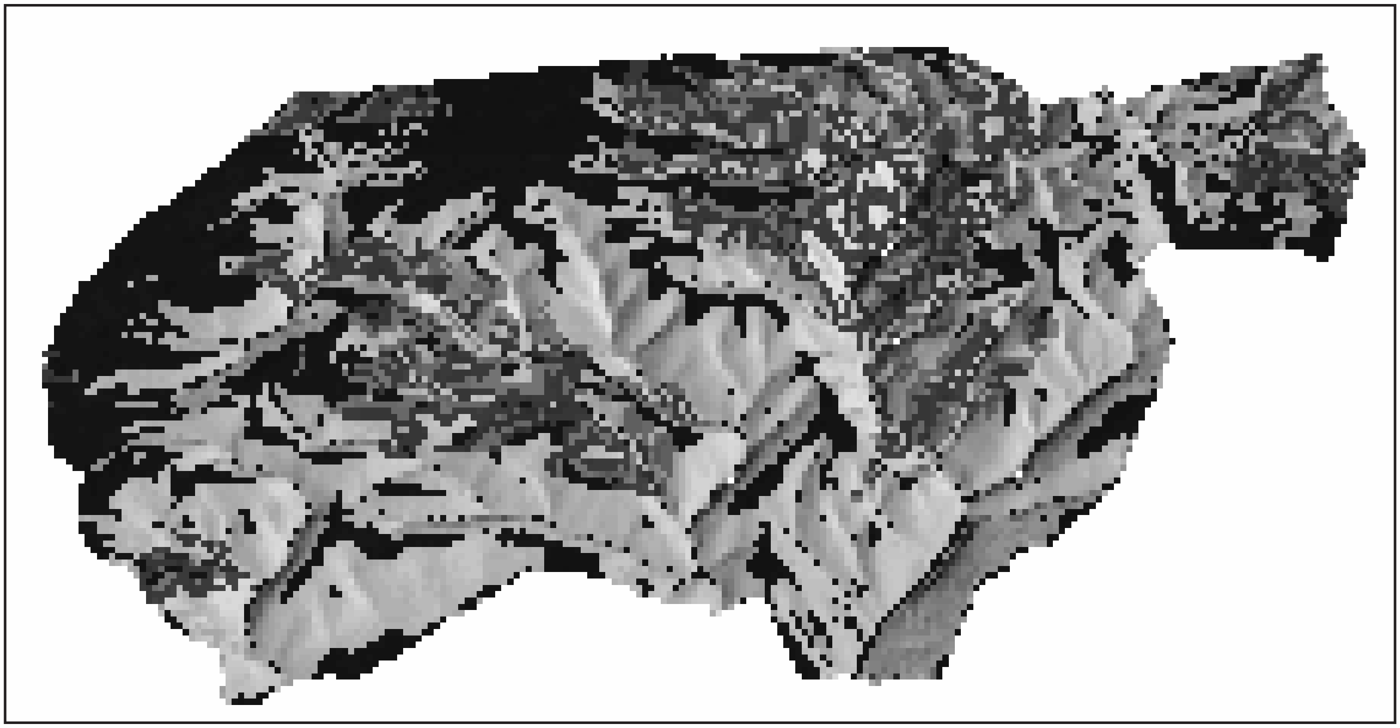


Figure 3—UVIEW image of a portion of the Starkey Experimental Forest and Range showing outputs from a forage allocation model that maximizes animal habitat preferences (see text). Gray shades show areas predicted by the model to be foraged primarily by cattle (dark gray), elk (medium gray), and deer (light gray) for the month of September. The image was created by linking the linear programming solution file to a UTOOLS spatial database.

Northwest Region have incorporated HEI standards into Forest plans and have adopted the models for monitoring long-term changes to elk habitat. The application of these models was facilitated by UTOOLS software that automates HEI calculations (Ager and others 1991; Ager and Hitchcock 1992, 1994; Hitchcock and Ager 1992). The HEIWEST program calculates HEI from coefficients of habitat use published by Wisdom and others (1986), whereas the HEICALC program calculates HEI for the Blue Mountains winter range model (Thomas and others 1988). These programs have been integrated with UTOOLS so that habitat and other data required by the programs can be organized and validated within a spatial database and subsequently exported to files formatted for HEICALC and HEIWEST. Typically, HEI values are calculated for many project alternatives by modifying existing vegetation with Paradox queries on a spatial database that contains timber harvest alternative units as well as stand conditions. These queries change canopy closure for all pixels that occur within a harvest prescription area; the canopy is reduced by some fixed amount to represent the posttreatment condition. The revised data are exported to HEI programs to complete big game habitat assessment for proposed alternatives. Frequent changes to alternatives are easily accommodated by this system, because queries to simulate alternatives are recorded in scripts that are simply replayed if harvest units are modified.

Spatial Analysis of SMART Stream Survey Data for the Columbia River Basin Assessment

McKinney (1995) described the application of UTOOLS for multiscale analysis of Forest Service stream survey data collected with the Hankin and Reeves (1988) method. The latter forms the basis for the stream management, analysis, reporting, and tracking (SMART) information system in Region 6. Before the adoption of UTOOLS, there was no usable method to analyze and view these data. McKinney (1995) developed a procedure for linking SMART data to stream segment maps for visualization with

UVIEW, and methods to analyze the data with Paradox queries. These procedures were used to assess aquatic habitat relations within the Columbia River basin as part of the Eastside Ecosystem Management Project (Lee and others, in prep.).

Analysis of Wildlife Telemetry Data for the Starkey Project

The Starkey Project is a long-term study to examine interactions of mule deer, elk, and cattle and their response to forest management activities in the Blue Mountains province of eastern Oregon (Johnson and others 1991; Rowland and others, in press; Wisdom 1992). The project uses a loran-C animal tracking system to record animal movements throughout the grazing season. A major component of this investigation is to refine habitat models for cattle, deer, and elk. Various habitat data for Starkey, to be used for model development, have been assembled in UTOOLS databases (Rowland and others, in prep.). Animal telemetry data also are converted to spatial database format and merged with habitat data. Telemetry observations are assigned to database records based on their coordinates. The association of habitat data with animal use in a single data structure allows for rapid exploration of the relation between animal locations and habitat characteristics. Data can be statistically analyzed with Parastat, or exported to an ASCII format compatible with statistical analysis system (SAS).

With the UVIEW scripting language, movies of the telemetry data are created depicting cattle, deer, and elk movements over the grazing season on a landscape image developed from a UVIEW terrain model. Vegetation is added to these images to create a realistic image of the landscape with animal locations. This technique provides a dynamic depiction of animal behavior over time that yields valuable insights into animal-habitat relations and interspecific interactions.

Visualizing Long-Term Vegetation Management—The Augusta Creek Project

The Augusta Creek Project used concepts of natural range of variability to develop a long-range treatment schedule for the watershed. The area was stratified by frequency and size of natural disturbance, like fire; silvicultural treatments for a 200-year planning horizon were then designed and scheduled to mimic the natural disturbance mechanisms. Changes in the landscape were visualized with a UVIEW movie. Vegetation changes were modeled with Paradox queries according to the harvest schedule and projected regrowth. Tree canopy was removed with treatments and grown back over time. UVIEW was then used to draw the vegetation images in 10-year increments, which were subsequently played in rapid succession to produce a time series of forest succession within the Augusta Creek area.

Landscape Management System

Developed at the University of Washington, the landscape management system (LMS) was designed to assist in landscape-level analysis and planning of forest ecosystems (Oliver and McCarter 1996). This system automates such tasks as graphic and tabular summarization, stand projection and visualization, and landscape visualization. The LMS incorporates distinct programs that store or process inventory information, produce graphic or tabular displays, and simulate stand development and growth, thereby connecting these diverse programs into a cohesive system. UVIEW and UTOOLS are used in LMS to create landscape visualizations of forest conditions over time with several alternative management strategies.

Building UTOOLS Spatial Databases

UTOOLS utility programs convert spatial data from their native formats to Paradox spatial databases (fig. 1). Specific DOS-based programs exist to deal with USGS digital elevation data (USGS 1987), ERDAS GIS data coverages (ERDAS, Inc. 1991), the ARC/INFO SAMPLE commands in the ARC GRID subsystem (Environmental Systems Research Institute, Inc. 1994), and ASCII flatfiles (fig. 1). Procedures for building spatial databases are explained in detail in the UTOOLS operations manual (Ager and McGaughey 1996) and are only briefly covered here. Vector layers (polygon, line, and point) are converted to raster and imported to Paradox by using the UCELL5 program. UCELL5 accepts data in MOSS import-export format (USDI 1990) by using either the State Plane or Universal Transverse Mercator coordinate system. Attribute data are imported into Paradox format and joined with a query based on vector subject codes common to both the vector theme and attribute database. Oracle attribute data are converted directly to Paradox with the Borland Data Pump or SQL Links.

The USGS digital elevation data are processed with three utilities in UTOOLS: IMPRTDEM, ADDELEV, and EXTELEV. IMPRTDEM imports raw USGS digital elevation data to a compact digital terrain model (McGaughey 1991). ADDELEV will populate a Paradox spatial database with elevation by using a DTM as input, and will interpolate if the database pixel size is different from the USGS raw data. EXTELEV translates Paradox elevation data into a terrain model that matches the database for UVIEW.

Data in ERDAS format (ERDAS, Inc. 1991) are added to spatial databases with the ADDERDAS program. This DOS program populates Paradox databases with integer values from ERDAS files. The program is typically run in DOS batch file to populate a spatial database with many quads of ERDAS data, such as LANDSAT thematic mapper data. ERDAS data also can be displayed along with vector data by using SHOERDAS. This program originally was developed to visually examine LANDSAT data before its incorporation into spatial databases. Additional fields for buffers, slope, aspect, or similar values, are added by using the UCELL5 program. Paradox queries can be used to compute new fields, representing either combinations of existing fields or complex calculations of fields in the spatial database.

The pixel size of a spatial database can be altered as needed for a project. Smaller pixel sizes afford less spatial error in vector-to-raster conversion but result in large databases that are slow to query and map. Most UTOOLS applications use a pixel size of 30 to 100 meters per side, thereby resulting in databases of 30,000 to 250,000 records and 10 to 50 megabytes (MB) in size. Paradox databases can be as large as 256 MB. Available hard drive space becomes an important factor with large databases because Paradox requires three to five times the size of the database in available space to efficiently perform queries. Specific procedures for transferring attribute data to the Paradox spatial database can be found in the UTOOLS operations manual (Ager and McGaughey 1996).

Hardware and Software Specifications and Distribution

UTOOLS operates on IBM-compatible personal computers running MS-DOS, Windows 3.x, or Windows95. Its operation requires microcomputer configurations with a 66 MHz (or faster) 80486, 4 MB of RAM, at least 200 MB of available space on the hard drive, and an SVGA display adapter. Lesser configurations are suitable for browsing the example data included with UTOOLS but will not provide satisfactory performance for most analysis problems. UTOOLS can be run without Paradox; however, its usefulness will be limited.

Three files comprise the UTOOLS distribution: UTOOLS1.EXE and UTOOLS2.EXE hold the UTOOLS documentation and programs, whereas UTOOLS3.EXE contains a tutorial exercise and an example dataset for use with UTOOLS. UTOOLS and UVIEW can be obtained on the Internet via anonymous FTP at forsys.cfr.washington.edu. Log in as “anonymous” and use your e-mail address as a password. The UTOOLS1.EXE, UTOOLS2.EXE, and UTOOLS3.EXE files are kept in the /pub/software/utools directory. The UTOOLS and UVIEW home pages and links to the FTP are located on the World Wide Web at:

http://forsys.cfr.washington.edu/utools.html

and at:

http://forsys.cfr.washington.edu/uview.html.

Documentation is contained within UMANUAL.DOC, an ASCII text file. Additional help files are provided for HEICALC, HEIWEST, and the DISPLAY programs (Flather and others 1992). Online help for UVIEW is available by clicking on the help button of the introductory screen or by pressing [F1] at any time. "Demo data" contains a spatial database for a 2025-hectare area in the Umatilla National Forest; vector, polygon, and line files; terrain models; and various other files to complete the training exercise in the UTOOLS manual.

Forest Service users can retrieve UTOOLS and UVIEW from the RIS site:

Host:	R06F14A
Staff:	PUBLIC
Drawer:	UTOOLS
Folder:	UTOOLS
Files:	UTOOLS1.EXE
	UTOOLS2.EXE
	UTOOLS3.EXE

All UTOOLS programs are in the public domain, and therefore recipients or users may not assert any proprietary rights, and the authors are not responsible for any erroneous results from analysis with UTOOLS.

Conclusions

UTOOLS meets a critical need for simple and efficient spatial analysis tools that address various land management and scientific issues within the Forest Service and elsewhere. The programs satisfy several criteria that are essential for software tools: usable by many resource specialists; free; capable of accessing diverse data sources and formats; and addresses specific needs of resource specialists as they relate to land management planning.

Acknowledgments

We thank Mark Hitchcock and David Hatfield for their contributions to UTOOLS software. Ed Pugh, Jim Merzenich, Ken Tu, Shaun McKinney, Bill Connelly, Bob Clements, Dave Kendrick, Alison Reger, and many others provided valuable feedback on early versions. Bruce Johnson and Michael Wisdom provided technical reviews of the manuscript. Portions of this work were completed as part of cooperative agreement PNW89-648 for the Starkey Research Development and Application Program between the Pacific Northwest Research Station and the Pacific Northwest Region of the Forest Service.

References

Ager, Alan; Hitchcock, Mark; Mrowka, Rob [and others]. 1991. Some new tools for analysis of elk habitat in eastern Oregon. In: Christensen, Alan G.; Lyon, L. Jack; Lonner, Terry N., comps. Proceedings of elk vulnerability—a symposium; 1991 April 10-12; Bozeman, MT. Bozeman, MT: Montana State University: 60-62.

Ager, Alan; Hitchcock, Mark. 1992. Microcomputer software for calculating the western Oregon elk habitat effectiveness index. Gen. Tech. Rep. PNW-GTR-303. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 12 p.

Ager, Alan; Hitchcock, Mark. 1994. HEICALC: elk habitat-effectiveness index software. Wildlife Society Bulletin. 22(1): 126-128.

Ager, A.A.; McGaughey, Robert. 1996. Operations manual for UTOOLS. 52 p. Unpublished manual. On file with: USDA Forest Service, Umatilla National Forest, 2517 Hailey Avenue, Pendleton, OR 97801.

Brown, E.R., tech. ed. 1985. Management of wildlife and fish habitats in forests of western Oregon and Washington. Publ. R6-F&WL-192. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 332 p.

Edge, W. Daniel; Olson-Edge, Sally L.; Irwin, Larry L. 1990. Planning for wildlife in National Forests: elk and mule deer habitats as an example. Wildlife Society Bulletin. 18: 87-98.

Environmental Systems Research Institute, Inc. 1994. Cell-based modeling with GRID. Redlands, CA: Environmental Systems Research Institute. 481 p.

ERDAS, Inc. 1991. PC system guide. Version 7.5. Atlanta, GA: ERDAS, Inc. 104 p.

Flather, C.; Brady, S.J.; Inkley, D.B. 1992. Regional habitat appraisal of wildlife communities: a landscape-level evaluation of a resource planning model using avian distribution data. Landscape Ecology. 7: 137-147.

Forest Ecosystem Management Assessment Team [FEMAT]. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior [and others]. [Irregular pagination].

Fridley, J.L.; McGaughey, R.J.; Lee, F.E. 1991. Visualizing engineering design alternatives on forest landscapes. Unpublished manuscript. On file with: Pacific Northwest Research Station, University of Washington, College of Forest Resources, Bloedel 361, P.O. Box 352100, Seattle, WA 98195-2100.

Hankin, D.G.; Reeves, G.H. 1988. Use of visual methods for estimating fish abundance and habitat areas in small streams. Canadian Journal of Fisheries and Aquatic Science. 54: 834-844.

Heasley, J. 1990. Simulating the visual effects of timber harvest practices. In: Resource technology 90. Washington, DC: American Society for Photogrammetry and Remote Sensing.

Hitchcock, Mark; Ager, Alan. 1992. Microcomputer software for calculating an elk habitat effectiveness index on Blue Mountain winter range. Gen. Tech. Rep. PNW-GTR-301. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 13 p.

Johnson, Bruce K.; Ager, Alan; Crim, Sarah A. [and others]. 1996. Allocating forage among wild and domestic ungulates--a new approach. In: Olson-Edge, Sally L.; Edge, W. Daniel, eds. Proceedings of a symposium on sustaining rangeland ecosystems; 1994 August 29-31; La Grande, OR. Spec. Rep. 953. Corvallis, OR: Oregon State University Extension Service: 166-169.

Johnson, Bruce K.; Noyes, James H.; Thomas, Jack Ward; Bryant, Larry D. 1991. Overview of the Starkey Project: current measures of elk vulnerability. In: Christensen, Alan G.; Lyon, L. Jack; Lonner, Terry N., comps. Proceedings of elk vulnerability—a symposium; 1991 April 10-12; Bozeman, MT. Bozeman, MT: Montana State University: 225-228.

Johnson, K.N.; Stuart, T.W.; Crim, S.A. 1986. FORPLAN version 2: an overview. Washington, DC: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section. 100 p.

Kvamme, K. 1988. Development and testing of quantitative models. In: Judge, J.; Sebastian, L., eds. Quantifying the present and predicting the past: theory, method, and application of archaeological predictive modeling. Denver, CO: U.S. Department of the Interior, Bureau of Land Management: 325-428.

Lee, D.; Sedell, J.R.; Rieman, B. [and others]. [In prep.]. Broadscale assessment of aquatic species and habitats. In: Quigley, T.M.; Arbelbide, S.J., eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

McGarigal, K. 1993. Relationships between landscape structure and avian abundance patterns in the Oregon Coast Range. Corvallis, OR: Oregon State University. 274 p. Ph.D. dissertation.

McGarigal, Kevin; Marks, Barbara J. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. Gen. Tech. Rep. PNW-GTR-351. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 122 p.

McGaughey, R.J. 1991. Timber harvest planning goes digital: PLANS—preliminary logging analysis system. Compiler. 9(3): 10-17.

McKinney, Shawn P. 1995. Spatial analysis of SMART stream survey data with UTOOLS. Aqua-Talk, R-6 Fish Habitat Relationship Tech. Bull. 10. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 10 p.

McNeil, B.; Flather, C. 1992. Documentation for DISPLAY. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p.

Mellen, Kim; Huff, M.; Hagestedt, R. 1995a. "HABSCAPES." Interpreting landscape patterns: a vertebrate habitat relationships approach. In: Thompson, J., comp. Analysis in support of ecosystem management, analysis workshop III; 1994 April 10-13; Fort Collins, CO. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Analysis Center: 135-145.

Mellen, Kim; Huff, Mark; Hagestedt, Rich. 1995b. "HABSCAPES:" reference manual and user's guide. Gresham, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Mount Hood National Forest. [Irregular pagination]. 7 chapters.

Oliver, C.D.; McCarter, J.B. 1996. Developments in decision support for landscape management. In: Heit, M.; Parker, H.D.; Shortreid, A., eds. GIS applications in natural resources 2. [Place of publication unknown]: GIS World Books: 501-509.

O'Neill, R.V.; Krummel, J.R.; Gardner, R.H. [and others]. 1988. Indices of landscape pattern. Landscape Ecology. 1: 153-162.

Orland, B.; Daniel, T.C.; Lynch, A.M.; Holsten, E.H. 1992. Data-driven visual simulation of alternative futures for forested landscapes. In: Wood, Geoff; Turner, Brian, eds. Proceedings: IUFRO—integrating forest information over space and time; 1992 January 13-17; Canberra, Australia. Canberra, Australia: International Union of Forest Research Organizations: 368-378.

Orland, B.; LaFontaine, J.; Daniel, T.C. 1990. Visualizing alternative futures for forested landscapes. In: Resources technology 90. Washington, DC: American Society for Photogrammetry and Remote Sensing: 46-57.

Rowland, Mary M.; Ager, Alan A.; Coe, Priscilla [and others]. [In prep.]. The Starkey habitat database for ungulate research: construction, documentation, and use.

Rowland, Mary M.; Bryant, Larry D.; Johnson, Bruce K. [and others]. [In press]. The Starkey Project: history, facilities, and data collection methods for ungulate research. Gen. Tech. Rep. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Skidmore, A.K. 1989. A comparison of techniques for calculating gradient and aspect from a gridded digital elevation model. International Journal of Geographical Systems. 3: 323-334.

Thomas, Jack Ward, tech. ed. 1979. Wildlife habitats in managed forests—the Blue Mountains of Oregon and Washington. Agric. Handb. 553. Washington, DC: U.S. Department of Agriculture. 512 p.

Thomas, Jack Ward; Leckenby, Donavin A.; Henjum, Mark [and others]. 1988. Habitat-effectiveness index for elk on Blue Mountain winter ranges. Gen. Tech. Rep. PNW-GTR-218. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 p.

Turner, M.G.; Gardner, R.H., eds. 1991. Quantitative methods in landscape ecology. New York: Springer. 536 p.

U.S. Department of the Interior, Bureau of Land Management. [1990]. Map overlay statistical system. MOSS user's manual. Denver, CO: Service Center. [Irregular pagination].

U.S. Geological Survey. 1987. Digital elevation models. Users guide 5. Reston, VA. U.S. Department of the Interior. 37 p.

Wisdom, Michael. 1992. The Starkey Project: new technologies chase old questions about deer and elk management. Western Wildlands: 32-38.

Wisdom, Michael J.; Bright, Larry R.; Carey, Chris G. [and others]. 1986. A model to evaluate elk habitat in western Oregon. R6-F&WL-216-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 36 p.

Wisdom, Michael J.; Rowland, Mary M., tech. comps. [In prep.]. Elk habitat and population monitoring in National Forests of the Blue Mountains of Oregon and Washington.

Appendix

Software Referenced in Text

Software	Company	Address or reference
ARC/INFO	Environmental Systems Research Institute, Inc. (ESRI)	380 New York Street Redlands, CA 92373-8100
Borland Data Pump and SQL Links	Borland International, Inc.	100 Borland Way P.O. Box 660001 Scotts Valley, CA 95066-3249
DISPLAY	Public domain	Flather and others 1992 McNeil and Flather 1992
ERDAS	ERDAS, Inc.	2801 Buford Highway, Suite 300 Atlanta, GA 30329
FRAGSTATS	Public domain	McGarigal and Marks 1995
HABSCAPES	Public domain	Mellen and others 1995a, b
HEICALC	Public domain	Hitchcock and Ager 1992
HEIWEST	Public domain	Ager and Hitchcock 1992
MOSS	Public domain	Bureau of Land Management Branch of Interim LIS Management Bldg. 50, Denver Federal Center P.O. Box 25047 Denver, CO 80225-0047
Oracle	Oracle Corporation	500 Oracle Parkway Redwood City, CA 94065
Paradox	Borland International, Inc.	100 Borland Way P.O. Box 660001 Scotts Valley, CA 95066-3249
Parastat	Financial Modeling Specialists, Inc.	2049 Woodford Road Vienna, VA 22182
Statistical Analysis System	SAS Institute Inc.	SAS Campus Drive Cary, NC 27513

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Ager, Alan A.; McGaughey, Robert J. 1997. UTOOLS: microcomputer software for spatial analysis and landscape visualization. Gen. Tech. Rep. PNW-GTR-397. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 15 p.

UTOOLS is a collection of programs designed to integrate various spatial data in a way that allows versatile spatial analysis and visualization. The programs were designed for watershed-scale assessments in which a wide array of resource data must be integrated, analyzed, and interpreted. UTOOLS software combines raster, attribute, and vector data into “spatial databases” in which each record represents a square pixel of fixed area, and each field in the database represents a map layer, theme, or attribute. UTOOLS includes several common GIS functions, such as procedures for calculating buffers, slope, aspect, patch size, convexity, and measures of topographic diversity. The UVIEW program provides rapid two- and three-dimensional images of digital elevation models, attribute data, and vegetation patterns at watershed scales. UTOOLS programs fulfill the routine analytical needs of resource professionals at low cost and without the expense and training required by many other spatial analysis and visualization systems.

Keywords: Geographic information system, wildlife habitat relations, landscape visualization, landscape ecology, ecosystem management, ecosystem planning, watershed analysis, habitat analysis, spatial analysis, spatial databases, visualization software.

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