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The USGS National Civil Applications Program – Supporting Federal Civil Agency Use of Classified Remote Sensing Data

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Since the 1960s, classified satellite imagery has been available to Federal civil agencies for their mapping and science applications. Used as an alternative data source or in combination with data collected from traditional sources, the unique capabilities of these data have proved to be valuable in a wide variety of applications that support the missions and mandates of the Federal civil agencies that are members of the Civil Applications Committee (CAC). The Department of the Interior (DOI) and all of its agencies are CAC members. Within the DOI, classified remote sensing data is used to support national mapping programs; land and resource management programs; detection and mitigation of hazards, such as earthquakes, volcanoes, forest fires, floods and hurricanes; and other scientific and environmental studies. The USGS, through its National Civil Applications Program (NCAP), supports Federal civil agency use of classified satellite imagery by providing imagery acquisition services and the use of secure facilities and data exploitation systems to all CAC member agencies. The Advanced Systems Center (ASC) and the National Center Collateral Facility (NCCF), both located at the USGS National Center in Reston, Virginia are the USGS Eastern Region secure facilities. This presentation will highlight Eastern Region projects that have made use of these unique data sources and will provide information on how to obtain and use classified data to support the programs, projects and scientific and environmental studies of the Appalachian Region.

The National Biological Information Infrastructure Southern Appalachian Information Node

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The NBII program was created in 1993 based on the recommendation of a special panel convened by the National Research Council to examine critical national biological resource issues. The National Biological Information Infrastructure NBII www.nbii.gov is an electronic information network that provides access to biological data and information on our nation 's plants, animals, and ecosystems. Data and information maintained by federal, state, and local government agencies; non-government organizations; and private-sector organizations are linked through the NBII gateway and made accessible to a variety of audiences including researchers, natural resource managers, decision-makers, educators, students, and other private citizens. Recently, a team of internationally renowned scientists (which included a Nobel prize winner) spoke of the need for a next generation NBII or NBII-2. Today, work on the new NBII is underway. One of the key components of the next generation NBII is a system of nodes that is being developed to ensure broad partnerships and information from all sectors of society. These nodes function as fully digital, distributed, and interactive systems that focus on developing, acquiring, and managing content on a defined subject area (thematic nodes) or a geographic region (regional nodes). The NBII Southern Appalachian Information Node (SAIN) is one of several regional nodes established in 2001.

SAIN is the biological component of the Southern Appalachian Regional Information System (SARIS) a unique source for integrated science including biological, physico-chemical, and socio-economic data and information created and coordinated in the region. The SAIN/SARIS system combines multi-agency information and regional resources to improve productivity, resource management, and sustainable development through the Southern Appalachian Man and the Biosphere (SAMAB) program and other partners.

SAIN is a leader in issues of ecosystems informatics and biodiversity information analysis and evaluation. SAIN also takes a national responsibility to build the integrated access system and clearinghouse to distribute NBII information.

SAIN/SARIS facilitates:

- Using environmental information effectively in public-and private- sector decision making for resource management, economic development, land use and planning and policy development.
- Assessing and controlling invasive species in Southern Appalachia.
- Innovation in the dissemination of spatially enabled data and information over the Web.
- Building a coalition to get broad and deep regional participation in and support for node development.

This paper will discuss the NBII Node enterprise with an emphasis on the NBII SAIN Regional Information Node activities and initiatives.

Physical Properties of Rocks of the Appalachian Region as Represented by Geochemical and Geophysical Data

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ABSTRACT

The U.S. Geological Survey (USGS) has large regional databases of geochemical and geophysical data of the Appalachian region. The geochemical data available are the results of chemical analyses of stream-sediment samples. The geophysical data are aeromagnetic, aeroradiometric, and gravity data compiled using a variety of data sources and surveys. All of the data sets have been processed by the USGS to improve their internal consistency. The data are available in digital formats that facilitate their use in geographic information systems. The geochemistry data from stream sediment samples reflect the chemical characteristics of the rocks and soils, and the geophysical data reflect the density, magnetization, and surface radioactivity of the geologic materials. Both the Geochemical and geophysical data provide direct and indirect information related to the geology and geologic processes that have formed the rocks and soils.

INTRODUCTION

The U.S. Geological Survey (USGS) has compiled geochemical and geophysical data that cover most of the Appalachian region as indicated by the shaded area in figure 1.

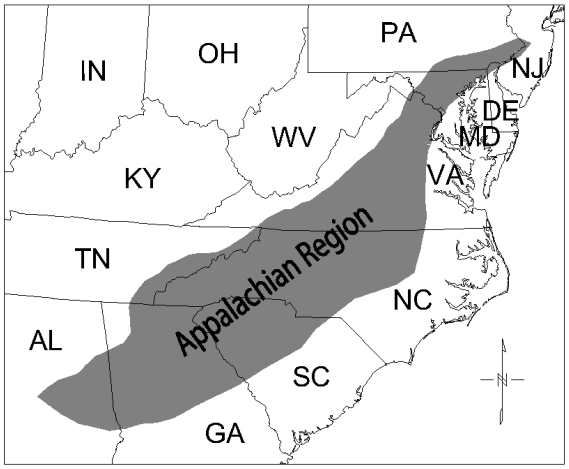

Figure 1. Shaded area shows the Appalachian region as used here.

The geochemical data presented here are based on stream-sediment samples collected as part of the National Uranium Resource Evaluation (NURE) Program of the U.S. Department of Energy from 1975 to about 1983. Uranium was analyzed during the original NURE program, mostly by delayed-neutron activation analysis. Arsenic was analyzed recently by the USGS in a subset of the same NURE samples using hydride generation atomic absorption spectrometry. The samples were extracted from a sample archive that is currently located at a USGS facility in Denver, Colorado. In addition to As, recent reanalyses also include forty major, minor, and trace elements by inductively coupled plasma-atomic emission spectrometry (ICP-AES), and mercury and selenium by atomic absorption. Arbogast (1996) provides more detailed information about the analytical methods and the elements measured. Information about the NURE Program and NURE geochemical data are available on the internet (Smith, 2000) and as a digital publication (Hoffman and Buttleman, 1994).

The aeromagnetic data presented here are from a compilation of many diverse airborne surveys and include some data digitized from contour maps. The USGS compiled the data and processed it to obtain an internally consistent database. Some of the data used in the compilation are available on the internet (USGS, 2001).

The USGS compiled the gravity data from data available from the National Geophysical Data Center (Dater and others, 1999), surveys done by the USGS, and data from the U.S. Defense Mapping Agency.

The aeroradiometric data are taken from a compilation of NURE aerial gamma-ray surveys

published by Phillips and others (1993). The original aerial gamma-ray data were processed by Duval and Riggle (1999).

DISCUSSION

Figure 2 shows a generalized lithologic map of the Appalachian region based upon the map compiled by Peper and others (2001). Hatcher and others (1989) edited a series of papers that provide a broad summary of the geologic history of the Appalachian and Ouachita Mountains in the United States and should be consulted for more detailed information. The region has been divided into broad physiographic provinces (for example see Bayer, 1989) as the Blue Ridge Province, Western Piedmont, Eastern Piedmont, and the Carolina Terrain.

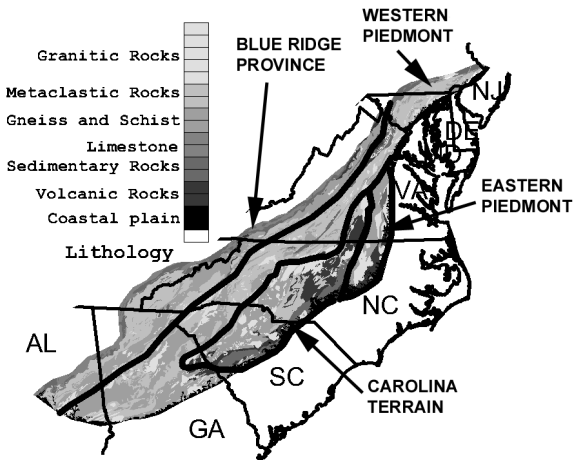

Figure 2. Generalized lithologic map based on the map published by Peper and others (2001).

Figure 3 shows the distribution of uranium in stream sediment samples (Hoffman and Buttleman, 1994; Smith, 2000). The stream sediments of the Carolina Terrain have concentrations generally less than about 3 ppm U whereas those of the Western Piedmont have concentrations greater than about 5 ppm U. The uranium in stream sediments of the Blue Ridge Province are varied but include areas of distinctly higher or lower concentrations of uranium.

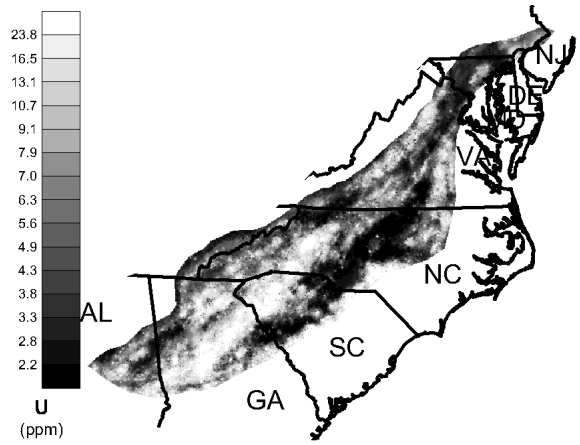

Figure 3. Uranium concentrations in stream sediment samples of the NURE Program.

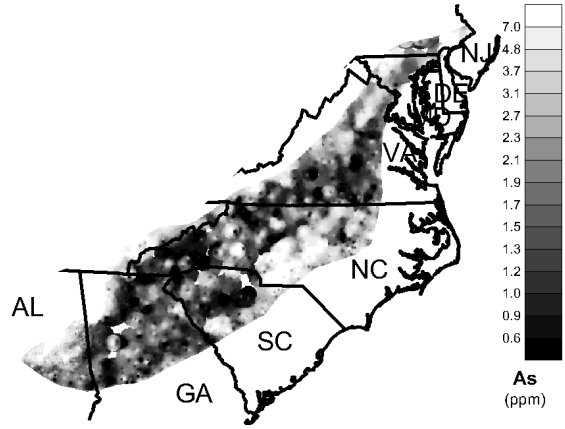

Figure 4. Arsenic concentrations in stream sediment samples of the NURE Program

Figure 4 shows the distribution of arsenic in stream sediment samples (unpublished data from USGS). Although the density of the sample coverage for arsenic is less than that for uranium, the data indicate that many of the stream sediments of the Carolina Terrain have generally higher concentrations of arsenic than other sediments in the region. The arsenic concentrations in the areas of the Blue Ridge Province, Western Piedmont, and Eastern Piedmont are varied but are generally lower than those in parts of the Carolina Terrain. The data in figures 3 and 4 suggest that the uranium and arsenic concentrations in stream sediments may have an inverse relationship for parts of the region.

Figure 5 shows the residual aeromagnetic data for the region. These data reflect the magnetite content of the rocks and many of the higher values are associated with volcanic rocks

along and near the boundary between the Blue Ridge Province and the Western Piedmont, in the southern part of the Western Piedmont, and in the northern part of the Carolina Terrain. Anomalies of smaller dimensions are associated with rocks at or near the surface, gabbroic intrusives, metamorphosed volcanic rocks, and volcanic sediments. Broad, diffuse anomalies reflect deeply buried rock bodies.

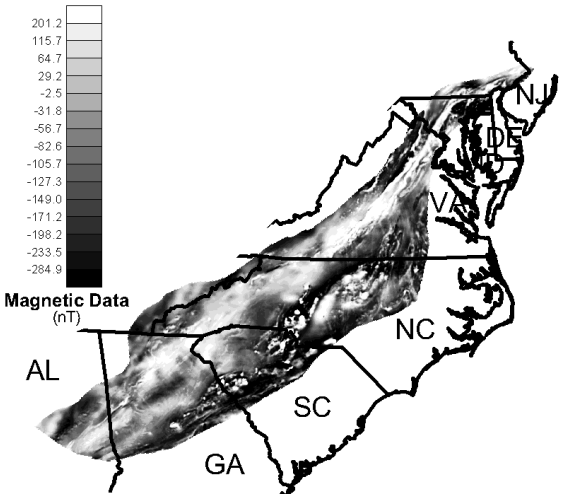

Figure 5. Residual aeromagnetic data.

Figure 6 shows the Bouguer gravity anomaly map for the region. This map largely reflects regional structures at the base of the crust. Anomalies of small dimensions reflect rocks at or close to the surface. Many of the higher values occur within the Carolina Terrain. The lowest gravity values are in the west-central part of the region. This gravity low is part of a broad area of lower gravity west of the Appalachian region.

Figures 7, 8, and 9 show the potassium, uranium, and thorium concentrations in the rocks and soils as measured by the aerial gamma-ray surveys of the NURE Program. The uranium and thorium concentrations are reported as equivalent uranium (eU) and equivalent thorium (eTh) because the gamma-ray data measure daughter products of the radioactive decay series rather than the parent uranium and thorium. Both uranium and thorium have relatively continuous bands of higher concentrations (greater than about 2.5 ppm eU and 9.0 ppm eTh) within the area of the Western Piedmont. These bands do not exhibit any apparent correlation with potassium. The rocks within these bands are paragneisses and the uranium-thorium signature may reflect the presence of abundant monazite formed during the metamorphic process or inherited from the original rock.

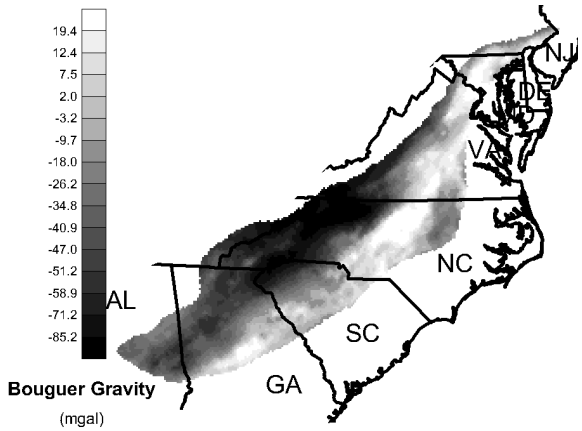

Figure 6. Bouguer gravity anomalies.

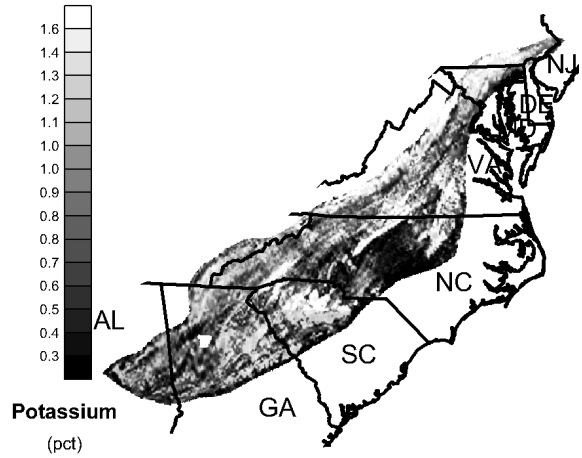

Figure 7. Potassium concentrations from aerial gamma-ray surveys of the NURE Program.

The potassium data do show an oval area of generally higher concentrations in northern South Carolina. Within this oval area the uranium and thorium data exhibit patterns that are similar to one another but distinct from the pattern of the potassium data. The geologic map shows abundant intrusive bodies of granite within the same area. The uranium and thorium patterns may be related to the granites but the regional potassium high suggests a regional enrichment of potassium.

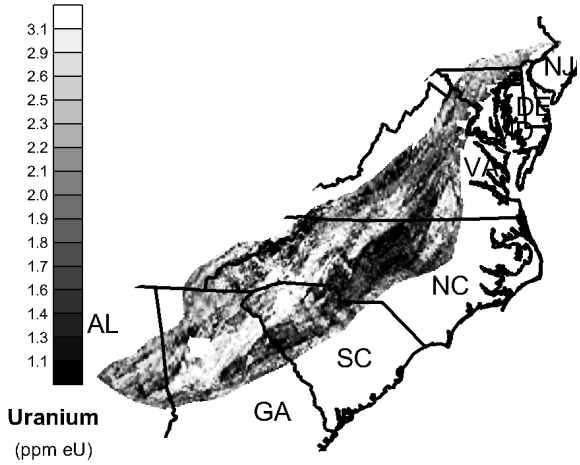

Figure 8. Uranium concentrations from aerial gamma-ray surveys of the NURE Program.

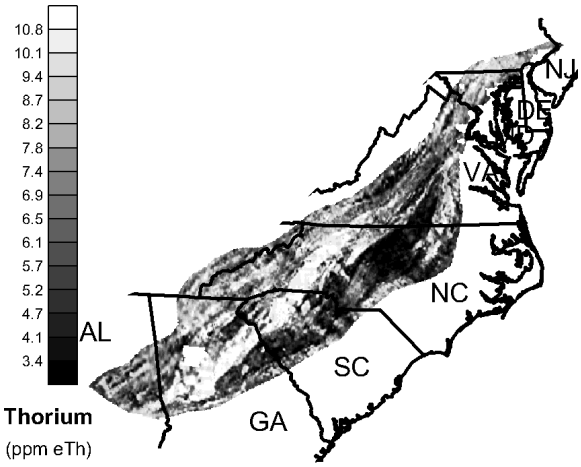

Figure 9. Thorium concentrations from aerial gamma-ray surveys of the NURE Program.

CONCLUSIONS

Extensive geophysical and geochemical data are available for the Appalachian region in a variety of digital formats. These data can be used, analyzed, and compared to an almost endless variety of other types of data. The geophysical data provide both direct and indirect indicators of the geology and geologic processes that have formed the rocks and soils present in the region. The geochemical data from stream-sediment samples reflect the chemical characteristics of the rocks and soils. Because the distribution of uranium from the geochemical uranium data (figure 3) show excellent agreement with the distribution of uranium from the aerial gamma-ray surveys supports, we conclude that the stream sediment samples have a dominant component derived from local rocks and soils. Together the geochemical and geophysical data represent valuable information that can significantly contribute to a variety of geological and environmental studies.

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Eastern Region Geography Activities

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The U.S. Geological Survey (USGS) fosters and promotes cooperation among Federal, State and local agencies, academia, and the private sector collect and produces geospatial data. Eastern Region Geography partnership activities cover the requirements of Federal agencies, regional consortia, 26 eastern states, and two territories (Puerto Rico and Virgin Islands). For more than 100 years the National Mapping Program has been partnered with the States and has contributed to producing geospatial products such as aerial photos, digital orthophoto quadrangles (DOQ), digital elevation models (DEM), digital line graphs (DLG) and the National Hydrography Dataset (NHD).

The USGS is working on projects at a variety of scales throughout the Eastern Region. North Carolina has projects that, include 1:12,000-scale color infra-red DOQs, Light Detection and Ranging (LIDAR) for Digital Flood Insurance Rate Maps (DFIRM), Photoinspection, and Graphic Revision; Kentucky is cooperatively producing statewide coverages for DOQs and DEMs, a revised hydrography data layer, and an NHD. A State Base map program in Tennessee is acquiring high-resolution statewide data coverages. The data themes being considered for production are imagery, DOQs, DEMs, and various planimetric layers. In Vermont a 1:24,000-scale NHD will be used to model flood frequency and to plan bridge replacements and road improvements. In Michigan, the completion of second- generation DOQs is underway for the preparation of a State digital base map. Additional projects are ongoing throughout the Eastern Region States to support 10-meter DEMs, Graphic Revision, statewide NHD, revised contours, and NAPP.

Through partnerships, the USGS is able to increase collection, application, and dissemination of data that benefit the public. The USGS is actively seeking for opportunities to build new alliances to decrease data redundancy and develop initiatives by working together within the States and the Regions. Such collaboration facilitates the acquisition of data needs to resolve earth science, social, and economic issues that have an effect on partnering agencies.

Digital Geologic Maps, Databases, and Isotopic Data of the Appalachian Region

Scott Southworth, John Aleinikoff, Tom Armstrong, Bill Burton, Pete Chirico, Avery Drake, Wright Horton, Mike Kunk, Chuck Naeser, Nancy Naeser, Nick Ratcliffe, and Jim Reddy

The Appalachian Regional Geology and Hydrology (ARGH) Project is completing geologic maps and databases that build on several decades of geologic mapping and field-based research. Funded by the National Cooperative Geologic Mapping Program, we have contributed to the publication of geologic maps of the States of MA, NH, NJ, and VA, while publishing quadrangle geologic maps of 1:250,000-, 1:100,000-, 1:50,000-, and 1:24,000-scale in VT, PA, NJ, MD, VA, D.C., WVA, NC, SC, TN, GA, and AL. Currently we are making a series of geologic maps of the Washington-Baltimore region, select National Parks, and Vermont.

Detailed geologic map coverage does not exist for much of the Appalachian region, yet regional investigations require the detailed data in a digital format. Our long-term goal is to provide the detailed geologic database of the Appalachian region by focusing on high-priority areas for maximum scientific and societal benefit. We will illustrate the importance of accuracy of our geologic map data and utility of our database of the National Capital Region by comparing them with existing regional-scale digital geologic maps of the Appalachian region such as the National Atlas, Tapestry, Lithology map.

We are now developing a new generation of digital geologic maps and databases in a geographic information systems (GIS) format for intergrated, multidisciplinary research. Field data collected at 1:24,000-scale or larger are published and released on the internet as digital files at 1:24,000- and 1:100,000-scale, with corresponding high-resolution DEM and aeromagnetic data. We are investigating historical topographic change in urban areas as well as researching innovative GIS applications of geologic, geophysical, and other data. Successful applications of the digital geologic data by others include 1) the cost benefit analysis of the Loudoun County, Va., landfill, 2) the production of new soil maps in the Blue Ridge and Piedmont of Virginia and Maryland, 3) land-use ordinances in Loudoun County, Va., based on karst in the Mesozoic Culpeper basin, 4) the statistical correlation of well water yield to bedrock units in the Blue Ridge province of northern Virginia, and 5) the identification of habitats favorable for endangered plant communities in park lands.

Our increased understanding of this bedrock framework supports a detailed investigation of the structural, thermal, and uplift history along several transects across the central Appalachians from the Atlantic Coastal Plain province west to the Appalachian Plateaus province. We are determining the U-Pb crystallization ages of zircons and other minerals in igneous rocks that could not be reliably dated by earlier methods using the high-resolution ion microprobe to better establish geochronology in complex settings of the Piedmont and Blue Ridge. We are also analyzing 40Ar/39Ar release spectra in mica and hornblende and fission tracks in apatite and zircon to determine the timing and conditions of Paleozoic metamorphism and cooling due to fault motion, uplift and erosion.

A Metapopulation Analysis for Black Bears in the Southern Appalachians

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Black bear (*Ursus americanus*) populations in the southern Appalachians are fragmented and may function as a metapopulation, with local extinctions and colonizations being dependent on habitat patch size and distribution. To determine whether such a relationship existed, we used an incidence function model developed by Hanski (1993) whereby, given bear presence/absence data and information on patch size and distribution, colonization and extinction rates for individual patches might be estimated. We acquired >10,000 black bear radiotelemetry locations from studies conducted in North Carolina, Tennessee, and Virginia and determined land-cover associations based on the Multi-Resolution Land-Cover database. Those land-cover types were used to delineate habitat patches at various spatial scales and resolutions (analysis units ranged from 5 km^2 to 300 km^2 in size). Occupancy of each patch was then determined based on adult female black bear distribution data obtained from state and federal biologists. We used non-linear regression to estimate 3 extinction and colonization parameters to predict species occurrence for a given habitat patch. The regression analyses produced significant models ($P < 0.001$, R^2=0.69–0.90) for all spatial scales. As patch area increased and isolation decreased, the probability of occupancy by bears increased. These results support the hypothesis that metapopulation theory is useful to explain the spatial distribution and source-sink dynamics of black bears in the southern Appalachians. Our study suggests that the isolation of habitat patches and, to a lesser extent, their size may warrant more consideration when making management decisions. To illustrate the applicability of the model, we compared prospective sites for black bear reintroduction in the southern Appalachians.

Land Use Change Adjacent to Protected Areas

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Resource managers of protected natural areas are becoming more concerned with human activity occurring on adjacent lands and within the context of the associated bio-geographic region. The source of a wide variety of threats to natural resources in protected areas and the aesthetics of the visitor experience is routinely attributed to human activities on adjacent lands. Threats to natural resources include habitat fragmentation; barriers to movement; interruptions of ecological continuums associated with elevational gradients; increased probability of introduced pests, pathogens and exotic species; introduction of pollution; baiting of wildlife; and increased public access to the perimeter of the protected area. Aesthetic threats include degradation of viewsheds due to development; light, noise haze pollution; and traffic congestion. As more people live adjacent to protected areas, potential hazards to humans include threats from wild fires, settlement in flash flood zones, and injury or infection from wildlife. This project relates directly to rapid development, or sprawl, a growing concern and immerging political issue. In the Appalachian Mountains, development pressure is most extreme on the fringes of metropolitan areas, in the vicinity of tourist areas, and adjacent to protected areas such as national forests and parks.

The objective of the research is to devise a methodology to characterize adjacent lands and the landscape setting of protected areas in the context of a thematic framework. This characterization will allow managers of protected areas to be better informed as to the dynamics of adjacent land use and policy, and existing and potential environmental and aesthetic impacts both inside and outside the protected area boundary. The intent is to empower resource managers through information, to be proactive in influencing public policy outside their protected area boundaries.

Themes of the interdisciplinary framework include ecosystem descriptors, land use/land cover, water resources, human dimensions, environmental conditions, and resource stewardship. The importance of public policy analysis concerning resource stewardship immerged during the course of the study. The scope of the study is to primarily utilize readily available national databases so that the methodology can be replicated. The exception is the resources stewardship theme reflecting state and local policies and programs. The intent is to focus on a general characterization of trends that may suggest current and emerging issues of concern. A limitation of the study is that the characterization is too general to infer impact analysis for biological communities let alone individual species. Incite gained from the analysis, however will provide guidance for designing a more specific study on a particular issue of concern.

Several indicators have been identified for each of the following subthemes.

- Ecosystem Theme
  - Geographic provinces
  - Bailey's ecoregions
  - Topography
- Land cover/use Theme
  - Land cover types
  - Habitat fragmentation
  - Agriculture
  - Recreational setting
  - Selected habitats
- Water Resources Theme
  - Rivers and streams
  - Wetlands
  - Riparian zones/habitat

Lakes/impoundments
Human Dimension Theme
Population dynamics
Social conditions
Social order
Economic dependencies
Human Imprint
Resource utilization
Point source pollution
Non-point source pollution
Water quality
Exotic pests, pathogens and invasive species
Vehicular traffic
Resource Stewardship Theme
Water resource policies
Terrestrial resource policies

As a case study, the proposed framework is being applied to the lands surrounding Great Smoky Mountains National Park, the Nation's most visited national park. This is an appropriate test case since several issues related to adjacent lands occur in the area. Concerns range from regional haze obscuring views of the mountains to air pollution impacting the health of vascular plants, local residents and park visitors. Traffic congestion and road construction to alleviate the problem are very controversial. Viewsheds extending outside the park boundaries are compromised by new development. Noise pollution from tourist helicopters has increased. Light pollution from increased development has further intruded on the dark sky sanctuary in the park. Major road construction projects have been delayed in two gateway communities due to controversy. As more development occurs on adjacent land, human conflicts with wildlife have increased. Human-bear interaction is the most serious concern.

The rivers flowing out of the national park provide graphic indicators of land use change. Water quality of three of the four rivers after leaving the western slope of the park does not meet the state standards for their designated use. The elevational gradient and stream order continuums are highly disrupted in terms of water quality and aquatic and riparian habitats. Fecal coliform, runoff from impervious surfaces, and sedimentation are the major sources of pollution. Use of water from these rivers for urban and industrial purposes is another issue.

The geographic focal point of concern is a 24-mile long tourist corridor that has spurred very rapid economic development and population growth. The southern terminus of this north-south corridor is the gateway community of Gatlinburg, TN. Three of the four other four gateway communities to the park provide a stark contrast where much less change has occurred. The contrast among the human dimensions indicators at the county level is particularly dramatic.

The most difficult, yet revealing part of the case study has been the policy analysis of land use and waterquality. Though there are a considerable number of progressive policies in place at the community level, their geographic limitations and lack of uniformity of compliance prove to be significant constraints to effective management of adjacent lands.

The black bear is utilized as an exemplar species to demonstrate the interdisciplinary nature of the impacts from rapid change in adjacent land use. The complexity and interdisciplinary nature of adjacent lands dynamics is reflected in the issues related to black bears. The interaction of the following influential factors on black bear behavior illustrates the complexity: their ecology and population dynamics; their utilization of adjacent lands, particularly during times of scarce natural food sources; their interaction with humans; and the policies to manage them at the federal, state and community levels.

Managing Regional Information: Lessons from Chesapeake Bay

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In any scientific study involving numerous investigators, information is both the raw material of the scientific process and it is the ultimate product. The effective management and sharing of a diverse information base, such as that which will be input into and generated by the multi-disciplinary Appalachian regional study, requires a customized and adaptable framework of information systems and software tools. Information managers must understand and tailor solutions for the specific requirements of the particular users they serve, avoiding the temptation to address user needs, which are too broad or too diverse. Plans for the management of data and information must, from the outset, be made an integral part of the total science plan for any study entailing substantial and distributed information-management activities. Information-management experiences in the Chesapeake Bay Program (a program related to the Appalachian region by geography and shared scientific concerns) offer lessons applicable to Appalachian science.

SESSION IV

Using Geology to Understand Flora, Fauna, and the Evolution of the Great Smoky Mountain Region
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Geology shapes the range of topography, watersheds, and soils that host the plant and animal communities as a function of climate, elevation, and the composition and chemistry of underlying materials. We are making a digital surficial and bedrock geologic map and database in a geographic information systems (GIS) format for interdisciplinary research in cooperation with the Biological Resources Discipline of USGS, National Park Service (NPS), Natural Resource Conservation Service, and The Nature Conservancy. We are integrating our geologic research with the All Taxonomy Biodiversity Inventory (ATBI) while supporting the Inventory and Monitoring, Resource Management, and Interpretation Programs of the NPS.

Our regional database is based on 1:24,000-scale field data from Knoxville, Tenn., southeast to Waynesville, N.C., that is being integrated with digital elevation model data to interpret the complex relationship between parent material, regolith, soils, flora, and fauna. In this area, regolith far exceeds the area of exposed bedrock and most of it has been transported and deposited by water (alluvium) and gravity (colluvium and debris flows). Much of this surficial material was not derived from the immediate underlying bedrock and slope deposits differ as a function of parent bedrock. Specific bedrock and surficial materials develop specific soils, flora, and fauna; examples include mollusks on limestone, purple spurge on gneiss regolith, cardamine, yellowood, and bunchflower on meta-sandstone boulder fields, and rare plant communities on mafic, ultramafic, and sulfidic rocks. Therefore we are mapping the diverse types of rock and surface materials, to provide a useful tool to help describe and understand the distribution of plants and animals. Classifying the bedrock and surficial materials by mineral abundance and general chemical composition defines “lithogeochemical” units that also help portray different soil types and differing acid neutralization capacity of streams (a measure of their sensitivity to acidification).

Research plans will determine the topographic signatures of surficial material types throughout the study area. Topographic signatures of slope, aspect, and curvature values will be quantitatively derived from the digital elevation model (DEM) data in a GIS analysis. Quantifying topographic parameters of surficial units will aid in understanding the relationship of surficial geologic materials to soil formation and flora and fauna diversity. The methodology developed may be applied to study areas throughout the Appalachian region for analyzing spatial correlation of surfical geologic materials and topography.

Our geologic research includes 1) the distribution and characterization of sulfidic slate recognized throughout the Great Smoky Group, 2) the inventory and setting of prehistoric and historic debris flows at high elevations on steep slopes underlain by slate and the subsequent affect of acid drainage, 3) the age and genesis of slope deposits, 4) characterization of karst in structural windows, 5) the tectonic evolution of the polymetamorphic rocks of the western Blue Ridge province, and 6) the crustal framework of the East Tennessee Seismic Zone, uplift history, and rates of erosion.

Existing mica, hornblende, and slate whole-rock 40Ar/39Ar analysis suggest that the rocks of the highlands of the Great Smoky Mountains and foothills to the northwest were metamorphosed in the Ordovician and Devonian and then transported west along the Great Smoky fault in post-Mississippian time. Fission-track analysis of detrital apatite and zircon in these rocks is helping define the Permian to Cenozoic thermal and structural history. Zircon fission-track data suggest that the rocks of the highlands and similar metasedimentary rocks of the foothills were at different crustal levels prior to Alleghanian thrust faulting. Emplacement of the Great Smoky thrust sheet was early Permian, and contractional faults that cut the sheet were active after the Cretaceous. Cosmogenic 10Be in quartz from stream sediment and

ridge outcrops, historical sediment yield data, and denudation rates calculated from fission tracks indicate similar rates of erosion, about 16 to 30 m/m.y., over both time and space. The similar spatial and temporal erosion rates over the last 150 million years suggests that there has been no rapid recent uplift and incision and suggests landscape equilibrium with rock type and setting.

A Model to Predict the Occurrence of Surviving Butternut Trees in the Southern Blue Ridge Mountains

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Butternut (*Juglans cinerea*) is a hardwood species native to eastern North America and is valued for high-quality lumber and as a mast source for wildlife. Many butternut populations are currently being devastated by an exotic fungus (*Sirococcus clavigignenti-juglandacearum*), which causes multiple cankers that girdle the tree and cause mortality. The decimation of butternut populations has been severe in many areas, particularly in the southeastern United States. A breeding program involving resistant genotypes might be a feasible strategy to conserve and eventually reintroduce the species. However, such an effort is critically dependent on the ability to locate enough disease-resistant stock for evaluation and subsequent breeding. We developed a data-based model to predict probable occurrence of surviving butternut trees. Field surveyors initially mapped 134 sites with surviving butternut trees in Great Smoky Mountains National Park (GSMNP). These locations were entered into a geographic information system (GIS) and overlayed with digital map layers of eleven different geographic variables that described the topographical and biological conditions at each sampling point. We then calculated the Mahalanobis distance statistic, a multivariate measure of dissimilarity, for each 92.9- × 92.9-m pixel in a 31,235-km^2 region encompassing the southern Blue Ridge Mountains to predict the relative likelihood of species presence. We then tested this model with independent presence/absence data from 130 test sites in this region as the dependent variable and Mahalanobis distance as the independent variable. We found that the Mahalanobis distance statistic showed a significant relationship with occurrence of butternut in the region. Although the field tests indicated that the species often was absent in areas predicted to be good butternut habitat, butternut decline due to the canker also may have contributed to that outcome. Biometric models such as the one we developed can be used by resource managers for collection purposes, restoration efforts, and to identify habitat associations across large areas.

Appalachia – An Endemic Area For La Crosse Encephalitis?

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For centuries, people have been intuitively aware of the relationships between human health and the environment. Today, geographic information systems, remote sensing satellites and other technologies are providing scientists with the tools and the data to make clear the geographic relationships between the habitats of disease agents, their vectors and vertebrate hosts, and the occurrence of disease in the human population. Although the utility of the foregoing tools as an aid to epidemiology was pointed out nearly 30 years ago, the medical community has been slow to put them to use. That may soon change as geographers, entomologists, epidemiologists, and spatial statisticians jointly focus their expertise on specific health issues.

A program of joint research is underway with scientists at the U.S. Geological Survey, the Centers for Disease Control and Prevention, and state health agencies, to examine the environmental influences on vector-borne diseases (such as Lyme disease, plague, and viral encephalitis). Specifically we are utilizing geographic information systems, remote sensing, and spatial analysis tools to:

- Define geographic distributions of disease cases and relationships to environmental factors.
- Develop and test a model predicting disease activity and transmission rates.
- Characterize the human population at risk.
- Devise ecology-based prevention and control measures.

In this presentation, we use the La Crosse encephalitis virus-vector-host system to demonstrate the current and potential uses of geographic information science and related technologies for the surveillance, prevention, and control of disease. Cases of La Crosse encephalitis recently have been concentrated within the Appalachian region of the United States, particularly in southern Ohio, West Virginia, Tennessee, and North Carolina. Are there particular ecological or socio-economic factors that cause children in Appalachia to be at greater risk for La Crosse encephalitis than in other parts of the country?

USGS, CDC, the West Virginia Department of Health, and Virginia Tech University scientists are engaged in a comprehensive study of the ecology and epidemiology of La Crosse encephalitis in West Virginia. Components of the study include case finding, serologic surveys, vector and vertebrate ecology, and public education. Precisely located (by GPS) mosquito sampling sites and human case residences provide “ground truth” data for calibration of remotely sensed data.

Our studies to date have shown that the landscapes surrounding case locations of the disease are dominated by a mixture of deciduous forest and pasture land. However, this fourteen-class categorization of land cover appears to be insufficient to discriminate positive and negative ovitrap sites placed throughout the study area. Additional geospatial data sets are being incorporated into the analysis to increase the discrimination power. Also socio-economic data are being analyzed to determine their utility as predictors of disease risk.

Geologic Aspects of Karst in the Appalachians

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Solution of relatively soluble rocks, such as limestone, dolomite, and gypsum, produces a terrain termed *karst* that is characterized by a variety of features, including caves, springs, sinking streams, and sinkholes. Ground-water movement may be very rapid through enlarged conduits, making shallow aquifers in karst extremely vulnerable to contamination from both point and non-point sources. Residual soil, which may plug sinkholes, can collapse and cause considerable destruction to homes, buildings, roads, railroads, impoundments, etc. Many millions of dollars in damage annually occurs in the U.S. from such collapse. Thus, understanding geologic controls on karst development is of national significance. This understanding can be accomplished by preparing maps that outline karst areas, by researching the processes that localize karst development, and by presenting this information in a manner useful for hazard mitigation.

A new project entitled Karst and Subsidence Hazards has been proposed to the National Cooperative Geologic Mapping Program. The main goal of this karst project is to produce geologic maps at a variety of scales, ranging from 1:24,000 to 1:7,500,000 that will form the foundation for developing new techniques and methods to better understand geologic controls on karst systems. Derivative maps and research papers will characterize the relationship of geologic structure and stratigraphy to karst development. A variety of tasks will be addressed: (1) ground-water contamination, (2) sinkhole formation, (3) development of new techniques for analyzing karst through remote sensing and geophysics, (4) identifying regional karst issues by producing a karst map of the Appalachians, and (5) addressing national issues through development of a new National Atlas karst map. New techniques will be used to address karst-subsidence hazards and ground-water contamination issues at local, regional, and national levels. These data will be presented to aid researchers and land-use managers in hazard mitigation and environmental protection.

One specific task involves detailed geologic mapping in the northern Shenandoah Valley of Virginia and West Virginia in the area of a major karst aquifer. A hydrogeologic framework will be determined through analysis of conduits and fractures and their relationship to springs, sinkholes, caves, and losing streams determined through a karst inventory. The geologic information will then be compared with water data to assess geologic controls on ground-water movement, storage, and quality. For example, water quality and quantity data can be correlated to stratigraphy and lithologies in order to investigate any relationships between hydrology and geology. A karst inventory will be produced by several methods of remote sensing that will include maps of sinkholes and surface basins that drain to sinkholes. This karst inventory will be compiled on geologic maps to evaluate geologic controls on karst development such as comparison to structures and stratigraphy.

Karstic rocks underlie about one-quarter of the land area of the U.S. In order to educate government managers and the public to the distribution of karst at the national and regional scales, a digital map of karst will be produced for the National Atlas at a scale of 1:7,500,000. Federal agencies (National Park Service, Bureau of Land Management, National Forest Service) have expressed an interest in combining a national karst map with one showing Federal lands. This map will be useful in determining which Federal facilities may have karst resources within their borders, especially those facilities that are unaware of it.

A detailed map of the Appalachian highlands will be the beginning of the national map. The effects of stratigraphic and structural control on karst development in this classic fold-fault belt of highly fractured rock will be researched and areas of importance delineated for further biologic, hydrologic, and geologic research. Karst features that may be included on the map are: exposed soluble rocks, including limestone, dolomite, and evaporites; intrastratal karst; karstic rocks beneath surficial overburden; percentage area covered by karst; and features analogous to karst, so-called “pseudokarst”.

Flood of July 2001 in West Virginia

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ABSTRACT

Rainfall of 3 to 6 inches during 5 to 6 hours in localized mountainous areas of Southern West Virginia on July 8, 2001 caused extensive flood damage. The U.S. Geological Survey (USGS) was active in assessing the magnitude and frequency of the flood at streamflow gaging stations and in several communities damaged by the flood. The intense rainfall caused debris flows and landslides in some areas which USGS researchers examined by overflights. Speculation that mountaintop-removal coal mining may have increased runoff rates has led to a USGS study comparing peak discharge from mined and unmined drainage basins. Studies are needed to evaluate flood reduction benefits and environmental costs of channel dredging projects. Reliability of surface water supplies susceptible to contamination from floodwaters and sediment transport during floods are areas of possible future USGS investigation.

INTRODUCTION

In the early morning hours of Sunday July 8, 2001, severe flooding and landslides caused by intense rainfall occurred in the Tug Fork and Guyandotte River Basins of Southern West Virginia. The flood caused two deaths and extensive property damage. The rain was the result of isolated thunderstorms that repeatedly formed and moved along near-identical tracks. Orographic lifting resulted in greatest rainfall intensity in the highest mountain elevations which form the headwaters of the drainage basins. Rainfall totals, as reported by the National Weather Service, were as great as 3 to 6 inches during a 5 to 6 hour period. Flooding was most severe in the small 1st and 2nd order streams. Stream levels rose rapidly allowing very little time for warnings. Rescuers used boats to save several people from floating mobile homes, and many people spent hours waiting on tops of roofs for rescue.

The counties most affected by the July 8, 2001 flooding were Boone, Fayette, McDowell, Mercer, Raleigh and Wyoming. Since the mid 1960's, each of these counties has been declared a Federal disaster area from 7 to 11 times because of flood damage. Most homes and business structures are built along stream valleys simply because that is where the only flat ground is located. Over 1,000 homes and about 700 other structures were destroyed. In addition, many roads were closed either because of floodwaters or mudslides. Several bridges were washed out.

USGS FLOOD RESPONSE

The U.S. Geological Survey (USGS) played an active role in obtaining information for flood mitigation and recovery and in developing studies on causes and consequences of the flood. This paper describes these USGS activities following the July 8, 2001 flood event in relation to ongoing data programs, Federal agency assistance, and interpretive studies.

Streamflow Gaging

The USGS streamflow gaging program is an integral part of every Water Resources Discipline office. The network in West Virginia consists of about 110 gaging stations with 91 of these transmitting data once every 4 hours via satellite which is then served over the Internet (http://water.usgs.gov/nwis). Flood plans are updated each year to determine discharge measurements necessary to define and maintain the stage-discharge ratings. Review of the

Internet data on Sunday afternoon showed that new record flows had occurred at some gaging stations in Southern West Virginia. The flood plan was activated. Immediate response was not possible on Sunday because roads in the flood area were closed due to high water and mudslides. Field technicians were advised to be prepared for overnight travel for the upcomming week and a Project Alert description of the flood situation was transmitted to USGS Headquarters.

Review of the Internet data early Monday morning revealed that the July 8 flood event had receded in the headwaters area of the Tug and the Guyandotte Basins (fig. 1) and that the flood wave was dissipating as it progressed downstream. Streamflow measurement teams were dispatched to gaging stations downstream of the hardest hit flood areas to obtain direct current meter measurements as the flood peak passed. Peak flow as measured at the Tug Fork at Williamson, downstream of the flood damage area, on Monday morning was at less than a 5 year recurrence interval.

No small drainage area gaging stations in the flood area were equipped with telemetry. Field crews were dispatched to inactive gage stations and non-DCP stations such as crest-stage gages to obtain high-water marks to define the areal extent of the flood. Inactive gage stations are seldom visited except at such flood times and it was found that reference marks for levels were no longer available at some stations. Field inspections of peak gage height were made at 21 active and discontinued streamflow gaging stations. High water marks were not apparent at some gaging stations and it was considered that the flood recurrence interval was less than 2-years in such cases. High-water marks obtained at each gaging station were related to the last available stage-discharge rating to determine an estimate of peak discharge.

At gaging stations for which the July 8, 2001 was significantly higher than the previous rating definition, either a conveyance-slope rating extension or indirect discharge measurement was performed. Flagging of high-water marks was a high priority because clearing of debris from the channels was initiated immediately as floodwaters receded. Information on channel sections to be flagged in the event of a flood are maintained as part of the station gage folders to aid personnel inexperienced in indirect measurement techniques. Indirect discharge measurements were run as described in U.S. Geological Survey Techniques of Water-Resources Investigations book 3, chapter A1 "General field and office procedures for indirect discharge measurements." Flood recurrence intervals were determined from station frequencies or regional equations as reported in U.S. Geological Survey Water-Resources Investigations Report 00-4080 "Estimating magnitude and frequency of peak discharges for rural, unregulated, streams in West Virginia." Results of the indirect discharge measurements showed that the flood exceeded the 100-year recurrence interval on the Guyandotte River at Baileysville (drainage area 306 mi^2), and approached the 100-year recurrence interval on the Tug Fork at Welch (174 mi^2).

FEMA Assistance

After an extreme rainfall event producing significant flooding, it is imperative that the Federal Emergency Management Agency (FEMA) quickly obtains data that describes the areal extent and severity of the event to aid in planning for response, recovery, and mitigation efforts. The type of assistance that FEMA can offer to flood victims is often dependent on the recurrence interval of the flood that caused their damage. For example, if the flood was of a high recurrence interval and not likely to reoccur often then clean-up and repair assistance may be all that is warranted, but if the recurrence interval was low and future flooding is likely then other mitigation options such as relocation are considered.

FEMA issued a Mission Assignment to the USGS on July 13, 2001 to collect data for accurate documentation of the magnitude of the flood disaster. A Statement of Work was developed that outlined initial tasks needed by

FEMA for rapid response by the USGS. General guidance in the Statement of Work directed that High Water Marks (HWMs) be obtained along streams and rivers that caused flood damages to buildings and infrastructure, and/or experienced record or near record flooding.

A preliminary assessment July 13, 2001 of communities that reported flood damage was conducted by interview with the West Virginia Office of Emergency Services. Field crews were assigned to survey HWMs on streams and rivers in 8 communities. As the extent of flooding became better defined, in consultation with the local FEMA contact, an additional 12 communities were added to the list of those for which documentation of HWMs were needed. High-water marks were surveyed in several communities along streams for which FEMA Flood Insurance Studies were available. By using Flood Insurance Rate Maps, the high-water mark locations were determined in relation to flood profiles in the flood studies. These flood profiles show the theoretical water elevations of the 10, 50, 100, and 500 year flood events. The surveyed high-water marks were plotted on the flood profiles and the recurrence interval of the July 8, 2001 flood was estimated for each surveyed location along channel.

Landslide Evaluation

Major highways were closed for several days because of washouts and mudslides. More than 200 Amtrack passengers were stranded in Charleston because mudslides closed 50 miles of railroad track. CSX Transportation identified 48 locations with either washouts or rock slides.

In response to reports of extensive landslide damage, the Office of Surface Mining and Reclamation in Charleston took USGS scientists and a geomorphologist from the West Virginia Geological and Economic Survey on an aerial tour of the flood area to observe landslide and debris flows activity. Although the tour was limited in areal extent, evidence of landslides and other debris flows were seen in natural areas, along the benches of old contour mines, and on valley fills of active mountaintop removal coal mines. USGS Geologic Discipline landslide researchers were contacted and a second overflight was organized for these experts. A study of landslide potential in parts of West Virginia is under consideration.

The USGS Center for Integration of Natural Disaster Information was contacted to help in obtaining remote sensing imagery of the flood area. Because repair of landslides, especially along roadways, railways, and on active mine sites is begun in earnest shortly after the flood recedes, it is imperative that imagery be captured soon after the flood event.

Only a very sparse network of official National Weather Service raingages was available to provide rainfall rate and volume data to aid in evaluation of flooding and landslides. Radar estimates of storm intensity and totals are available but data accuracy is unknown. Rainfall gages are operated as part of the West Virginia Integrated Flood Warning System and some are even operated at USGS streamflow gaging stations, but gage calibration is not routinely checked. Often, rainfall gages are operated at streamflow gages just as rough indicators of rainfall intensity even though forest canopy or other obstructions may affect the data quality.

Study of Mountaintop-Removal Coal Mining Impacts

At one coal mine, mud and rock from a valley fill slid into a pond and displaced the water into an already-flooded stream. Over about five minutes Sunday afternoon, a “wall of water” swept down Bulgar Hollow in Raleigh County causing extensive property damage (Charleston Gazette, July 10, 2001). No other instances of pond failures were known to have occurred during this flood event, but much speculation was presented in the press that mountaintop-removal coal mining and related timbering may have increased runoff rates. Governor Bob Wise

publicly stated that officials need to study whether environmental factors such as mountaintop mining methods or timbering contributed to the flooding.

The USGS, in cooperation with the Office of Surface Mining and Reclamation, has begun a project to compare peak streamflows from mountaintop-removal coal mine areas with flows from unmined areas. Peak flood discharge of six small stream basins in the southern coal fields flood area will be obtained by indirect methods. The stream basins selected are in close proximity to minimize the variability in rainfall rate and volume that may have occurred over the study area. Three of the small basins are undisturbed by coal mining and three contain reclaimed mountaintop-removal coal mines.

Channel Clearing and Dredging

The floodwaters carried massive amounts of debris into the stream channels which blocked many bridges. These debris consisted of a wide variety of materials such as cars, tires, brush, trees, and the remains of many homes and their contents. Recovery efforts focused on bridge and channel clearing both to salvage personal property and to reopen waterways in the event of further flooding. Public perception generally is that additional dredging of natural channels will eliminate potential of future floods. Demands for channel dredging projects have been a common theme in the press and at public meetings both from private citizens and community officials.

Channel dredging, however, may have little impact on reducing flood peaks for major floods and may actually result in greater flood damage because of increased flow velocity. The West Virginia Department of Natural Resources (WVDNR) recently issued a report which is critical of the extensive amount of channel disturbance from these channel dredging projects because of damage to aquatic habitat. In addition, subsequent to the July 8 flood the WVDNR along with the West Virginia Department of Environmental Protection and the West Virginia Soil Conservation Agency developed a pamphlet titled “Stream Restoration After Flooding” which cautions that dredging is seldom the answer to prevent future flooding. A study to evaluate the degree to which flood levels might be reduced by typical channel dredging projects would be useful to regulators in assessment of potential flood-protection benefits versus environmental damage of proposed dredging projects.

Sedimentation

No fluvial sediment sampling was conducted by USGS in connection with the July 8 flood because of restricted access to the flood area and because of the rapid stream elevation rise and recession. Photographs of the floodwaters taken by residents during the flood all showed that the streams were all heavily laden with sediment. Inside of a USGS wire-weight gage box which had been overtopped during the flood a layer of coarse sand was found. This showed that turbulence was so great that even very coarse material was carried throughout the water column. Fine organic sediments were deposited at the edges of flow and inside structures where water movement was slack. According to one flood recovery worker, “It’s the black mud people say they can’t stand. It smells like rotting fish. It’s on everything they own, and it won’t wash off” (Charleston Gazette, July 11, 2001).

Water Supply Reliability

Several sewage treatment plants were overwhelmed during the flood and many septic tanks were actually washed into streams as banks were cut by the floodwaters. Water treatment facilities in some areas were unable to use surface water as a source of supply for weeks after the flood because of extreme sediment and bacteria content. The State Department of Health issued boil-water orders for those water systems able to continue in operation. Reliability of surface water for public supply during times of drought or because of contamination is an area of possible future USGS investigation.

SUMMARY

Floods are among West Virginia's most frequent and costly natural hazard in terms of human hardship and economic loss. Two people died in the July 8, 2001 flood in Southern West Virginia, over 1,000 homes were destroyed, many roads and railways were closed by floodwaters or mudslides, and several bridges were washed out. The U.S. Geological Survey helped in recovery efforts by providing information on flood magnitudes and recurrence intervals which was needed for determining the type of Federal flood assistance to make available for flood victims. Flood data were obtained from current and inactive gaging stations, and by surveying high-water marks in flood affected communities. Efforts were made to initiate USGS studies on landslide potential and on possible flood impacts of coal- mining practices. Some possible future investigations related to flooding include evaluation of channel dredging benefits, sediment transport, and surface water supply reliability.