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REGIONAL MANAGEMENT OF THE ENERGY-ENVIRONMENT INTERFACE: TECHNIQUES APPLIED TO COLORADO OIL SHALE DEVELOPMENT*

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ABSTRACT

Northwest Colorado is a resource-rich region endowed with massive deposits of oil shale supplementing a rich mix of other energy, mineral, agricultural, recreational, and aesthetic resources. Variations in national interest concerning synthetic fuels subject the region to drastic changes in economic activity and environmental impact. Booms and busts occur as energy companies and the federal government make incremental changes in strategy. The ability of such a region to anticipate and help shape its future depends upon capacity to measure projected economic activity and calculate potential social and environmental impacts. Environmental impact assessment tools are not sufficient when change is so wide-spread and pervasive. A Colorado Resource Information System has been developed as an integrated tabular and spatial system capable of tracking multi-source growth and calculating potential associated impacts. The organization and scope of this management system is described and its potential for assisting the region evaluated.

RESOURCE-RICH REGIONS: COPING WITH THE VORTEX OF CHANGE

Environmental impact assessment (EIA) can be considered a management technique which typically focuses on a specific project, with the intent of identifying a broad range of consequences, the distribution of benefits and costs

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of impacts, alternatives, public responses, and potential conflicts [1-3]. In all of this, the focus is narrowed to a specific trigger action which is the project itself.

A smaller number of environmental impact assessments are programmatic, with broader focus on programs which usually protend multi-project impacts on a broader regional basis. But these also are triggered by a specific potential decision, usually at the federal government level. The intent of the programmatic impact assessment is similar to the project-specific EIA, but much less specific on project related impacts. Both of these types of EIA's can be termed top-down impetus for impact assessment.

There is another dimension to EIA which comes from abandoning the significant federal action trigger to impact assessments. Subnational regions (be they blocks of states, individual states, or groups of counties within or cutting across state boundaries) have an interest in assessing the sources of potential future regional development and the associated consequences or impacts [4-6]. This is especially true for resource-rich regions (defined broadly to include not only natural resources, but also environmental quality, aesthetic beauty, and recreational as well as human settlement potential). For these areas it is not sufficient to be reactive to top-down stimuli from major project development proposals. Defense of regional integrity requires a proactive capability to anticipate future sources of development on a comprehensive regional basis and to identify likely impacts [7-9]. This is what can be termed the bottom-up approach to EIA.

This type of impact assessment is the greater challenge to achieve because analytic resources are scarce at the regional level. Also, traditional political and administrative patterns are designed for simpler days, reactive postures, and the individual political entities comprising a region [10, 11]. But the broader region itself, which is defined by the common resources rather than a joint political and administrative structure, usually lacks the capacity to focus on EIA. Finally, comprehensive, region-wide projections of future development are methodologically and quantitatively difficult.

While challenging, the potential for such bottom-up initiative at anticipating and controlling regional development futures is immense. Freed from the reactive mode of waiting to respond to initiatives from above or outside, the region can think creatively about alternative futures and their implications for altering the current socioeconomic and environmental conditions, goals, and regional resources [12, 13]. Such projective planning is not to be mistaken for a prediction of the future which cannot be made; but regional scenarios of growth and change can broaden and deepen analytical techniques and public participation in goal articulation. Since it is impossible to make such projections and impact identifications (even on a tentative basis) without a broad base of participation, such an effort serves as a focus for government/industry/citizen group dialogue and cooperation. Perhaps most important, as responsibility for EIA activity shifts from the federal level to states, counties, and municipalities,

experience in broader regional assessment can be created to help defend regional interests as the patterns of development are planned and implemented.

There are advantages also to the individual political entities within the resource-rich region. Particular projects can be put in perspective against a richer understanding of the region, its organization, goals, and potential patterns of development. While the comprehensive region-wide EIA can be initiated separate from the project-specific focused investigations required of a single project, there is a synergism between the two types of assessment.

Northwest Colorado is in the midst of rapid change defined by multi-resource development [14]. Numerous individual projects aimed at developing the rich array of resources present in the region coalesce to thrust upon a sparsely settled rural area explosive change. External forces dictate abrupt changes in direction of development efforts by both the federal government (the major land and resource owner in the region) and private companies. What are often incremental mid-course corrections for national entities whiplash into potentially catastrophic booms and busts for Northwest Colorado. The lessons learned by this region from such rapid change and the mechanisms created to cope with such forces offer a valuable perspective into tools potentially useful for other regions faced with similar conditions of abrupt and rapid change.

NORTHWEST COLORADO IN THE NATIONAL CONTEXT

Starting in early 1979 a wave of worldwide and national interest in synthetic fuels development focused attention on those few unique regions with potential for large-scale production [15-17]. One such region is the Piceance Creek Basin in Northwest Colorado, shown in Figure 1, where 64 percent of the nation's rich oil shale reserves are located [18-21]. Such resource abundance is comingled with significant amounts of coal, oil, gas, and uranium as well as selected wildlife of national and regional significance. To compound the abundance and the problems of resource development, scenic beauty and clean air and water are part of the region's resource base, some of such national significance as monuments, parks, wilderness areas, forests, and public lands.

Increasing world prices for petroleum and projected shortages of supply in future years came together in 1979 to place immense pressure on Northwest Colorado. Various projections by federal and state agencies, as well as private study groups, indicated that there could be substantial oil shale development activity in Northwest Colorado in the near future [22, 23]. This must be recognized as only the latest projected boom for oil shale, a resource recognized for its potential and feared for its economic, environmental, and technological complexity over the last sixty years [24, 25]. Colorado had been through numerous other speculative predictions of boom and reacted suspiciously at first to this latest tempest.

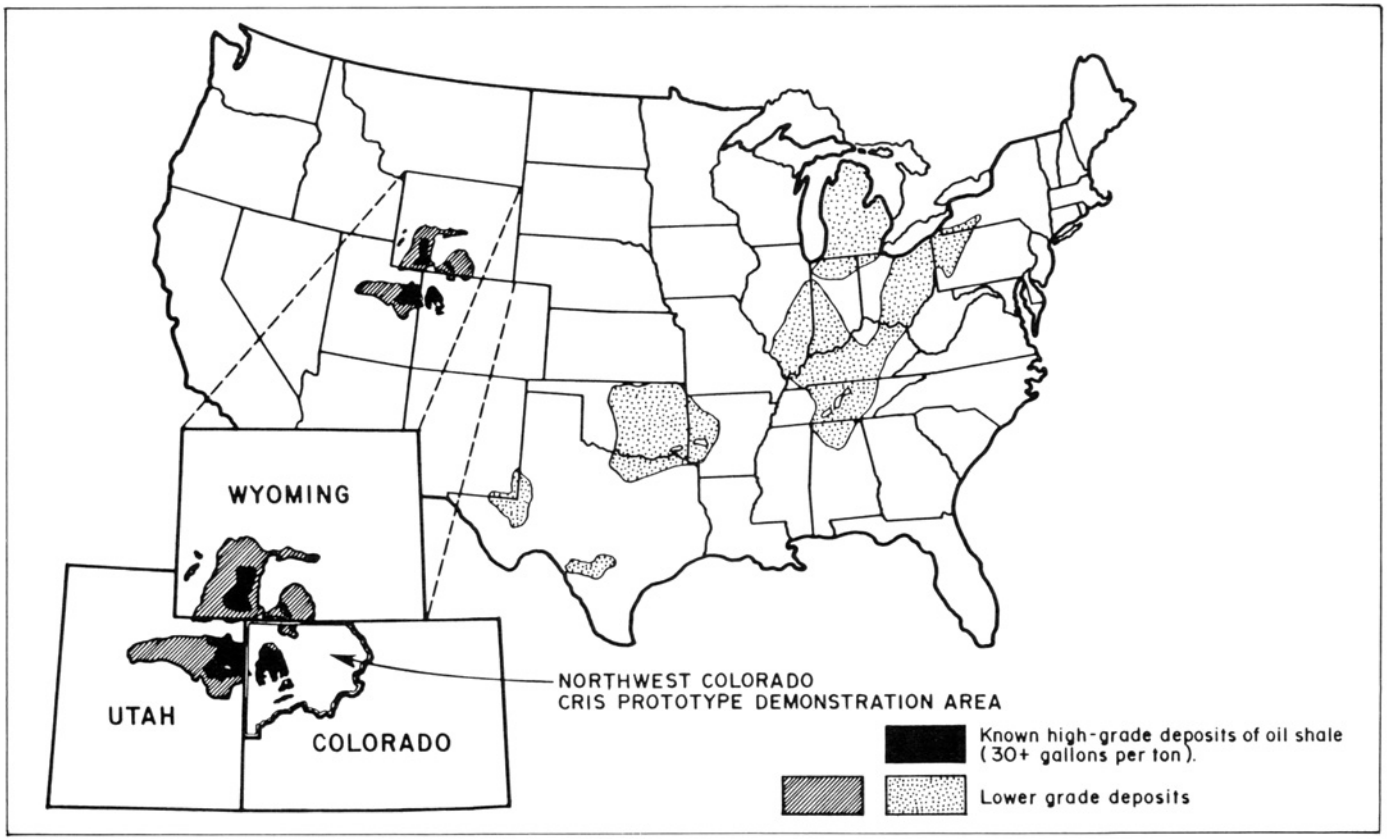

Figure 1. U.S. Oil Shale Deposits **Source:** Colorado Department of Natural Resources

But announcements of development interest and project starts accompanied this latest boom. By late 1981 major development efforts were underway on four projects, two on federal lease tracts and two on private land with partial subsidies from the Federal Government. Each was a multi-billion dollar undertaking which threatened to bring thousands of workers and dependants into the area. This presented Colorado with at least the first wave of what was anticipated as a regional boom beyond anything previously experienced in the region or the state [26].

The magnitude, uncertainty, and volatility of the potential development facing Northwest Colorado can be seen in Table 1. Not only do the projected levels of daily production of crude oil from shale in 1990 rise abruptly by latter 1979, but the sites and asociated developers expand similarly. Wildly divergent projections bombarded Colorado from all directions. By the month potential site developers changed plans, often in anticipation of federal funding from the Synthetic Fuels Corporation.

Northwest Colorado is a sparsely populated rural area dependent on a mix of agricultural services, tourism, and, in recent years, increasing energy activity (from development of oil, gas, coal, and in a small and preliminary manner oil shale) to form its economic base. Speculation about and anticipation of oil shale development has been a constant companion in this region of Colorado for nearly fifty years. But by early 1980 many indices pointed to the fulfillment of this potential role of oil shale as a synthetic fuel, with commercial scale production of oil from shale apparently finally at hand [27, 28]. There was no uniformity of concensus that oil shale's time had arrived; some observers focused on the substantial financial, technological, and environmental risks which still exist as barriers to a viable private sector development of this energy resource. In fact, the risks to private enterprise appear so great that many people consider oil shale and other synthetic fuels as still and perhaps never feasible for commercial scale development [29-34].

A position which had considerable national support in 1980 argues that enhanced domestic production of energy is critical to national interests and that the federal government should assist in overcoming the substantial barriers to commercial scale synthetic fuels development [35, 36]. The stated objectives of the new Reagan Administration reinforced the idea of enhanced U.S. energy self-sufficiency and appeared to offer potential for subsidies, weakened national environmental standards, and more active leasing of rich federal resources to stimulate achievement of this goal (although fiscal restraint and fundamental objection to government involvement in private sector affairs sent contradictory signals).

By late 1981 a crisis was upon Northwest Colorado. Workers seeking employment in the newly opening and highly publicized oil shale sites were camping on public and private land as freezing weather set in, while construction crews rushed to finish accommodations in towns and company sponsored trailer

Table 1. Projections of Oil Shale Production for 1990 By Site for Northwest Colorado
1990 Projection Date and Short Title[a] (In Barrels Per Day)

Colorado Sites	*Oct. 79 DNR*	*Nov. 79 DRI for EPA*	*March 80 DRI for EPA*	*April 80 DOE*	*Jan. 81 CWACOG*	*Feb. 81 DNR Medium*	*Feb. 81 TRW for DOE*	*March 81 EPA*	*April 81 DOE/RA*	*Dec. 81 RMOGA*	*March 82 RMOGA*
Colony	50,000	46,200	46,200	47,000	47,000	48,300	50,000	50,000	45,000	47,000	0
Union	30,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
C-a "Rio Blanco"	47,250	76,000	76,000	60,000	76,000	56,700	76,000	76,000	76,000		
C-b "Cathedral Bluffs"	30,000	200,000	100,000	50,000	95,000	94,000	33,000	79,000	94,000		0
Superior (Land Exchange)	24,000	12,000	12,000	13,000			30,000	50,000	11,590		
Chevron		66,600	66,600		50,000	41,400	50,000	50,000	50,000	15,000	15,000
Mobil		50,000	50,000				12,000	10,000	50,000	0	0
Exxon (Land Exchange)			60,000	60,000				60,000	60,000		
Carter Oil		60,000				60,000					
Naval Reserve		28,000	28,000					50,000			
Texaco										0	0
Cities Service		0						50,000		0	0
ARCO										0	0
Multi Mineral						0			50,000	0	0
Getty										0	0
Equity	1,000	0				1,000				0	0
C-c						10,000					
C-d						10,000					
Superior Pacific									50,000		
Thermo-Mist (Savage)									5,000		
Total	182,250	588,800	488,880	280,000	318,000	370,700	301,000	525,000	541,590	112,000	65,000

[a]Key to Projection Dates and Short Titles—Oct. 79 DNR "Projected Development Plans"; Nov. 79 DRI for EPA "Predicted Shale Oil"; March 80 DRI for EPA Revised Draft "Maximum"; April 80 DOE Resource Applications "400,000 by 1990 President's Goal"; Jan. 81 CWACOG "Trust Fund Request"; Feb. 81 DNR "Medium"; Feb. 81 TRW for DOE "Industry Plans"; March 81 EPA; April 81 DOE/RA "Oil Shale Projects"; Dec. 81 RMOGA; March 82 RMOGA.

Source: Colorado College, Southwest Studies Program, Regional Resource Management Study.

camps for those with jobs and an income. Monthly expenditures at the sites were measured in the millions of dollars, while small communities struggled to find resources for expansion of public services.

But in less than six months the boom had bust. On Sunday May 2, 1982, Exxon announced cancellation of its $5 to 6 billion dollar Colony Project and quickly thereafter fired contractors and workers, sold off equipment, and left behind a ghost site. The tremors of this shock plunged Northwest Colorado into greater uncertainty faster than had the boom in the months before. Most other sites and proposed plans were likewise retrenching in the face of slackening world oil demand and prices. The Exxon decision to close the Colony Project is barely mentioned in the Company's Annual Report; for Northwest Colorado once again slight mid-course alterations in corporate and government plans translated into dashed hopes, bankrupt local businessmen, and uncertainty about potential development [37-39].

And yet, the potential for development lingers on. Union Oil is spending $600 million dollars to complete a first phase oil shale plant capable of producing 10,000 barrels per day; plans call for additional phases until production is 90,000 barrels per day by the mid-1990's. Projections of regional development even after the Exxon "bust", as shown in Figure 2, while down drastically, still portend significant growth for the region [40-44].

Physical activity is a strong force to convince people that growth is upon them. In the case of Northwest Colorado several oil shale projects started construction in 1980 while others entered the planning and approval stages in a serious way. Projections of future growth were super-exponential, implying doublings of population, unimagined requirements for public and private capital, and projected socioeconomic and environmental impacts which would literally change the region's resource base and way of life.

COPING WITH CHANGE: IMPETUS FOR REGIONAL RESOURCE MANAGEMENT TOOLS

Resource rich regions often find that either development initiatives come from a number of different directions simultaneously, or that a single resource stimulates such large scale development that project specific and even programmatic EIA's are inadequate and too late. Development in such regions tends to accelerate in pace and magnitude until control and even perception of future change is lost.

Northwest Colorado faced such a predicament by early 1980. A broad array of resources were being developed simultaneously, while oil shale plans and development dwarfed all other growth in potential scope, magnitude, and impact. Uncertainty was rampant concerning the path which development would take—but growth at an accelerated rate was presumed certain.

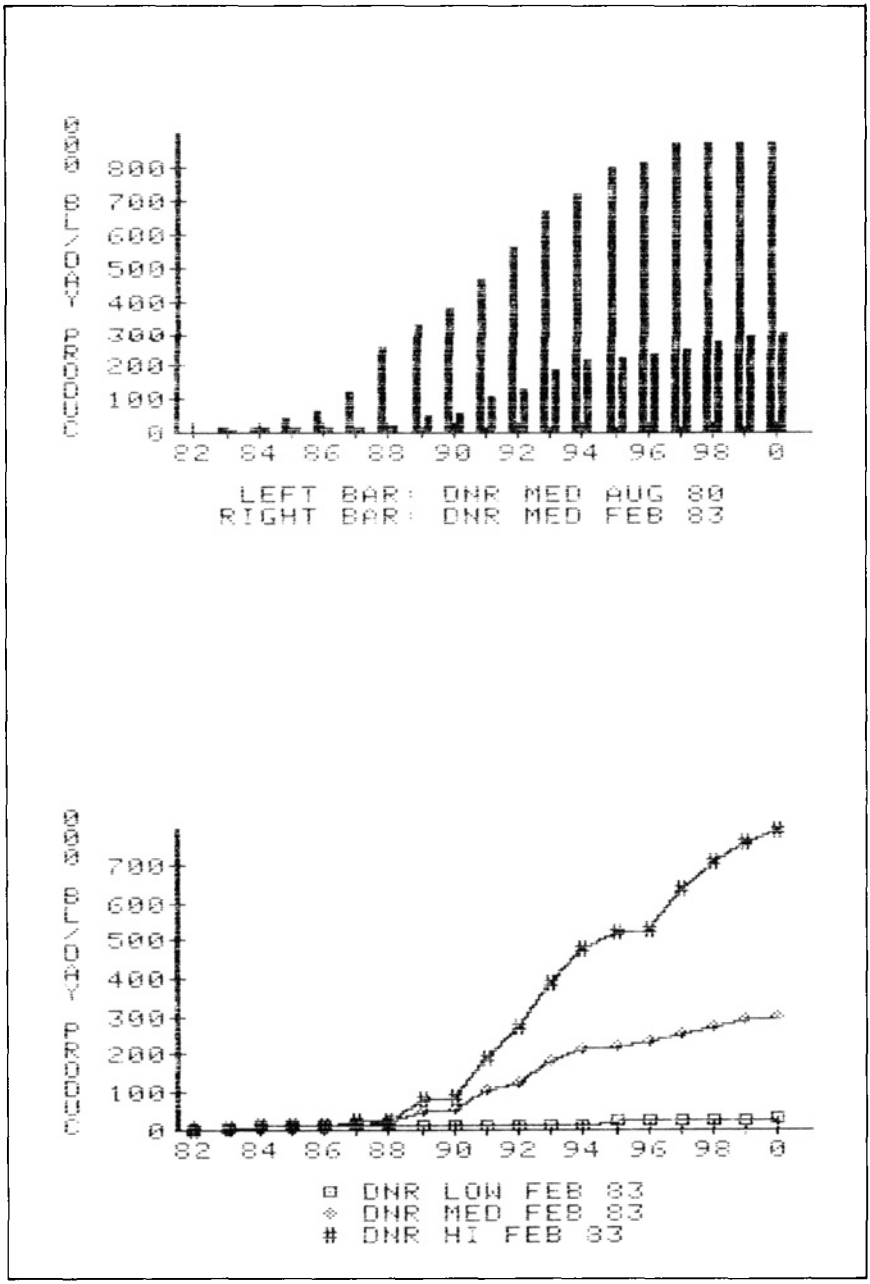

Figure 2. Projections of Oil Shale Production Through The Year 2000 For Northwest Colorado

Source: Colorado Department of Natural Resources

In the face of all this pressure and uncertainty, information about potential future patterns of development and their impacts becomes the scarcest resource. Given the heavy responsibilities of state and local government to facilitate private and federal government development initiatives through timely provision of public services, orderly government planning and budgeting becomes threatened with chaos.

As an alternative to the normal reactive pattern of response, concerted efforts started in Colorado during the summer of 1979 to anticipate potential and likely future patterns of regional development and impacts for Northwest Colorado. The Colorado Department of Natural Resources (DNR), mandated by the legislature to enhance development and protect natural resources, while encouraging full utilization of each of the State's natural resources consistent with realistic conservation principles, was an integral part of a Colorado initiative to break the traditional patterns of top-down reactive response on a project by project basis.

Three major initiatives were instituted to strengthen the State's and the region's participation in planning for and implementing development in Northwest Colorado [45]. The Joint Review Process was designed and implemented in the spirit of streamlining the multijurisdiction governmental decision process, from first intention of project developers to consider development through the planning and permitting stages [46]. At a broader level the Colorado Resource Information System (CRIS) was constructed to serve as a nucleus of information and analytical capabilities [47, 48]. The intent was to provide broad regional perspectives on potential future development and associated impacts. A third effort was a Cumulative Impacts Task Force, intended to transcend the anticipatory stages and create a public-private forum capable of marshalling the resources to accommodate growth at a pace and magnitude beyond existing capabilities [49-52].

These three initiatives in fact interact among themselves. Further, a number of Federal Government initiatives at "regional" planning of energy development in Northwest Colorado overlap and sometimes conflict with the "Colorado" initiatives. All of this activity and analysis makes the oil shale region of Northwest Colorado perhaps the most intensively studied and "managed" resource-rich region in the world. This broader scope of resource management for oil shale in the Piceance Basin in Colorado has been extensively charted elsewhere [45]; the focus here is on CRIS as an interdisciplinary systems approach to managing the energy-environment interface as it is subjected to development pressures.

The tools which a region can marshall to anticipate and manage rapid growth are substantial. The experience of Colorado in developing CRIS is directly relevant, both because of the broad nature of the management system constructed and due to the impetus which the region took in facing complex issues and substantial forces on its own terms. The following sections summarize

the development and operation of this regional resource management information system and evaluate its potential for regional resource management.

Overview of CRIS

The approach taken in designing an information system for Northwest Colorado was driven by the objectives of creating comprehensive regional projections of energy and associated development activity and identifying associated impacts of such projections. The philosophy behind this effort centers upon the assumption that such objectives should be part of a process which must be continuous in the face of abrupt change. Without such a process of continual identification and analysis, regional participation in shaping orderly development levels and providing public services to accommodate them cannot go forward [53, 54].

The goals in establishing this resource management tool were to:

- improve information on energy development plans available to state and local governments;
- serve as a decision assistance tool which would be capable of providing rapid response capability for analyzing changing energy production plans in Northwest Colorado;
- facilitate the response which state government could make to the federal government and private industry initiatives for accelerated domestic energy production; and
- provide a common base of information, analysis, and impact identification as a means of testing the usefulness of an information system for managing natural resources in Colorado [55].

The system designed for Northwest Colorado is an interactive, user-oriented set of integrated tabular and spatial information systems. Both the data input and information output modes have been designed to provide timely information for decision makers. As shown in Figure 3, it is a system oriented towards support for management decision; the user focuses its application through the identification of an issue or problem requiring information analysis and support. Successive stages develop the information required for producing the types of analysis which support the decisions which must be made. In reality these steps are iterative, with the first round of system application resulting in a clarification of the issues and further runs refining the information until it is organized in the best fashion for decision assistance support.

The overall data structure and organization of CRIS is shown in Figure 4. It is a combined tabular and spatial information system building upon site-specific data for the various types of development activities projected for the region. Such information includes numerical profiles of development and spatial or map-based information both for the sites and for the region. Analysis of the

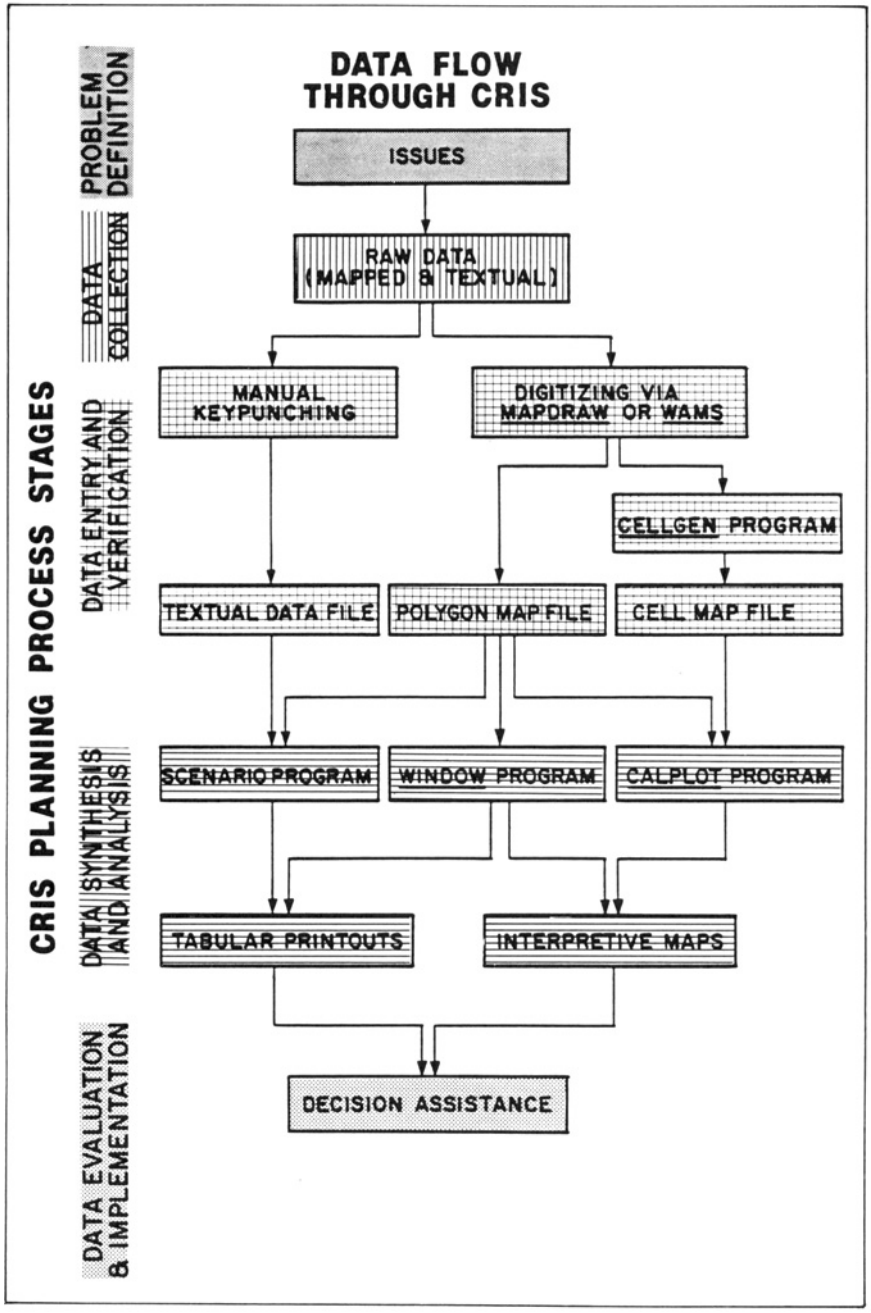

Figure 3. CRIS Organization For Data Analysis and Decision Assistance

Source: Colorado Department of Natural Resources

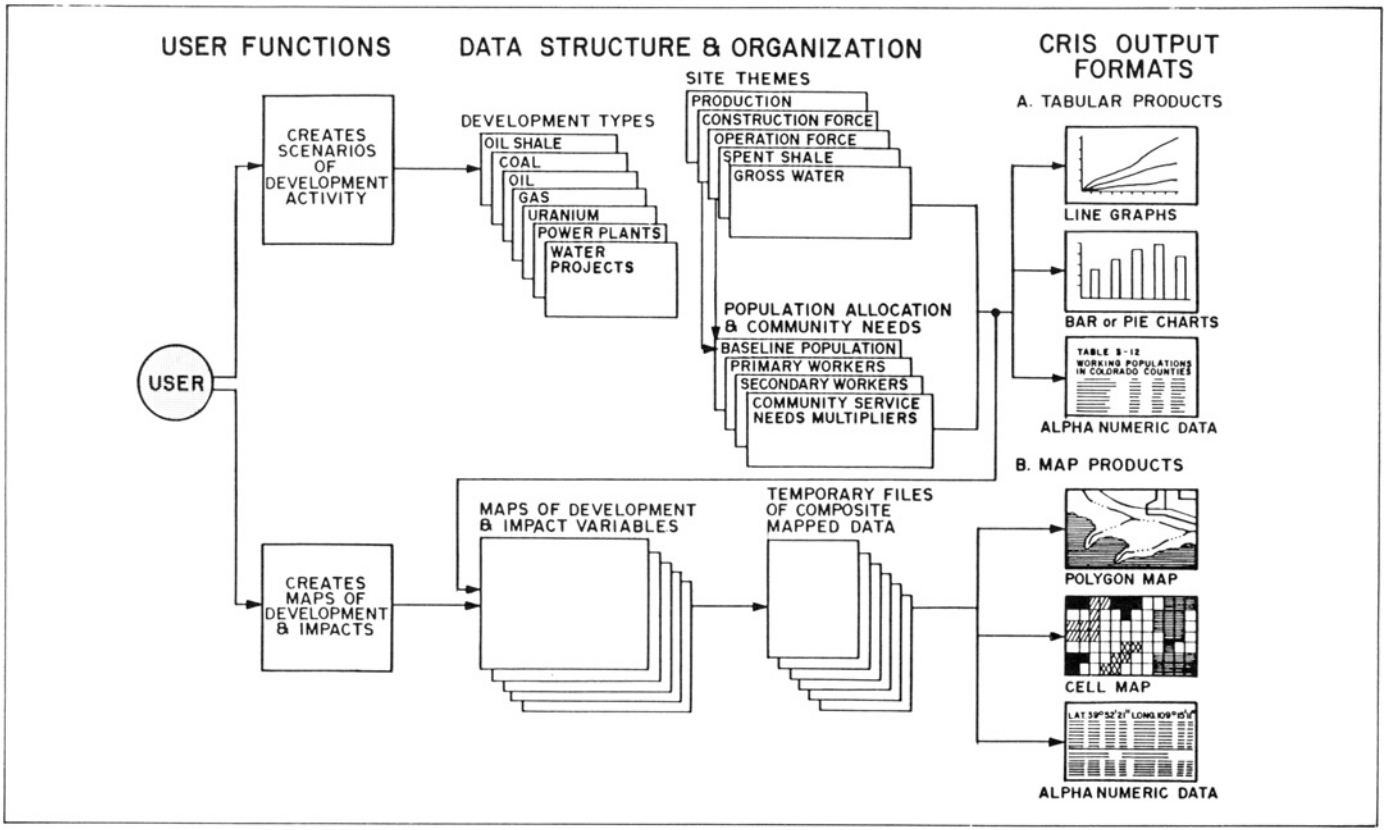

Figure 4. CRIS Data Structure and Methods of User Access. **Source:** Colorado Department of Natural Resources

projected development levels results in both tabular products such as graphs and charts as well as maps and spatial analysis.

This information system is built upon some unique programs (software) which can be stored and accessed on a variety of different types of equipment (hardware). The maintenance of flexibility in user access is important [56]; this has been accomplished by placing the software on the CDC CIBER system at Colorado State University at Fort Collins. Work stations can access this main frame computer over telephone lines from remote sites. In addition, the software is being shifted to computers in Colorado State Government.

The software consists of programs which allow data entry, manipulation, and output. The organization of spatial (map base) data is designed around a geographical information system approach to data manipulation. Unique to geographic information systems is the process of computer entry and storage of spatial data. As depicted in Figure 5, polygon maps are registered and encoded into the computer so that overlays of different spatial themes is possible. Further, polygon maps are converted into cell maps, with the resulting cells forming the basis for much analytical work including overlay and compositing as well as weighting of cell attributes. The analytical power of geographical information systems stems largely from their ability to perform calculations and support inference. Computer stored map data on Northwest Colorado which is available in the CRIS system [57], represents over 200 mapped variables and covers a wide variety of themes which have been organized into the following major categories: land cover, land use, land ownership, fish and wildlife, and energy.

The tabular portion of the data are entered, stored, and accessed in a fashion similar to most computer management information systems, as depicted in Figure 6. While simple in theory, much of the work involved in developing such an information system revolves around collection and maintenance of timely files on development proposals, population, and community requirements. These are prerequisites to analysis of impacts stemming from development projections and to participation as a region in the protection of regional amenities and life styles.

One major type of decision assistance support which CRIS can provide involves development of comprehensive regional production scenarios for Northwest Colorado and the identification of potential impacts. The tabular portion of the system maintains three alternative levels of potential future production (high, medium, and low) for a number of sites associated with each of the following development categories: coal; coal gas/liquid; oil; gas; oil shale; uranium; reservoirs, salinity projects; and power plants. Development activity is linked to a number of separate themes, including construction and operation work forces, communities of residence, project physical and financial inputs, and project product and waste outputs.

CRIS can be used to put together a set of production projections building upon specific development sites from each category of development activity

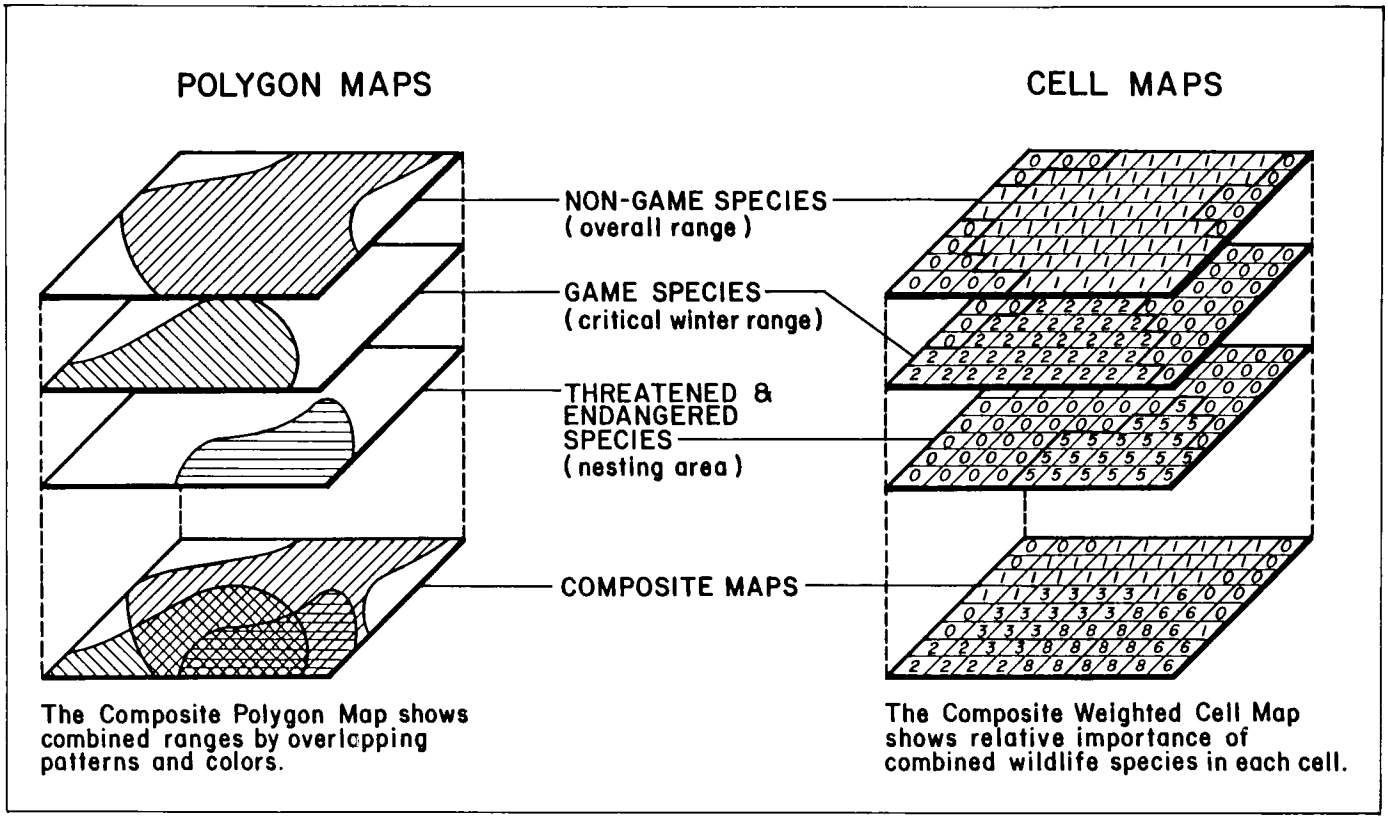

Figure 5. Composite Mapping. **Source:** Colorado Department of Natural Resources

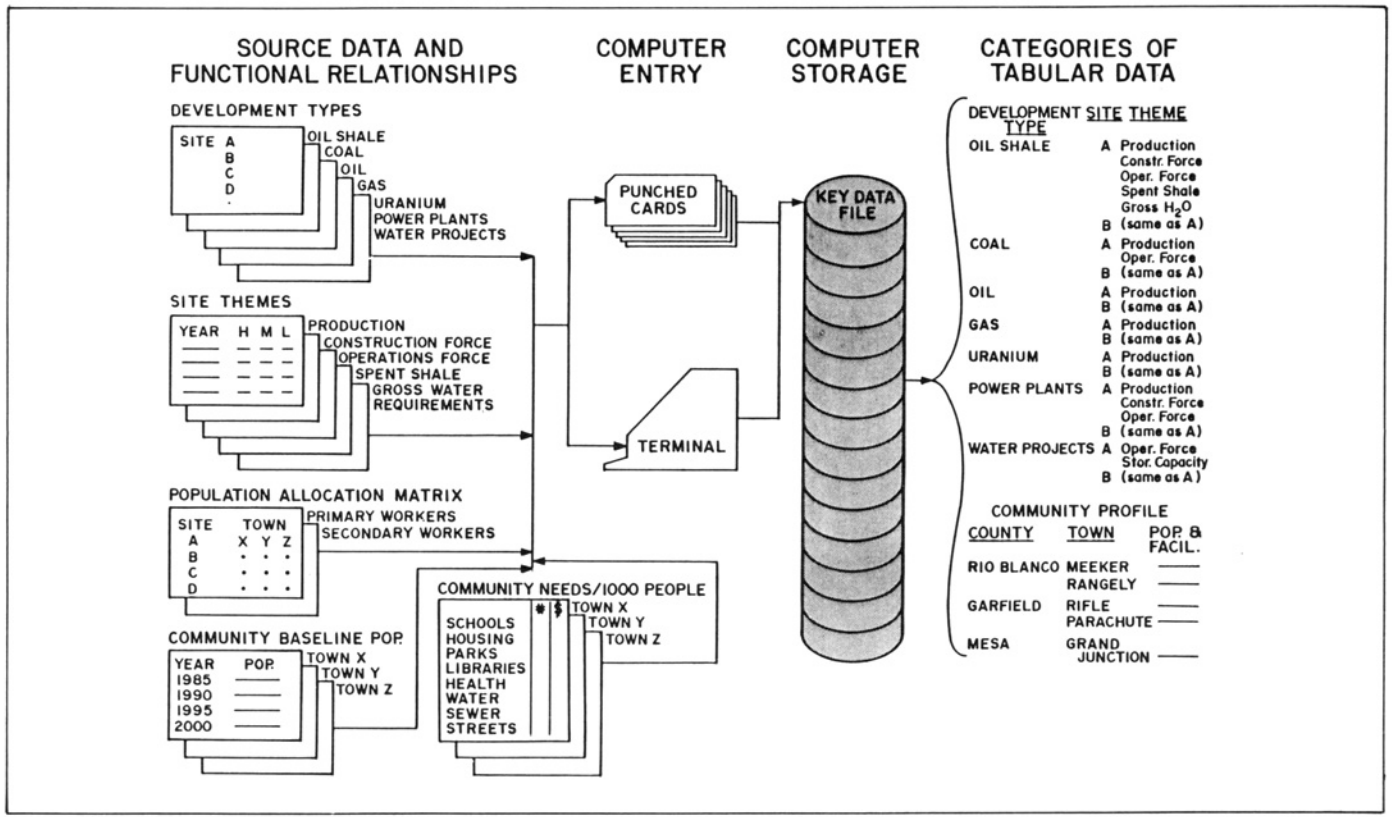

Figure 6. CRIS Data Entry and Organization of Tabular Information. **Source:** Colorado Department of Natural Resources

likely to enter into the growth process through the end of the century. Work force themes associated with each site drive a population allocation module within CRIS which distributes workers and their families to expected communities of residence throughout Northwest Colorado. The growth-induced increment of population, when added to projections of base line population growth, provides a profile of community growth patterns. Community needs and financial requirements can be calculated and measured against desired standards and existing capabilities.

The capabilities of such an information system allow considerable flexibility in analysis. Periodic regional profiles of projected development activity can be produced with supporting tabular and mapped output. Specific proposals for development can be reviewed both for their spatial impacts through the map base and overlay-analytical capabilities, and for their contribution to regional growth and change. Anticipatory search capabilities exist to simulate possible future development and evaluate the possible impacts for particular sites and for the broader region [58-64]. Linkages between CRIS and other regional modeling and monitoring efforts offer a rich variety of additional analysis of development impacts, including perspectives on impacts affecting air, water quality and quantity, wildlife, solid waste disposal, vegetation, economic activity, and esthetic resources of the region.

One sign of the strength CRIS has developed can be seen in its integral participation in a growing number of Northwest Colorado monitoring-modeling efforts. Increasing planning activity by the federal government in this region is resulting in a number of efforts which draw data from and compliment CRIS. As shown in Figure 7, some of these efforts compliment the socioeconomic and built environment portion of CRIS while others deal primarily with the natural environment aspects of development. As detailed in a recent survey and analysis of these information systems [45], extensive efforts have gone into coordination and sharing of data and analytical techniques. This adds to the rich data base and growing understanding of development pressures and management efforts in perhaps the most intensively studied resource-rich region in the world.

Regional strategies for shaping development both in spatial and temporal dimensions can be developed and improved as a means of fully participating in the development process [65]. All of these uses have been supported by CRIS as the State and Northwest Colorado struggled to anticipate and shape change.

CRIS As An Impact Assessment Tool

The intent in developing CRIS was to provide a comprehensive regional perspective on potential future levels of development activity, grounded in site-specific detail. It is intended to serve as a nucleus of information around which additional analytical capabilities can operate. CRIS cannot do site-specific detailed development planning; it was never intended to function in this capacity.

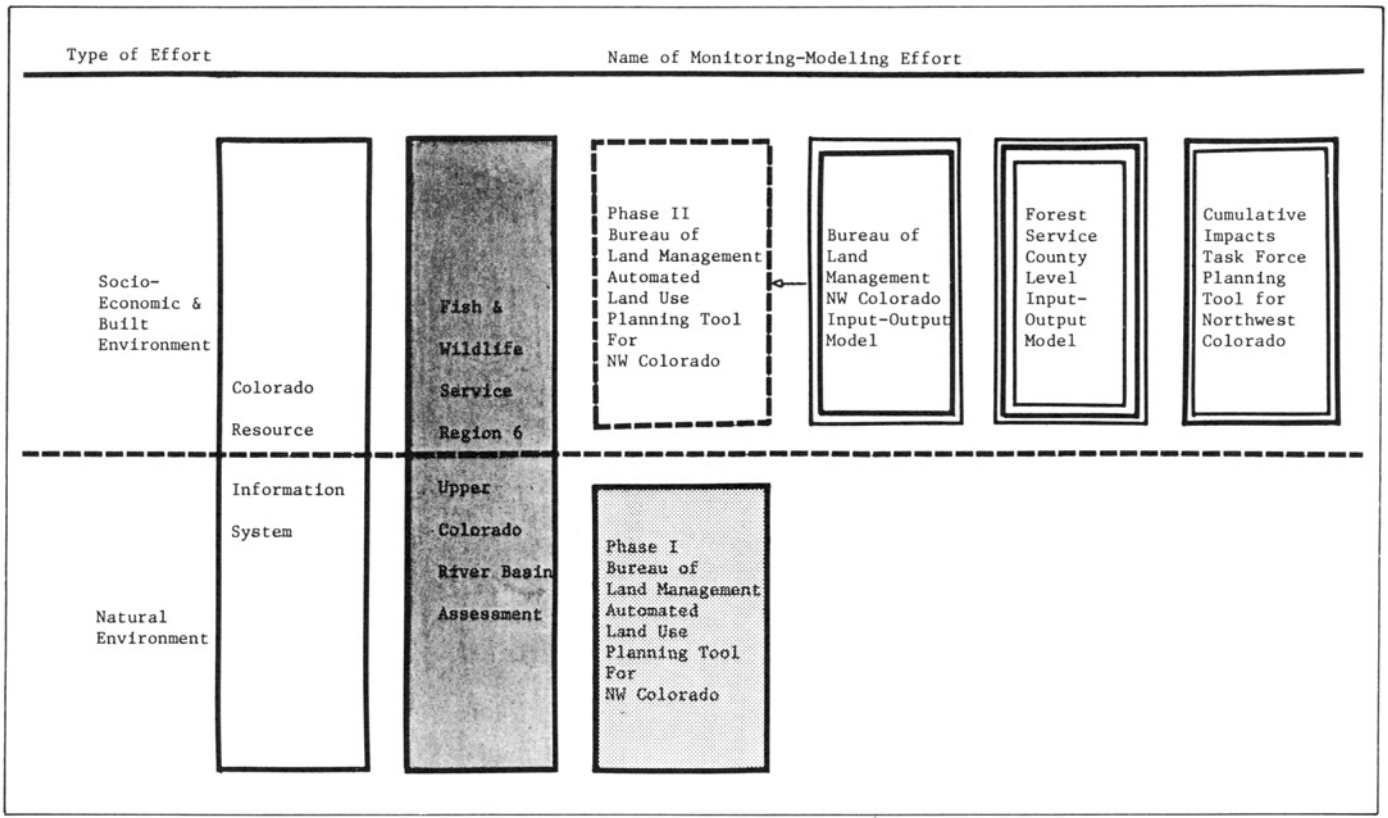

Figure 7. Northwest Colorado Monitoring-Modeling Efforts

Source: Colorado College, Southwest Studies Program Regional Resource Management Study

Such responsibility exists with the project proponent as well as the individual governmental agencies that grant permits and approvals for a project as it moves through the review process.

It is also true that CRIS cannot make decisions. It can support and facilitate deliberations of the decision makers by providing information in ways which answer the questions the decision makers must ask about development and its impacts. Despite the suspicions of traditional resource managers, such an information system is not endowed with mystical capabilities. There are few functions which CRIS performs which could not be accomplished using traditional approaches, given sufficient time and effort. The important thing to remember is that resource-rich regions like Northwest Colorado when under stress no longer have sufficient lead time and cannot afford the effort which would be entailed to use traditional analysis techniques.

The comprehensive regional impact assessment analysis being attempted for Northwest Colorado pioneers new territory in the development of information system capabilities appropriate to regional resources and needs. As these tools develop, a clearer perspective can be gained of the possible alternative paths of development, and associated impacts. Such knowledge can support a more orderly process by which resource-rich regions plan for desirable alternative futures and seek the policy tools which can help guide development.

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