Information Technology in the U.S. Forest Service

Cathleen Stasz, Tora Bikson, J. D. Eveland, Brian S. Mittman
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An Assessment of Late-Stage Implementation

Cathleen Stasz, Tora Bikson, J. D. Eveland, Brian S. Mittman

July 1990

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RAND
PREFACE

In 1985 The RAND Corporation undertook a research project for the U.S. Forest Service on the implementation of its new agency-wide information system. That exploratory study examined the impact of the system on individuals and the organization, and provided a snapshot of system effects from installation through initial use. This study, conducted in 1988–89, follows from the previous research and examines system impacts during late-stage implementation, at a time when the system has become internalized into the agency's work. The report follows up on issues emerging from initial implementation, describes current technology uses in mission-related work, draws conclusions about late-stage technology implementation, and makes recommendations for future innovation efforts. The report also includes and integrates findings from two previous RAND studies of cost-benefit analyses and demographic work force changes in the agency.

In addition to informing current and future systems planning in the Forest Service, this research hopes to provide lessons and examples for large national organizations to draw on as they move from implementation to internalization of distributed systems, shared databases, and electronic communications.

The follow-on study was supported by a grant with the U.S. Department of Agriculture Forest Service. The cost-benefit analysis and demographic work force study were conducted within RAND's Institute for Research on Interactive Systems (IRIS) when the Forest Service was an IRIS sponsor. All work was conducted in RAND's Domestic Research Division.
SUMMARY

In 1983 the United States Forest Service began the implementation of a new distributed information system to enable its employees to better perform increasingly information-intensive work. That system installation, now complete, links over 900 units in the National Forest System and supports a wide variety of tasks—from general office work to complex data analytic activities. It forms the backbone of a complex array of systems (e.g., microcomputers, mainframe computers) by providing connections between different computer-based tools. By all accounts, the system has improved the agency’s ability to perform its missions and has affected the structure and culture of the organization as well.

About two-thirds through the initial installation, the Forest Service contracted RAND to study the implementation process. An innovative effort of this magnitude raises many questions: How readily can workers and offices accept and use the new tools? How well do system capabilities meet users’ needs? How does the system affect work performance? Our 1985 study explored these and other questions and identified several issues that the agency needed to address as the implementation process continued.\(^1\) Three years later, upon completion of the scheduled installation, we took another snapshot of the process to review the status of previously identified issues, to assess the progress of system internalization into the agency’s work, and to identify any new issues that arise with later-stage implementation of advanced technology. As few studies have examined late-stage implementation longitudinally, little is known \textit{a priori} about what kind of differences to expect. Thus, the present study begins to fill an important gap in our understanding of the extended impact of the implementation of computer technologies in information-intensive work.

Our approach for studying the impact of technology transfer in this and our previous study addressed three major classes of factors:

- Characteristics of the organization.
- Characteristics of the technology.
- Characteristics of the implementation process—the process by which the organization embeds the technology in its work.

In this study we gave special attention to how the technology is being used to accomplish mission-related work and what steps the agency can take to improve current and future implementation efforts.

INTERNALIZATION FINDINGS

"Internalization" refers to the transition from initial acceptance and use of the technology to its full incorporation into day-to-day work of the organization. To discuss longer-term implementation findings and issues, we organize them into four areas: hardware, software, systems-in-use, and "humanware."

Hardware

Looking at hardware policies, capabilities, and future directions, our study found that the Forest Service:

- Successfully internalized the new technology. We find evidence for internalization in the extent to which the technology has become part of the established ways of working within the domains we studied—land management planning, fire management, and program development and budget. Other indicators are the technology’s high level of use and fiscal internalization—i.e., a shift of hardware expenses from lower- to higher-level units and from special to regular budget categories. The Forest Service will meet its document and archival requirements to the National Archives with computer-based files, thus making it the first U.S. agency to employ electronic documents as its official record.
- Continues to upgrade its hardware capabilities. While the initial installation is complete, purchasing continues as user standards and expectations keep increasing.
- Confronts a changing marketplace that stimulates varied regional responses. Technology advances and more decentralized acquisition policies enabled different regions to take different approaches to their later-stage hardware needs. As a result, regions face difficult trade-offs between an array of flexible and powerful marketplace tools on the one hand and strong needs for sharable information on the other.
Software

The following findings concern software use as well as current and future software development.

- Early decisions about software tools have paid off. Generic tools for standard electronic office functions, such as word processing and electronic mail, and for data analysis or procedures for specialized tasks are widely used and, for the most part, receive high evaluations from users.

- Local software development is not always the best solution. While generic tools are being used at an increasing rate and in more sophisticated ways, local software development is not always the best solution to late-stage implementation needs. Buying off-the-shelf software can save programming and other labor costs because it comes with training/support materials and typically offers compatible updates as new versions are developed. Borrowing or sharing applications developed in-house by individuals is also effective for meeting software needs, provided that strategies for disseminating those applications are in place.

- Software integration is sometimes problematic. The capstone of the Forest Service’s information technology philosophy is the ability to share information. Three kinds of integration difficulties pose a challenge for current and future information sharing: it is not always possible to move data between applications, incompatible databases make data aggregation difficult, and some applications are linked to particular databases.

Systems-In-Use

Systems-in-use issues concern the diversity of hardware and software that local units use to carry out their missions while participating in the overall information structure and communications networks.

- The interface between centralized and local systems needs improvement. While central mainframe computers must still be used for many data-intensive analytic tasks, the relationship between the Data General (DG) and centralized systems seems to have stabilized at this stage of the implementation process. The DG serves as the infrastructure for using the Fort Collins Computing Center (FCCC) in several ways—data can be accessed and analyzed remotely, with the DG acting as a dumb
terminal, or data may be accessed and downloaded directly into command-line interpreter (CLI) applications or through CEO-CONNEC'T (communications software) for local data analysis. However, users cite many problems with the interface between old and new systems. This is exacerbated by the necessity to use standardized, centralized databases and systems for some information work. A late-stage implementation issue, then, is how to take full advantage of an information technology mix that requires users to navigate through a number of systems and understand what tasks are best done with which tools.

- **Database (mis)management problems hamper effective use.** Problems most commonly cited by users were: too much duplication of files takes up scarce storage space and slows system processes; needed data files can be hard to find, updating is not done promptly or on regular schedules, and “information overload” has intensified. For most users, the proliferation of these problems can be traced to a lack of any formal training in database management.

- **Different computing subcultures have emerged.** Differences between units in early implementation strategies resulted in even greater diversity as the system was internalized. Different approaches translated into different systems-in-use and different computing orientations. One region puts emphasis on making the same tools available to everyone; the other, on allowing people to have individual tools. These orientations promote quite different computing practices.

**Humanware**

“Humanware”—the skills, knowledge resources, and technical support provided by and to individual people—is as important to making a system work well as are its hardware and software components. While the Forest Service has tackled and solved many humanware problems over the course of system implementation, new issues, in need of careful attention, have come to the fore.

- **Employee computer skills continue to improve, but at an uneven rate.** This variation results in many inefficiencies.
- **Training needs improvement.** While training practices are adequate for turning the uninitiated into novice users, training beyond “the basics” is inadequate. District-level units, in particular, lack systematic strategies for training staffs on relevant applications or assisting individuals who self-identify training
needs. Self-teaching, while indicative of the positive, "can do" attitude of Forest Service employees, can also lead to costly "reinvention" of applications.

- **Gurus are an endangered species.** A key element in humanware is the local "computer guru"—the individual who by virtue of talents, interests, and an understanding of organizational missions becomes significantly more informed about the system and its uses than his or her peers. The guru acts as a local trainer and consultant and, particularly in smaller units, is the source of system expertise. Unfortunately, gurus are fast becoming an "endangered species" within the Forest Service. Currently, the agency has no provisions for rewarding and supporting individuals for becoming local experts, nor for retaining them.

- **Expertise is not easily replaced under current human resource policies.** Humanware is a perishable and scarce commodity that cannot readily be replaced once lost. Whenever a person moves on, there is always lag time before the replacement (assuming a replacement is found) comes up to speed. Many employees with expert computer skills have job titles that do not reflect their capabilities; in other words, job titles have not kept pace with job content.

**CONCLUSIONS**

During the period that the DG system has been in operation in the Forest Service, major consequences have unfolded. The agency has put into place a tool that has fundamentally reshaped and conditioned almost all aspects of its work. It has done so in an atmosphere not wholly without controversy, but in general characterized by a high degree of efficiency and good will. The Forest Service has succeeded in internalizing the new technology to a startlting and gratifying degree while maintaining its mission focus and essential organizational culture. In short, the agency remains at the leading edge of government, and other organizations as well, in the implementation of large-scale distributed communication and information processing technologies. We come away with four major conclusions.

First, early skeptics and enthusiasts have come to share the same vision of the technology and its place in the Forest Service's culture. This has entailed compromises on both sides. Early enthusiasts realize that the DG will not "do all things for all people." And skeptics see that real foresters do use keyboards.
Our second conclusion is that the Forest Service has internalized computing, not computers. That is, the process and use of the technology, not just the machines, have diffused throughout the organization. Using the technology has become an important part of the work. Computer subcultures, with more or less implicit assumptions, beliefs, and values about computers and computing, flourish.

Third, we conclude that new, late-stage implementation issues have replaced old issues. Issues of acceptance (e.g., Will real foresters use a keyboard?) have been replaced by issues of full utilization (e.g., Do foresters have the knowledge and support they need to make best use of corporate information systems?). Questions about whether DG applications-building tools would ever be used have been replaced by questions about how to maintain and diffuse all the locally developed applications. Questions about how the agency would deal with the shift to an electronic environment are superseded by questions about how to move forward steadily in it, given that the environment will continue to change.

Finally, healthy and stimulating tensions between centralization and decentralization of the computing environment still exist. The centralized nature of the original procurement was balanced by a pluralism in implementation strategies among regions and forests that allowed local needs to be taken into account. While some functions have become more centralized, and while the communications system allows a much closer degree of interaction between central management and the field, the essential decentralized nature of the Forest Service has been preserved.

RECOMMENDATIONS

Technology

At this stage of the implementation process we see a need for new policies to govern hardware and software acquisition and use. First, the Forest Service needs an agency-wide strategy for developing, interconnecting, and supporting a mixed hardware (and software) environment. Second, while the Forest Service has succeeded in using generic tools to build a great many different specific applications, in the "buy or build" decision, it may be better to "buy," in light of the variety of commercial software available. The agency should also think about ways to encourage and assist "borrowing," beyond having applications libraries that do not seem to be used.
Organizational

Every analysis of the impact of information systems on organizations must come to the conclusion that the specifics of the technology are far less critical to its effective use than the organizational arrangements for managing, supporting, and assessing the results of system use. While the Forest Service has made major strides in coming to terms with these issues, we believe that issues of training and personnel management, centralization, and dissemination need particular emphasis.

The agency needs, first of all, to develop new human resource policies and practices. Policies to recognize local experts, for example, might assure that they are allocated time and resources for the information system activities they perform. In addition, while “collateral duty” is a useful transition policy to fill short-term vacancies or skill needs, it cannot satisfy the agency’s needs over the longer term for a special cadre of trained systems people. Creation of new career paths in systems-related jobs, or job descriptions that reflect necessary computer skills, would be steps in the right direction.

The Forest Service must monitor organizational tensions and find the appropriate balance of authority and responsibility among the different levels of the agency in relation to system configuration design, connectivity, and data structures.

Finally, strategies need to be developed and strengthened for disseminating the lessons learned about system implementation and use, both within the Forest Service and outside its boundaries.

Implementation

The Forest Service needs to improve its training and support capabilities in future implementation efforts. Opportunities for beginning, intermediate, and advanced learning must be made available. Learning needs to focus on functions rather than applications. Training should be organized around the collection of applications that a user might need for the job, and should include how to use the tools effectively, how to move between them efficiently, and a broad understanding of system architecture.

The Forest Service should develop an ongoing self-evaluation capability. Key questions about direct relationships between the technology available and the nature of the work performed remain defined largely by anecdote and impression. In particular, the agency needs to develop ways to measure the elusive, organization-wide benefits of interactivity, such as the ability to share information and move it where it is needed.
Finally, we recommend the development of long-term system strategies or design "skeletons" which focus on generic requirements without specifying particular system components. This approach, coupled with regular assessment of emerging technologies and their likely influence on current and planned Forest Service information systems design, would permit the agency to plan more effectively within the rapidly changing technological environment.
ACKNOWLEDGMENTS

We are indebted to many Forest Service employees for their cooperation and candid discussion, which made this study possible. In particular, we thank Mr. Charles R. Hartgraves and Mr. Clyde Shumway, of the Forest Service, for supporting this research and sharing their vision.

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# GLOSSARY

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<tr>
<td>AROS</td>
<td>Automated Resource Order System</td>
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<td>ASCII</td>
<td>American Symbolic Code for Information Interchange</td>
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<td>BEHAVE</td>
<td>A fire modeling computer program</td>
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<td>BMANotes</td>
<td>Budget spreadsheet program for financial records</td>
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<td>CAD</td>
<td>Computer Aided Design</td>
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<td>CEO</td>
<td>Comprehensive Electronic Office</td>
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<td>CEO-CONNECT</td>
<td>DG computer program for modem communications</td>
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<td>CLI</td>
<td>Command Line Interpreter</td>
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<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
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<tr>
<td>DG</td>
<td>Data General</td>
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<tr>
<td>EIS</td>
<td>Environmental Impact Statement</td>
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<td>FCCC</td>
<td>Fort Collins Computer Center</td>
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<td>FLIPS</td>
<td>Forest Level Information Processing System</td>
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<tr>
<td>FORPLAN</td>
<td>Forest Plan (computer program)</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<tr>
<td>LAI</td>
<td>LABAT-ANDERSON, Inc.</td>
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<td>LMP</td>
<td>Land Management Planning</td>
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<td>NFC</td>
<td>National Finance Center</td>
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<td>NFS</td>
<td>National Forest System</td>
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<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PRESENT</td>
<td>Computer program for constructing forms</td>
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<td>RD</td>
<td>Ranger District</td>
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<td>RO</td>
<td>Regional Office</td>
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<td>SQL</td>
<td>Structured Query Language</td>
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<td>Sales Tracking and Reporting System</td>
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I. INTRODUCTION

In 1983, the United States Forest Service began the installation of a new distributed computer network that would significantly change the way the agency carried out its missions. That system, one of the largest distributed installations in this country to date, provides electronic links among over 900 organizational units in the National Forest System. It supports a wide range of mission-related activities, from standard “office automation” capabilities (e.g., word processing, electronic mail, databases) to specialized applications development (e.g., models of elk habitat). In addition, the distributed system links to other computers (e.g., microcomputers, mainframe computers), providing connectivity among a variety of computer-based tools.

An innovative effort of this magnitude raises many questions whose answers are valuable to any organization attempting to develop and deploy large, complex, multifunction systems in geographically distributed work environments. For example: How readily can workers and offices assimilate new computer tools into their day-to-day functions? How can system capabilities be fully exploited? What effects does the system have on work performance? Do system benefits outweigh their costs? What long-term consequences for the agency as an organization result from internalizing an interactive information system? How can organizations cope with continual needs for technology upgrades as computer-based tools advance and change?

To investigate these and other questions, in 1985 we conducted an initial exploratory study of the system implementation and its effects on information tasks at four levels of the Forest Service (national, regional, forest, district). The results of that exploratory study, which focused on the early installation phase of the implementation process, are reported in a RAND Note. The Note identifies ways in which the system had begun to change the organizational culture and work of the Forest Service, and discusses emerging implementation policy issues the agency would face.

The present study follows from the first and focuses on later-stage implementation impacts and issues. Its purpose is to identify and evaluate later-stage effects of the system on the organization, integrating findings from prior studies into that account. The study’s primary objective, and the main focus of this report, is:

• To update the view of the system documented in the previous RAND implementation study, discussing how the system has changed and the impact of those changes for accomplishing Forest Service missions.

The research also had two secondary objectives:

• To examine cost-benefit analyses conducted by other evaluators,\(^2\) taking a closer look at patterns of changes in computer-supported tasks. The study provides a more qualitative and context-based description of the changes, to supplement the quantitative analyses and link them to Forest Service missions.

• To integrate quantitative findings from a RAND study of demographic and job-related changes following the implementation of the agency-wide information system\(^3\) with qualitative information about changes in work performance—again orienting the results to Forest Service missions.

In addition to informing current and future systems planning in the Forest Service, this research hopes to provide lessons and examples for large national organizations to draw on as they move from implementation to internalization of distributed systems, shared databases, and electronic communications.

The report is divided into five sections and three appendixes. After this Introduction (Sec. I), Sec. II describes the approach, reviews important conclusions from our initial study, and presents the current study methodology. Section III discusses the missions and task areas we examined, the technology used to accomplish them, and how the technology has significantly affected the accomplishment of mission-related work. Section IV presents findings regarding the status and effects of the system as the agency moves from installation to internalization phases of the implementation process. Section V presents overall conclusions and recommendations for future implementation efforts. Details of the analyses that address our two secondary objectives are presented in appendixes. Where appropriate, relevant findings from these analyses are included in the main body of the report. A third appendix presents a sample of the interview guides used to gather information for this study.


II. RESEARCH APPROACH

CONCEPTUAL FRAMEWORK

The conceptual framework that guided this and the early implementation study\(^1\) derives from a growing body of empirical work on technological innovation in a variety of task domains and user settings. The consensus from this research— including RAND's contributions—is that understanding technological innovation in organizations requires attending to three components:

1. Features of the innovative technology.
2. Characteristics of the organizational setting.
3. The nature of the implementation process—i.e., the sequence of activities undertaken to embed new technologies in organizations.

The literature and our previous studies suggest that these components are inherently interrelated. Moreover, the properties of the implementation process itself have been most significantly associated with successful or unsuccessful outcomes.\(^2\)

Beginning with such a framework, then, we sought information about three classes of explanatory variables: information system features, organizational context characteristics, and properties of the implementation process. Since this was a follow-on study, we began with what we had learned about the technology, the organization, and the implementation process from our initial study. Below we elaborate on our perspective for examining these variables and summarize findings from our previous work.\(^3\) Together, our framework and previous findings form the starting point for this research.

\(^1\)Throughout the remainder of this report, mentions of the “initial study” or the “early implementation study” refer to C. Stasz, T. K. Bikson, and N. Z. Shapiro, Assessing the Forest Service's Implementation of an Agency-Wide Information System: An Exploratory Study, The RAND Corporation, N-2463-USFS, May 1986.


\(^3\)See the initial study report for more details about the Forest Service's organization, information technologies, and implementation processes.
System Features

Computer systems can be described from many perspectives and at varying levels of specificity—from purely technical hardware specifications, to functionality of software applications, to human-computer interface features. In this research, we were most interested in the system features that users interact with most directly. These are primarily software features and applications (e.g., electronic mail, word processing, spreadsheets, data analysis capabilities, and the interface to them presented by CEO). Our aim was to understand how these features support information work in various mission-related areas. We gave less attention to hardware characteristics except as they became important to users (e.g., response time, equipment reliability).

The Forest Service’s information system consists of hardware, software, and “humanware” (knowledge resources, training and support) components. The Data General (DG) distributed-processing system, comprising over 900 interconnected local minicomputer systems, supports a wide range of mission-related activities. “Generic tools” provide standard office automation capabilities (e.g., word processing, electronic mail, spreadsheet creation and manipulation), and they support specialized application development (e.g., models of elk habitat). The agency-wide DG system links to other computers (e.g., microcomputers and mainframe computers), providing a network of computer-based tools. Thus, the distributed system serves as the backbone of the agency’s information technology. Actual hardware and software configurations—“systems-in-use”—vary for each organizational unit. While the system vendor provided initial training and support, local units now assume responsibility for these functions. As a result, the level of expertise of users and system managers varies across units, with greater expertise typically found at higher-level units (e.g., regional offices and the Washington office). Individual expertise also changes continually, but not at a uniform pace.

Organizational Context

According to our framework, which views implementation as requiring reciprocal adaptation, rapid technological changes are likely to stimulate organizational changes. Organizational changes generally occur less rapidly than technology changes, but we still expected to see some effects in the short term (e.g., changes in information-based tasks). Organizational variables of interest include characteristics of

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4CEO, or Comprehensive Electronic Office, is a registered trademark office automation system of the Data General Corporation.
the Forest Service that exist independently of the information system and that are likely to have a bearing on its incorporation in day-to-day work. Our previous research identifies the following basic kinds of descriptive variables: organizational structures, missions of work units, and types of information-related functions performed at each level of the agency. These become important for understanding the structural and functional features of the systems-in-use. In addition, since implementation is inevitably a people-based process, shared values, implicit behavior codes, and other aspects of the organizational culture can promote or impede system implementation.

Structure. Compared to other federal agencies, the Forest Service has a relatively flat organization. That flatness is reinforced by significant delegations of authority to lower line levels to commit resources and approve action plans without the necessity for higher-level review that characterizes many other federal agencies. Four levels of offices in the National Forest System include the Washington office, nine regional offices, 123 national forest supervisor offices, and approximately 653 ranger district offices. In this “staff and line” organization, all unit heads and their deputies are line officers with decision-making authority.5

Staff provide services to line management (e.g., computing services, special subject matter information) and primarily assume an advisory role. Professional staff carry out functions requiring special education or expertise (e.g., forestry, silviculture, engineering, mineralogy). In addition to these mostly college-educated and career-oriented employees are the nonprofessional staff, who provide technical and clerical support to agency units.

Missions and Tasks. Briefly, the missions of the Forest Service are to (a) protect and manage resources on 191 million acres of National Forest System lands, (b) cooperate with state and local governments, forest industries, and private landowners to help protect and manage non-federal forest and rangeland, (c) conduct research on all aspects of forestry, range management, and forest resources utilization, and (d) participate with other agencies in human resource programs aimed at improving living conditions in rural areas.6 Toward these ends, the Forest Service performs a very wide range of functions involving many information-intensive tasks. We elaborate on some of these in Sec. III.

5Line officers or managers include the Chief of the Forest Service, Regional Foresters, Forest Supervisors, District Rangers and their designated deputies. Everyone else is staff. Thus the term “line manager” is not equivalent to “management” or “manager” in most organizations. The manager of a regional office’s timber or wildlife staff, for example, may supervise more people than a District Ranger; he or she would still be considered “staff.” Forest Service occupational categories are discussed further in App. B.

Culture. Although the Forest Service is a large, geographically dispersed agency, it is a tight-knit organization with many career employees and a strong culture. The "Marines of the Civil Service" boast a colorful history and well-defined central values, including respect for the individual, a commitment to training, decentralized authority, shared decisionmaking, respect for information, and a desire to communicate.

Implementation Process

By "implementation" we mean the series of events that take place from initial planning for system acquisition to the system's full incorporation as a tool for information work. Such processes can vary widely between organizations and also within organizations at different levels or work units. Many properties of technological change strategies can affect an innovation's success or failure, including: the vision that stimulates the innovation and how it is articulated, participation of users in decisionmaking and action processes, the kinds of training and support available to workers, and the organization's ability to manage long-term, incremental technology transfer.

The Forest Service's implementation of the agency-wide system was farsighted and innovative. Planning began a decade before the acquisition process, long before the requisite technology was even available. The characteristics and missions of the organization drove its conceptualizations of computing needs and information tasks, as well as various programmatic, legislative, and productivity requirements. The national implementation strategy had the following key components: begin with generic tools, put the tools where the work is done, provide all units with common information structures, implement the system from the top down, and provide peer units at each level with comparable systems at approximately the same time. National implementation guidelines were liberally interpreted by each region, which developed its own implementation plans. As a result, regions varied widely in their actual implementation practices. But the new technology, by diverse routes, became a part of the Forest Service's way of doing business.

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7 Others have written extensively about the culture of the Forest Service. Most notable is Herbert Kaufman's classic work The Forest Ranger: A Study in Administrative Behavior, Johns Hopkins Press, Baltimore, 1986.

FINDINGS FROM INITIAL IMPLEMENTATION STUDY

Beginning with the conceptual framework for technology transfer, our initial study aimed at assessing the implementation of the agency-wide system and its effects on the organization and its work. The study concluded that the first stage of the Forest Service's implementation—installation and initial training—was remarkably successful overall; it proceeded according to schedule, the systems were reliable, and use was high. We found evidence that the system was having a positive impact on agency work and noted issues that the agency would have to face as it moved from installation to internalization—that is, the time when information tools become fully incorporated into the work and users can exploit most of the system's capabilities. Our major conclusions follow.

- The Forest Service employees' "can-do" attitude and pride in the agency greatly aided the transition process, despite the problems that invariably accompany large-scale organizational change.
- Clerical and computer staffs were reduced, and tasks were redistributed across jobs (e.g., professionals do more typing and clerical workers perform technical system-related tasks).
- The system altered information tasks by increasing capabilities for local database creation, updating, and analysis; electronic mail and text processing changed many general office procedures.
- Increased communication capabilities through electronic mail satisfied a longstanding desire to communicate within and across organizational units. This new capability, however, could challenge decentralized decisionmaking and alter traditional communication patterns.
- Different regional interpretations of Washington office implementation guidelines produced striking variations in local implementation practices and the resulting systems-in-use. Tensions between nationwide guidelines and local autonomy (an important part of agency culture) were evident.
- Four emerging implementation policy issues needed further scrutiny: the relationship of the distributed system to the centralized Fort Collins Computing Center (FCCC), the relationship of the

9The Fort Collins Computer Center (FCCC) is a centralized, mainframe-based data processing center used by the Forest Service since the early 1970s. Before the agency-wide system was installed, much information work was sent to FCCC for entry, edit, storage, analysis, and so on. Currently FCCC retains some large databases, which users can access remotely by various means (e.g., DG workstation, PC).
agency-wide system to microcomputers, restrictions on hardware acquisition, and local software development.

Despite the difficulties noted, we found overall that the Forest Service developed and implemented a system concept that was ahead of its time. It was innovative in design, informed by insights into organizational culture and missions, and unprecedented in scope; it positively affected administrative functions across the agency.

FOLLOW-ON STUDY DESIGN AND RESEARCH QUESTIONS

While our first study focused on early stages of the implementation process, our primary goal in this research was to provide a critical review of later-stage implementation—namely, the transition from installation to internalization. We focused our inquiry to follow up issues and problems identified in the earlier study and to reveal new issues related to later-stage implementation. To assess features of the implementation process, for example, we were particularly concerned with the four emerging policy issues mentioned above, as well as other issues that merit special examination in the context of late-stage implementation (e.g., the need for long-term training).

Our approach was also guided by the thesis that system impacts should be addressed primarily in terms of mission-related outcomes rather than isolated changes in tasks or procedures. Similarly, we were more interested in system effects on work groups rather than the work of individuals. Thus, we concentrated data collection in two mission areas: fire management and land management planning (LMP). We chose these information-intensive task domains, in part, because of their high degree of interconnectedness across organizational levels; that is, work in these areas demands a great deal of interlevel and intralevel interaction. Further, they are critical and visible activity areas both within the agency and to the public. Thus, they have the potential to make evident both shortcomings and value-added implications of the system. In addition to these functional areas, we took a close look at two processes that support them: electronic communication, and program development and budgeting. The first ties missions together and links vertical and horizontal organizational units and their members within missions. The second, budgeting, is an especially important administrative function that cuts across all mission areas and must be responsive to Congressional requirements and constraints.
The present study is unique in providing the opportunity to examine late-stage issues that arise with technology implementation. Most case study or comparative research on organizations attempting to implement new technologies relies on a single data collection or on several data collection waves within a relatively brief time period during a long-term, incremental process. Hence, little is known about some important questions: (1) Do late-stage implementation issues differ from early-stage issues? Every organization attempting to deploy large, complex, multifunction systems could benefit from knowing the answer. A second major question was directly motivated by findings from our initial study: (2) What kinds of systems-in-use resulted from centralized acquisition but decentralized implementation policies? Although there is one "basic" agency-wide system in theory, there are many systems in practice—what do these look like? To assess the degree of system internalization, we asked: (3) Have the Forest Service's long-term technology objectives for the agency-wide system been met? Positive indications would be the extent to which the "office automation" and the data analysis capabilities are used by employees to perform their work, and whether integration between the distributed system and other Forest Service computers has been achieved. Finally, we looked to the future: (4) What lessons can be learned that will ensure continued full utilization of the networked minicomputer system even as new technologies are being introduced? How can the Forest Service maintain and improve the capabilities of present systems as new technologies are brought on board? Answering such questions was our primary research goal.

Research that addressed our two secondary goals was conducted somewhat independently of the late-stage implementation study and analysis, but affected this study in overall design and data collection efforts. Our examination of a cost-benefit analysis (detailed in App. A) provides a qualitative, contextual discussion of the changes identified in a quantitative evaluation (conducted by another evaluator) and attempts to link them to Forest Service missions. This goal required us to include some units from the other evaluator's study in the current study's sample. The employment impact analysis (detailed in App. B) examined effects of agency-wide system implementation on the size and composition of the Forest Service work force and on the content and characteristics of individual jobs. Data for the job analysis were collected in conjunction with the present study. Where appropriate, selected data from these analyses are also included in the main body of the report.
PROCEDURES

We collected data for this late-stage implementation study over a six-month period from April to September 1988. The primary research procedures were structured interviews and site visits at all four levels of the Forest Service. Data from these interviews, along with observations and data from archival records, inform the findings reported in Secs. III, IV, and V.

Following the rationale outlined in the original study, we gathered data at the Washington office, at two regional offices, at two national forests within each region, and at two ranger districts within each forest (see Table 1). We revisited the two regions selected for inclusion in the previous study; in each of these we revisited one forest and two of its districts. Other forests visited for the first time in each region were chosen because they were included in LABAT-ANDERSON's (LAI) cost-benefit study sample. Districts within forests were chosen to match the previous study sample (where the forest was in that sample) or, otherwise, for their availability or inherent interest. This sampling plan enabled us to follow up on units from the original study as well as to gather comparable data from new units not previously sampled.

At every unit, we interviewed the line officer or his or her deputy. Staff interviews at all units were conducted with the information system manager (or whoever had responsibility for the operation of the computer system), employees in three target areas (land management planning, fire management, budget), and personnel staff (see Table 2). Interviews with the latter group provided more specific information about job

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<th>Washington Office (9)</th>
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<th>Region A (6)</th>
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Table 1
NUMBER OF INTERVIEWS BY UNIT
(N = 82)

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<th>Region A (6)</th>
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10At district levels very few people are formally designated as “LMP staff.” Therefore, we interviewed employees in wildlife, recreation, timber, and so on, who provided input into land management plans and used their outputs, but who were not charged with the responsibility of producing or defending plans themselves.
Table 2
NUMBER OF INTERVIEWS BY FUNCTIONAL AREA

<table>
<thead>
<tr>
<th>Functional Area</th>
<th>Number</th>
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<tr>
<td>Line officers</td>
<td>15</td>
</tr>
<tr>
<td>Land management planning</td>
<td>16</td>
</tr>
<tr>
<td>Fire protection</td>
<td>14</td>
</tr>
<tr>
<td>Budget</td>
<td>9</td>
</tr>
<tr>
<td>Systems/technical</td>
<td>17</td>
</tr>
<tr>
<td>Personnel</td>
<td>11</td>
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evolution patterns, one component of the demographic analysis. The numbers in parentheses in Table 1 represent formal interviews only; they do not include informal interactions and observations, although we used information from both sources in developing and interpreting our findings. Interviews were conducted with the aid of a protocol (see App. C for an example) that guided but did not strictly determine the interview process. This practice enabled us to pursue issues that were important to users but not always anticipated in advance of field visits. Flexibility was also necessary because employees in lower-level units often held more than one targeted function (e.g., systems manager and budget administrator); questions repeated on different interview guides were asked of a respondent only once regardless of number of positions held.

As was the case with the early implementation study, it is important to note that data gathered from interviews and informal interactions cannot be construed as representing official Forest Service policy or documented fact. Rather, they represent users’ perceptions of and experiences with the computer-based work environment.
III. MISSIONS AND TECHNOLOGY IN THE FOREST SERVICE

This section describes selected mission and support areas in the Forest Service and the technologies employed to perform mission-related work. It also describes how electronic mail capabilities facilitate the accomplishment of work in these areas. Section II presented a brief overview of the Forest Service's organizational structure, mission areas, and culture. Below we focus our discussion on three areas—land management planning (LMP), fire management, and program development and budget. For each, we describe work tasks and procedures, the technology employed to accomplish them, and reported effects of the technology.

LAND MANAGEMENT PLANNING

The Forest Service manages and protects the 191-million-acre National Forest System (NFS). The land management planning process is used to determine the best use of resources in the NFS, including recreation, fish and wildlife, water, timber, minerals, range, and wilderness. This process is mandated by the National Forest Management Act of 1976.

Regional Guides (and associated environmental impact statements, or EISs) are developed for each of the nine regions of the Forest Service. These programmatic documents address major regional issues and concerns and provide procedural guidance for development of Forest Plans.

A Forest Plan (and associated EIS) is developed for each national forest (or, in some cases, another administrative unit) in the Forest Service. These plans provide more specific land management guidance and include such items as forest-wide goals and objectives, desired future condition, standards and guidelines, identification of lands suited or selected for timber harvest, allowable sale quantity, recommendations for Wilderness or other special designations, and similar resource direction. They generally do not contain site-specific project-level decisions, however; these are typically made on an individual basis in compliance with the overall guidance contained within the Forest Plan.
As of August 1989, 97 of 123 plans had been finalized, with 26 in draft form. Final Forest Plans are subject to administrative appeal. This appeals process provides an avenue for the public to request higher-level agency review of decisions made in Forest Plans. Approximately 825 appeals have thus far been filed on Forest Plans, with 515 resolved to date (49 plans have been cleared of all appeals).

Of the four forests visited in the current study, one had a final Forest Plan and two had draft plans. The fourth forest withdrew its 1986 draft plan after devastating fires in 1987 changed forest conditions to such an extent that the draft plan was essentially obsolete.

The Plan Development Process

Development of a Forest Plan and associated EIS is a complex undertaking. It often requires 3 to 5 years or longer from the start of the process to an approved final plan. Plans are developed by an interdisciplinary planning team with public participation. Forest Plans must be developed in compliance with a myriad of regulations, most notably those relating to the National Forest Management Act and the National Environmental Policy Act.

The process can be generally outlined by the following steps:

1. Identification of issues, concerns, and opportunities
2. Development of planning criteria
3. Collection of inventory data and other information
4. Development of an “Analysis of the Management Situation”
5. Formulation of alternatives (for managing the forest)
6. Estimation of effects of alternatives
7. Evaluation of alternatives
8. Recommendation of preferred alternative
9. Plan approval
10. Monitoring and evaluation

Considerable data analysis efforts are associated with this ten-step process. FORPLAN, a linear programming computer model designed for this purpose, is used by all forests in development of their plans. Within the framework of steps described above, the analysis process begins with an inventory of the forest’s resources. Resource inventories are typically mapped and digitized into a database. Lands with similar features or capabilities are identified by overlaying the various resource data layers in the inventory. These “capability areas” are consolidated with other “capability areas” that have compatible characteristics and similar responses to land management. The combined
areas are called “analysis areas” and form the basic source of information used in FORPLAN analysis.

The FORPLAN model includes management prescriptions which describe a sequence of activities that could be applied to each analysis area. Cost data, value data (dollar values assigned to both market and nonmarket goods), and scheduled outputs (such as tons of sediment or board feet of timber) are linked to each combination of a prescription and an analysis area. As a result, the model predicts the costs, values, and resource outputs of applying a particular activity (management prescription) to an area of land (analysis area).

The linear program is used to optimize present net value given any set of constraints. The constraints vary based on the purpose of the model assumptions being made. For the Analysis of the Management Situation step, “benchmark” runs are made to maximize each resource; that is, to determine the maximum capability of the forest to produce that output with no constraints except legal requirements. In the alternative development steps, varying mixes of resources and constraints are modeled to illustrate alternatives for the overall management of the area. In this way the model can be used to explore, for example, tradeoffs between preserving more wilderness and permitting more recreation.

A full range of Forest Service personnel are involved in plan development. The Forest Supervisor is responsible for the process and supervises the interdisciplinary team that does most of the analytic work. This team consists of diverse resource specialists who are selected on the basis of the resource issues that will be addressed in the plan. This core team is supplemented, at one time or another, by almost all resource specialists at the forest who help as needed with the massive task. In addition, the planning process typically requires considerable assistance from support services personnel and the public affairs staff.

Forest Service line officers are involved throughout the process. District Rangers are involved in reviewing various products of the planning process to assure their accuracy and “workability.” They typically advise the Forest Supervisor on such matters and will be responsible for implementing the plan once it is completed. While Forest Supervisors are responsible for the planning process, they recommend the developed Forest Plan to the Regional Forester for approval. The Regional Forester is responsible for approving the final plan. Any administrative appeals are then handled by the next highest level, which is the Chief’s Office in Washington.

The preceding description illustrates several key features of the land management planning process: it is information intensive, it involves
specialists from different disciplines who must work in cooperation to produce a final product, and it spans organizational levels. Next we discuss how technology is used in land management planning, and in particular, how the distributed agency-wide system has affected the work.

Technology Uses

Before the networked minicomputer technology was available, forests had varying sources and types of computing capabilities. Some LMP staffs had either microcomputers or terminals to connect to FCCC to run FORPLAN analyses. In some cases, the forest had connections with a local university's computer operations. In addition, some forests had other computer capabilities to support the planning process, such as word processing systems or dedicated statistical computers.

At the time of our interviews, LMP staffs (or others involved in the LMP process) used a variety of technologies. The number of DG terminals in the minicomputer system ranged from one per LMP staff in a small ranger district to seven at a regional office. About half of the LMP staffs had microcomputers; only a few had portables for use in the field. FORPLAN analysis still requires the use of a mainframe computer at FCCC, although there is a microcomputer version of the model available within the agency for research purposes.

A variety of software tools aid land management planning and the myriad other tasks that contribute to the planning process (e.g., timber appraisals, wildlife habitat modeling, recreational use projections). Word processing, spreadsheet, and graphics applications are utilized on the minicomputer system (e.g., CEO, PRESENT) and on the microcomputers (e.g., WORDPERFECT, Lotus 1-2-3, CAD), but all electronic mail capabilities reside in the distributed system. Other specialized applications, running on varied hardware, come from a variety of sources. For example, the timber management information system (TMIS), sales tracking and reporting system (STARS), timber activity control system (TRACS), and timber sale program information reporting system (TSPIRS) were nationally developed and are used in several districts. Other applications are locally developed and less widely used (e.g., a seed and seedling accountability system between national forests and nurseries). One district we visited is experimenting with applications of a geographic information system (GIS) as part of a major agency-wide evaluation of GIS technologies.
Technology Impact

Although agency-wide information technology has not changed the nature of land management planning, respondents report that it has affected the process in many ways. The system makes it easier to track the procedural aspects of planning. For example, electronic mail enables easy distribution of agendas, results, comments, and the like to all parties involved in the planning process. While the FORPLAN analysis must still be run at FCCC, the networked minicomputer system promotes easier and faster transfer of data and results between FCCC and local units.

In addition, small portable computers can be used in the field to record resource inventories and upload the data automatically. Previously, recording was done on coding sheets, which were keypunched and batch processed. Data previously kept in aggregate form for ease of storage and reporting can now be kept online in disaggregated form. Thus, when plans change, the implications of the changes can be examined in terms of very low-level units of analysis. No details have been lost. Analytic capabilities provided by the distributed system enable specialists to run small models locally and adjust them, thus creating site-specific simulations.

Generally, the agency-wide system capabilities make users feel that they have more control over the pace and timing of the planning process. Before this system was available, the process “took longer and was more work.” Some staffs were reduced in size during the course of system implementation (none had increased), but the system allowed them to complete the work with fewer people.

FIRE MANAGEMENT

The fire management mission is to provide fire protection on NFS lands as well as technical and financial fire management assistance on almost 900 million acres of state-protected lands. Fire protection is a complex program, comprising such elements as presuppression, suppression, fire prevention, and fuels management. Working with state, local, and other federal fire protection agencies, Forest Service forces provide a high degree of professional firefighting ability. These abilities have been critical in recent years. The 1987 fire season was the most destructive for NFS lands since 1929, in terms of acres burned and resource values lost.

The Washington office (WO) fire management staff provides national program direction and development, interprets Congressional directives, and gathers information from lower-level units about fire
behavior, outcomes of fire management decisions and procedures, expected needs, and so on. Rather than give "how to" advice and information to local units, the WO provides program objectives, legal requirements, and the like. The WO also coordinates the National Fire Management Analysis system, a procedure for examining alternative fire suppression strategies from a cost-benefit standpoint. Fire history data are used for modeling and planning. Each forest, with contributions from its districts, annually engages in modeling and planning using its own fire history. The fire management officer at the forest level does the modeling and the WO aggregates the results. The WO also recommends fire and aviation policy, and is responsible for national coordination of fire resources, to meet inter-regional needs within the Forest Service and to support cooperative efforts between the Forest Service and other federal and state agencies.

At the time of our interviews—which were purposely scheduled to occur before the summer fire season—all but two of the sites we visited had already had fires or helped fight other fires. Data (such as the drought index and moisture content of vegetation) indicated an early fire season, and many units were hiring firefighters ahead of schedule or making other preparations. A number of employees we had hoped to interview were in fact away on fires.

**Technology Uses**

The Forest Service employs a wide variety of information and other technologies for fire management. National fire management, described above, is accomplished through both the distributed and centralized systems. It is extensively used to handle the complex logistics of fire crew management, including assigning and deploying personnel, maintaining resource inventories, recordkeeping, and communication. In addition, after each fire, a fire report is sent by electronic mail to FCCC for inclusion in the national database.

Technology also plays a part in implementing the "incident command system." When a fire starts, it may be confined within a district; the officer in charge at that unit is the "commander" of the incident at that time. As the fire grows, the incident may fall under the command of a higher-unit officer. With large fires, a national incident command team may be deployed (17 such teams are available). Before the agency-wide system was available, radio and telephone connections to and from dispatching offices passed along a fire order (a call for firefighting resources, e.g., materials or personnel) until it arrived at a place where it could be filled out. Now this process can be accomplished with electronic mail, using a fire order form. But electronic
mail will soon be replaced with the Automated Resource Order System (AROS), a form that "knows" where to go to request needed resources and can automatically activate the request-filling process.

The sites that had fought fires at the time of our visit reported a variety of technology uses.¹ At a regional office, the agency-wide system had been used to coordinate aerial dispatch of firefighting aircraft, teams, and supplies. This region also employs six remote stations, or "kits," made up of small DG microcomputer units and prepackaged software, that can be taken to a fire site (even parachuted in) and connected to the local forest or district network for backup of data, network access, and so on. Other federal and state agencies in this region have DG terminals, which enables interagency communication during fire emergencies. In several districts the distributed system is used for a number of other related purposes, such as determining who was in the forest in the area of the fire, and tracking crews and equipment loaned to other forests and regions. Coordinating and dispatching needed materials and personnel pose difficult and expensive problems that are significantly reduced with the aid of this technology.

Respondents also reported varied uses of the system to prepare for anticipated fires. Some units compile and maintain inventory lists or maintain monthly aircraft reports using the system's data tables. One district has put its fuels database online for planning purposes and uses the system to model needed fire control activities associated with timber sales (e.g., burning of slash and other post-sales material). A wide array of software applications support fire protection activities. For example, most ranger districts use a program called BEHAVE for fire modeling, either on the distributed system or stand-alone computers. In general, our respondents indicated that spreadsheets and other data table applications have been developed locally or received from the regional office or from colleagues in other units.

**Technology Impact**

The distributed agency-wide system improves the firefighting process in a number of significant ways. Previously, fire management records were on paper forms and handled manually. The switch to electronic records and standard electronic forms streamlines information updating and handling—"having better information makes everything easier." A second major impact is in communications. Daily

status reports on weather, fires, and locations of crews and equipment were once transmitted by teletype. Electronic mail speeds the widespread distribution and reception of these communications.

Sampled units also reported some personnel changes with technology adoption. One regional office now employs computer analysts specifically for fire management. One forest employs more computer operators and systems managers to integrate the various telecommunications systems. Another reported that people with computer skills are now recruited to support firefighting teams. In major incidents, on-site computer skills are needed to use the software developed for incident management.

PROGRAM DEVELOPMENT AND BUDGETING

The Forest Service’s budgeting process is a complex, distributed effort involving units at all organizational levels. Budget planning and programming begins three years before a budget actually goes into effect, and the process of preparing those budgets involves countless communications between all levels of the Forest Service.

The budget process is managed from the Washington office, but its national budget proposals—and the supporting justification for those proposals—are based on proposals submitted by regional offices, research stations, and other major units within the Forest Service. Budget proposals are submitted to the Washington office in electronic data formats, while justifications for those proposals are submitted electronically in narrative form.

The regional offices, in turn, build their budget proposals based on inputs from their subordinate units—national forests; those units likewise base their submissions on the needs of their subordinate units, the ranger districts. The end result is a budget proposal that is based on the expressed needs of each level of the Forest Service. The degree of detail about the budget is greatest at the lowest level of the Forest Service organizational structure.

After a budget has been passed by the Congress, it must be distributed to all the subordinate units in the Forest Service. The Washington office allocates funds to regional offices (and to research stations and other subordinate units), and those units in turn distribute their funds to their subordinate units. Organizational units at each level have budget authority within their own allocations; units at the same level exhibit considerable variety in the types and level of detail of budget categories employed.
As units begin carrying out their programs, the funds they spend are captured electronically at the Department of Agriculture's National Finance Center (NFC). Throughout the year, electronic communications between the Forest Service's distributed processing systems and the NFC mainframe computers are used to keep Forest Managers abreast of the status of the funds they have been authorized to spend. And, at many points in the complex program development and budget process, electronic mail is used to revise and resolve questions about proposals submitted, funds available, and the like. In such a complex process, questions inevitably arise concerning proposals submitted by subordinate units, and those units must be contacted to resolve those questions.

**Technology Uses**

Efficient communications are the key to the successful implementation of the decentralized program development and budget process described above. The Forest Service distributed processing network enables all levels of the organization to communicate rapidly concerning questions about various budget proposals.

The network also enables the Forest Service to be much more responsive to Congressional requests for information. For example, Congress recently asked for forest-level budget data related to land management plans. The Washington office does not normally ask for nor store information by national forest, but rather has retained information at the regional level (its immediately subordinate level) only. In the past, that type of request would have been very difficult—if not impossible—to meet in a timely way. Using the distributed system, however, the Forest Service was able in a very short time to develop and implement a special data collection process that provided Congress with the requested information.

The ability of the Forest Service to respond quickly to situations such as the one described above is facilitated by a range of generic software on the agency-wide system, and by communications capabilities between it and other computer systems (e.g., microcomputers) that might be in use in particular locations. Many requests for information can be resolved using standard software available on the agency-wide systems, such as its spreadsheets or data tables. Information entered into these agency-standard applications can be easily moved between units using standard electronic mail capabilities.

Other requests for information can often be resolved by a mixture of technologies—local units that have some budget information stored on personal computers, for example, can upload needed data to the
network for transmission to the office that needs the data. Here the
distributed system serves as the communication link that allows budget
data to be moved around in the organization.

That the use of agency-wide generic software is preferred by the
Washington office and by some regions does not preclude the develop-
ment of special budgeting applications. A “Work Planning System,”
for example, developed for project management, enables assignment of
people to projects and tasks over the lifetime of the project, and also
provides accounting for and reporting on equipment and supplies used.
This menu-driven application became the primary budgeting system for
the region that developed it, and has since been adopted by several
other regions. Units that do not yet have this planning system report
that they are looking forward to using it. The Washington office also
heavily uses (and encourages use of) the “Forms Entry System” to gen-
erate input forms and reports. Users create their own entry screens
and then, after an interactive query, the system writes a CEO-
PRESENT program for report generation.

Technology Impact

Document and data exchange, along with electronic mail, are the
chief merits of the agency-wide system in the budgeting process.
Timely and accurate communications, which used to be a major con-
cern for this agency, are no longer an issue. Electronic mail substan-
tially increases intraorganizational communication for sharing prob-
lems and generating ideas. In addition, the program development and
budgeting branch recently received a seven-figure rebate from the
federal government’s National Finance Center (NFC) in New Orleans
because the Forest Service’s data were sent electronically.

Effort saved in data handling for the NFC resulted in “cost
avoidance” while completing the task with fewer people. Respondents
report that work roles are also changing. Work is less boring and
repetitive, and employees experience more learning and broader com-
unication.

According to a respondent in one region, a side effect of total de-
dependence on the electric technology is that the manual filing system has
“gone to pot.” There is a tendency to avoid making paper copies
because the data are available on the system. Problems arise when
employees forget where the data file is or are unable to access it. Com-
plete reliance on electronic archiving can be risky because there are as
yet no standard procedures or practices for documentation.

Unlike other functional areas, the program planning and budget area
has experienced little impact from information technology on its
number or types of employees. Generally speaking, the extensive use of microcomputers for budgeting and planning suggests that the agency-wide system is less integrated in this area, as compared to fire management or land management planning. Nonetheless, information technology has played as much of a role in budgeting tasks as in the other areas.

COMMUNICATIONS

All functional or support areas described above make extensive use of electronic communications in their mission-related work. At the time of our previous study, when the network was just being installed, the electronic mail system did not support unbridled lateral communication. This had been done by design, since the agency had well-established communication standards to ensure that agency directives were transmitted through line officers—the “chain of command.” Eventually these restrictions were lifted, and employees are able to communicate freely across unit, functional, and hierarchical boundaries. To determine the extent of intra-agency communications and to assess progress in electronic communications with other agencies, we asked respondents about changes in communication patterns.

The previous discussion notes specific ways that electronic communication capabilities affect land management planning, fire management, and program planning and budget. In addition, virtually all respondents agreed that communications were faster and more frequent. Employees in each area also noted differences in the communication environment. One region uses a finance mailing list for vertical communications about budget matters to forests and districts. Fire officers mention the frequency and convenience of communications, and note that they receive more mission-related information and notices than in the past. They also have more frequent contact with fire officers in other forests, zones, and regions. Those involved in forest planning see an increase in both vertical and horizontal communications. A wildlife specialist in one forest had put together a wilderness management “network” (an on-line interest group) of over 100 people in 19 forests. He was also planning to organize a network group of 50 receptionists for the purpose of exchanging recreation information (e.g., current weather conditions, campsite availability). Future plans call for a broadened network of wildlife specialists to include National Park Service and state forestry members.
With the exception of the fire management area, electronic communications remain largely intra-agency. One forest we visited has established electronic communications with its state's Department of Lands, and additional interagency links are being planned. As computer technologies diffuse throughout more and more agencies and organizations, we can expect greater interest in forming interagency electronic networks.

Much research indicates that interactive technologies, including electronic mail, can alter the organization of work and work groups. The mission areas in our study report such changes in work group organization. Land management planning personnel report more and broader involvement in the planning process because it is easy to solicit comments and participation. They also note fewer large meetings and more committee or team organization. Forest-level fire officers also report more teamwork, plus the formation of more ad hoc teams. They see greater interforest cooperation on fire as well as other matters. Interestingly, these work group changes do not appear to occur at the district level, but rather in larger higher-level units.

Research also indicates that fast communication and widespread distribution can have nuisance costs, such as a proliferation of junk mail, too-hasty decisionmaking, lack of personal warmth, and so on.2 Thus, we asked our respondents to comment on how such costs were associated with their use of electronic mail. By and large, interviewees do not see many problems. The most frequently mentioned problem was too much duplication or forwarding of messages, which takes time and ties up scarce storage space. Presumably more training on effective information management in an electronic environment would alleviate this problem. Several respondents also feel that the tone of communication suffers without the "human link," and that electronic mail "has undermined personal contact." One respondent reported that he avoids using electronic mail to communicate for this very reason, particularly with people on his own staff. He prefers to print out his messages and, whenever possible, answer them in person. Others cite problems with the sheer quantity of mail, and especially the increase in junk mail. By and large, however, these nuisance costs are judged to be low and seem tolerable to users relative to the high payoffs that electronic communication capabilities afford.

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IV. INTERNALIZATION FINDINGS

In this section we discuss the internalization of the Forest Service’s agency-wide information system. As we have said, “internalization” refers to the transition from initial acceptance and use of the technology to its full incorporation into the regular day-to-day work of the organization. For convenience, these longer-term implementation issues and trends are grouped into four areas: hardware, software, systems-in-use, and humanware. In each of these areas we provide observations about the current situation and, where applicable, revisit earlier implementation issues raised in the first study. While the first study focused on post-installation characteristics and consequences of the new technology, the current study aimed to explore the kinds of issues and outcomes that would emerge in later phases of its use. Since implementation is a process, rather than an event, we expected the technology as well as its uses and its effects to differ over time. However, few previous studies have examined later-stage system implementation longitudinally, so little is known a priori about what kinds of differences to expect.\footnote{There is a reasonable amount of longitudinal study that goes from system adoption to early implementation but little that extends to internalization. We believe one reason for this is the assumption that late-stage implementation is static or reaches a point of stasis. However, we have suggested in other research (e.g., Bikson, Stasz, and Mankin, 1985) that this assumption probably does not hold for rapidly advancing technologies, especially those that are interactive and networked.} This research, then, begins to fill an important gap in our understanding of the extended impacts of the implementation of computer-based technologies in information-intensive work.

HARDWARE

In this section the discussion focuses on issues concerning hardware policies, capabilities, and future directions. Our study found that the Forest Service:

- Successfully internalized the new technology.
- Continues to upgrade its hardware capabilities.
- Confronts a changing marketplace that stimulates varied regional responses.
Embracing the New Technology Milieu

In its original implementation plan, the Forest Service opted for a single-vendor solution. The plan, driven by the organization and its needs, was oriented around a single, all-purpose system that would perform many functions: general office tasks (text processing, electronic mail); data entry, editing, and manipulation; database management; modeling; and so on. More importantly, the agency needed a distributed system, appropriate for forest-level work, that could effectively link over 900 separate locations. Although different systems could have been configured at different locations (many nationwide organizations proceed on such a basis, with operationally autonomous divisions making independent system decisions), the technology available at the time, together with the strong desire for connectivity (e.g., to enable data transfer) and consistency (e.g., to facilitate personnel transfer), favored a single-vendor system-wide solution.²

As the original study pointed out, this decision caused a number of problems, particularly in units that had existing computer-based tools. The basic issue was adaptation—how to move work gracefully from the old procedure (whether done manually or on a different vendor’s computer) to the new agency-wide DG system. By restricting non-DG hardware purchases, the agency forced adaptation: employees had to use the new system in order to do their work by computer. The agency was aware that these restrictive centralized policies would generate complaints. It also realized that the restrictions would not be sustainable after the initial large-scale procurement of the technology base, when budget responsibility for incremental acquisitions would be passed on to lower levels of the organization. In sum, the agency decided that a single-vendor fully networked agency-wide environment was appropriate as an early implementation strategy, in spite of the protests such a strategy would raise within a pro-decentralization organization like the Forest Service.

With its 1983 procurement, then, the agency acted in the belief that the advantages of establishing a common computing infrastructure throughout the Forest Service would outweigh the disadvantages, and that the system would gain widespread acceptance and use. That assumption proved in the main to be correct. When we surveyed employees in the two regions we studied, 99 percent of respondents

²By “connectivity” we mean simply the degree of connectedness between nodes in a computer network, representing the density of communication paths among them. For a discussion of system-wide design in government agencies, see McDonough, 1988.
reported using the DG system in their work. Other accepted indexes of "full incorporation" are similarly corroborative.3

For instance, a question routinely asked in interviews was "What are the most important outcomes from the use of the system that you’ve seen to date?” The typical response began with “It’s changed our whole way of doing business...” The preceding section provides more complete information about how the technology has become part of established ways of working within the task domains we studied.

Another internalization indicator is extent or intensity of system use. A technical representative in each site was asked what proportion of its regular employees were frequent (“at least daily”) users, occasional (“at least weekly”) users, and nonusers. Frequent-user figures ranged from 50 percent to 100 percent. The remainder of employees—typically those who spend a good deal of time in the field—were categorized as occasional users. Nonusers were said to be virtually nonexistent, corroborating self-report findings.

A third indicator is fiscal internalization, reflected in shifts of hardware expenses from higher to lower levels and from special to regular budget categories. Initial acquisitions were supported by national and regional budgets, while current acquisitions are supported by regional and forest-level budgets; and control over hardware purchasing has decentralized commensurately.

Finally, according formal or official status to innovative procedures is usually taken as a mark of institutionalization. A clear example is provided in a letter from the Chief of the Forest Service to the Archivist of the United States announcing the agency’s intent to meet its documentation and archival requirements with computer-based files. In so doing, the Forest Service in 1988 became the first U.S. agency to treat electronic documents as official record material.

The DG system, then, has been successfully internalized by the agency, having become an electronic infrastructure for carrying out and documenting its missions. Both advocates and skeptics say its uses exceed their initial expectations.

Hardware Implementation Continues

It would be inappropriate, however, to conclude that the process is now complete. We asked technical representatives in each unit whether they were “finished with the major work of implementing the DG system.” The answer was invariably “yes and no.” That is, initially projected installations were finished, but they had barely been completed before hardware upgrading was begun. There had been early concerns that the system might be undersized, and given the scope and speed of its internalization, these concerns were well founded.

Most units reported the need for both memory and CPU upgrades; many had already undertaken their first upgrade and were planning the next. While storage capacity problems were to some extent manageable by diligent attention to housekeeping chores, system slowness due to CPU overload presented much more intrusive and intractable difficulties.

Most units also found they did not have enough workstations.\(^4\) Very few employees had exclusive use of one, and in the regions we visited it was not uncommon to encounter workstation-to-user ratios of 1:4 to 1:8. A ratio of 1:2 was near the positive end of the distribution, although these units were likely to be aiming at 1:1 ratios. (Needless to say, in many cases the acquisition of more terminals only intensified the CPU overload problem.)

It does not appear, then, that the hardware implementation process has come to an end. In part this reflects successful internalization of information technology and subsequent changes in user attitudes. As one interviewee remarked, “our standards and expectations keep increasing.”

Confronting the Changing Technology Marketplace

While the Forest Service was carrying out its strategic plan—to create a network of common minicomputer-based information environments within which specialized tools could be embedded—the technology marketplace was rapidly changing. Many new offerings have appeared in the past few years. Two major classes of advances were in local processing power (e.g., 80286 and 80386 chips and related machines) and local mass storage (e.g., inexpensive 30- and 40-megabyte hard disks). There has also been a proliferation of inexpensive peripherals such as plotters, laser

\(^4\)We use the term “workstation” to refer to any video display/keyboard unit used by employees for computer-based work, whether it is a terminal to a shared CPU, a standard microcomputer, or a more powerful stand-alone workstation.
printers, and the like, as well as inexpensive protocol software for local area networks. Finally, the implementation of CEO-CONNECT, a communications package, permits linking the agency-wide DG system to other available computing resources (e.g., standard microcomputers). Hardware advances present a range of new alternatives for meeting continuing demands for increased system capacity.

With new options on the market and more decentralized acquisition procedures in place, different regions took quite different directions in addressing their late-stage hardware needs. Of the two we visited, for example, one region has chosen to stay with a common, shared-information environment; it has systematically upgraded its DG equipment and will approve other purchases only when they can be shown to be coherent with these group goals (versus individual needs).

The chief disadvantages of the latter choice are twofold. First, the DG versions of some commonly used applications (e.g., spreadsheets) are widely acknowledged to be much more cumbersome than their more popular counterparts that run on other equipment. Second, tasks that involve a lot of processing (any large number-crunching effort, for instance) tax the already overburdened CPUs and ought to be done off-line. One unit, for example, was looking forward to acquiring its first DG engineering workstation so that it could begin to do road design and other engineering applications with an independent source of processing power. "Bootlegged" PCs are meeting interim needs in other units.

The key advantage of the policy is that it enables units in this region to exploit more fully the connectivity provided by the agency-wide DG system for information exchange and use—not simply electronic mail but also formatted documents, processable data tables, and the like. It preserves the shareability of information, applications, and programs—a critical agency-wide goal.

Another region elected instead to make use of low-cost microcomputers now on the market from a number of vendors to augment its computing resources.

One major advantage of this approach is that it alleviates the load on the minicomputer-based system. Another is that it permits users to choose from the array of familiar flexible software packages on the market for meeting ordinary business needs (Lotus 1-2-3, for instance, was in frequent use in this region).
The salient disadvantage of the strategy is that it means sacrificing many—but not all—of the benefits of connectivity. CEO-CONNECT allows microcomputer users to exchange electronic mail and ASCII files with the DG system. But formatted documents, processable spreadsheets, and the like cannot be transferred between systems. A number of respondents, for example, described how they would print out data from the agency-wide DG system, key it into a microcomputer spreadsheet for analysis, and then rekey the results back into the DG system.

Our brief survey of employees in the two regions studied showed that on average 57 percent use some other hardware in addition to the distributed agency-wide system (including not only microcomputers but also other minicomputers, hand-held portables, and the FCCC mainframe). As the foregoing discussion suggests, however, distribution of non-DG hardware use varies substantially by region. Employee survey data are shown by region in Table 3. In addition, occupational differences also result in considerable variation in use of non-DG hardware, as we learned when we examined survey responses by job series (see Table 4).

Microcomputer use within our sample is greatest among technical employees, particularly the forestry (31 percent) and engineering (51 percent) technicians; both groups are also relatively heavy users of the centralized Fort Collins computer facilities. Microcomputer use is next highest among administrative employees, especially computer specialists (50 percent); these specialists report using FCCC in similar proportions. A quarter of professional employees report using microcomputers, with civil engineers the heaviest users in that category (38 percent); a third of civil engineers also use FCCC. Few employees in the clerical category use microcomputers. These data tend to confirm

Table 3

<table>
<thead>
<tr>
<th>PERCENT OF RESPONDENTS PER REGION USING NON-DG HARDWARE</th>
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</thead>
<tbody>
<tr>
<td>Hardware Type</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Micro</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Region A</td>
</tr>
<tr>
<td>Region B</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>
Table 4

PERCENT OF RESPONDENTS PER OCCUPATION USING NON-DG HARDWARE

<table>
<thead>
<tr>
<th>Hardware Type</th>
<th>Micro</th>
<th>FCCC</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional</td>
<td>25%</td>
<td>24%</td>
<td>8%</td>
</tr>
<tr>
<td>Administrative</td>
<td>31%</td>
<td>25%</td>
<td>8%</td>
</tr>
<tr>
<td>Technical</td>
<td>37%</td>
<td>29%</td>
<td>10%</td>
</tr>
<tr>
<td>Clerical</td>
<td>4%</td>
<td>26%</td>
<td>2%</td>
</tr>
</tbody>
</table>

conclusions drawn from interviews about microcomputers; that is, they are used to support quite diverse tasks (e.g., road design, silviculture, budget analysis) whose main commonality is the consumption of a lot of processing cycles.⁵

At this point, then, regions appear to be confronting and responding differently to difficult trade-offs between an array of flexible and powerful marketplace tools on the one hand and strong needs for shareable information on the other.⁶

SOFTWARE

Below we discuss issues concerning software use as well as current and future software development. Our primary findings are:

- Early decisions about software tools have paid off.
- Local development is not always the best solution.
- Software integration is sometimes problematic.

⁵While “computer specialists” typically have higher-level administrative positions, employees with computer expertise and technical responsibilities may be found in a number of positions (e.g., Forestry Technician). Table B.6 in App. B lists titles of jobs with computer-related responsibilities by occupational category.

⁶This is a significant late-stage implementation issue that most large organizations will face. A major difference, however, is that few organizations moving rapidly toward end-user computing in the 1980s began by building a generic infrastructure; more often they began by buying microcomputers and developing “islands of power” that they are now trying to interconnect.
Generic Tools Are Used

The Forest Service's original software implementation strategy was to begin with generic information tools along with tools for the development and use of applications for substantive specialties. These generic tools provided for standard electronic office functions (through CEO software supplied by DG) and additionally gave regions, forests, and districts the capability to design other software (e.g., data entry forms, report generators, tailored spreadsheets and databases, and the like) and to extend or customize in some respects the programs prepared and disseminated by the Washington office. In contrast to the hardware, which was thought to be undersized initially, many believed that the software was "oversized." That is, employees were skeptical about whether the varied options it provided would be used unless the user chanced to be a "card-carrying COBOL programmer." In fact, many local units were able to exploit these agency-wide tools to create special-purpose software applications that meet their needs; use of these tools seems to be increasing. However, taking full advantage of the system's capabilities—a longer-term issue—continues to be hampered by lack of advanced training and commensurate user skills.

The preceding section describes how software applications were used in the context of the task domains we selected for focused study. In addition, we queried interviewees more broadly about the ways the agency-wide system was affecting their unit's work. As explained above, all were asked about important system outcomes. Subsequent items asked about the "biggest payoff" and about unexpected outcomes from information technology use.

Electronic mail—and the capability it provides for ongoing communication with other units—was almost invariably named in response to all three questions. First, electronic mail is accorded great importance as a change agent, being viewed as the aspect of the new technology most responsible for changing the way the Forest Service performs its missions on a day-to-day basis. The perceived payoffs are numerous and varied: interviewees cited greater efficiency in coordination tasks (e.g., coordinating equipment and supplies with the fire dispatch center and fire camps), improved ability to handle teamwork (e.g., interdistrict Wilderness Area management), better recordkeeping and accountability, and the like.

Interestingly, a substantial proportion of employees were surprised both at the extent of use of electronic mail and at its value. One fairly high-level respondent said he and many others had expected word processing to be the most valuable general office application, with electronic mail just a side benefit or luxury of the software. Another
remarked that he and other number-crunching types thought the main benefits of computer technology would come from analysis and modeling, and had been dubious about whether general office technology would offer them anything worthwhile; they were surprised at the extent of their own use of electronic mail (e.g., to get feedback on models, to share methods or programs). As we noted in our discussion of electronic communications in Sec. III, electronic mail procedures were initially structured to replicate formal, hierarchical communication channels, but adept system users could accomplish lateral interactions. As one respondent put it, “e-mail violations of the chain of command” made it “easier to build relationships.” The Forest Service soon removed its hierarchical communication constraints, with the result that later stages of use exhibit substantially increased lateral interaction.

This is not to say that the transition to electronic communication has otherwise been wholly unproblematic. Two persistently mentioned problems are (1) excessive copying, usually by use of distribution lists that send pieces of mail to many more people than want or need them; and (2) inefficiencies in the handling of urgent mail. The former problem could be eliminated by better training in electronic mail practices, according to technical interviewees; they attribute the latter problem partly to users (misuse of the “urgent” option) and partly to the system (it does not consistently do a good job of “pushing urgent mail through”).

Another CEO application, word processing, was also frequently mentioned as having widespread use and significant value. Beneficial outcomes were attributed primarily to time and labor savings, since most employees now do their writing on-line. Besides eliminating keyboarding as a separate step in text production, this practice has also led to reuse of well-worked-out text for types of documents that are inherently repetitious (e.g., some quarterly reports, some kinds of correspondence). Ease of revision is also believed to improve the quality of documents (especially in conjunction with electronic mail, which facilitates the solicitation of feedback). While of significant economic worth (see LAI report and App. A), these kinds of advantages did not take users by surprise.

The CEO graphics package, on the other hand, received lukewarm evaluations from interviewees. At the time of the first study, this software had not yet been implemented, but employees had positive expectations for it just as they did for word processing. By now it is in regular use, but its capabilities have been surpassed by desktop publishing software that appeared on the market in the interim. Respondents commented, however, that in advance they would not have
anticipated they could make use of more graphics capabilities than the CEO package provided. Lowest marks for CEO software go to the spreadsheet and database applications, which also compare unfavorably to commercially available microcomputer packages (these too had not been implemented at the time of the first study). The major problems seem to be (a) a less-than-friendly user interface and (b) enormous memory requirements, particularly for the spreadsheet. At least one district has forbidden any use of spreadsheets except between midnight and 6:00 a.m., to avoid system crashes. As the previous section points out, dissatisfaction with these needed analysis tools partially accounts for the move to acquire standard DG-compatible microcomputers in some sites (in spite of the trade-offs such a move entails).

Procedures for more specialized tasks are developed in the CLI/IS² environment, which provides a range of options for users to design or modify the way they handle information. User-definable function keys, for example, allow individuals to specify frequently used sequences of steps for execution as a single function. Interviews with technical representatives in the sites we visited indicated that a minority of users (ranging from less than 5 percent to about 35 percent) invent their own keyboard macros by consulting the manuals, experimenting, and eventually arriving at procedures that suit their preferences. The majority of others also make use of the specially defined function keys, but they do so by relying on technical help from someone else.

Widespread use of the agency-wide system's applications-building capabilities was reported as well. Instances include forms generation (e.g., property control forms, local personnel forms, law enforcement action records, building maintenance request forms, standardized contracts, standardized offer letters, and the like), tailored queries and report generation (e.g., tabulations of vegetation data, wildlife data, watershed data), and creation of specialized local databases (e.g., range data tables, timber data tables, fire cache inventories, personnel data tables). Additionally, data analysis programs can be designed to incorporate domain-specific requirements along with regular statistical routines. Such applications are typically developed by employees with substantive skills and are used for accomplishing domain-specific tasks. Employees believe these tools not only save time and make report preparation easier, but also improve decisionmaking and resource management. Moreover, these applications seem to be well liked. As

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²The comprehensive electronic office (CEO) is a user-friendly front end to a limited number of functions that can be accessed more directly through the command line interpreter (CLI) or a newer alternative set of information system (IS) tools; the CLI/IS environment also provides access to a broader range of system functions (e.g., statistical programming) not available in CEO.
one systems operator remarked, there are still people who “don’t want to do their own word processing” but “don’t mind running their own application programs.” In fact, subject matter specialists usually find their own applications superior to ones written by systems professionals (who are often unfamiliar with the user’s domain). Initial decisions about software tools, then, have paid off.

Buy, Borrow, or Build?

While generic tools are being used at an increasing rate and in more sophisticated ways, local software development is not necessarily the best solution to late-stage implementation needs. When the Forest Service began its transition to computer-based work, considerable effort was required to build software applications that would support its extremely varied information-intensive missions; it would not have been possible to purchase them ready-made, and there were no portable precedents within the agency or in other agencies to borrow. At present, however, it makes sense to revisit the buy-or-build question in the light of other alternatives.

With this issue in mind, we asked technical representatives in each participating unit about the sources of their current array of software applications. The proportion of locally developed software in these sites ranged from about 1 percent to about 25 percent. Such applications were reported most frequently to support local personnel practices, to meet unique project-oriented needs, or to handle analytic tasks in timber, watershed, and engineering domains. The advantages of the “build” option have already been outlined—sometimes it can be the only way to get what is needed, and sometimes competent people who are highly invested in their missions feel that no one else could produce something just right for them. On the other hand, locally developed applications have a number of drawbacks. For instance, sites report they are very labor intensive—not just to build, but especially to document, maintain, and update. Additionally they sometimes make for difficulties in data sharing. For instance, when local units develop their own timber data tables, combining timber data from multiple districts can be problematic; similarly, combining timber data with range data, even within the same unit, can become problematic.

An alternative to building is buying applications for use on non-DG microcomputer equipment. Off-the-shelf commercial software can save programming and other labor costs because it comes with manuals and training/help support, and it typically offers compatible updates as prior versions become outmoded. Further, the use of such familiar products may improve a local unit’s ability to recruit and train
personnel. In one region we observed extensive use of popular off-the-shelf office software (e.g., spreadsheet and word processing packages). In response to our interview questions, a technical representative in that region commented that the initially planned agency-wide "generic tools were good, but they aren't good enough now relative to PC tools."

However, when DOS-based applications are used, it becomes problematic to combine the resulting data with data from DG applications in the same or different organizational units, as we have noted.

A third option is to "borrow" applications from other units or functional areas. Technical representatives say that they now "look around a lot first" before they undertake any applications writing of their own; they build only when necessary. And one forest representative reported that his unit had initially written its own budget package, but it was subsequently given up in favor of an application borrowed from another unit, which they like better. While we saw many examples of borrowing—especially with engineering applications—we believe it is an option too infrequently exercised relative to its potential value.

Interviewees consistently reported that most borrowing takes place on an informal person-to-person basis, usually across organizational lines (and frequently across regional boundaries). The typical route is via employees who transfer to other units; they remember an application available in their previous location and try to import it to their new unit. There is a software reference library of Forest Service programs maintained at the Washington office, but rarely used. Further, one of the regions we visited conducts an annual software survey, but the results are of little value because many people do not contribute to it. Other avenues mentioned for the diffusion of applications were meetings and conferences as well as networks of users within substantive domains and interest groups. While the agency-wide system would support such sharing, that capability is not systematically exploited to promote the location and transfer of useful software developed locally. The agency should devise ways to encourage and assist borrowing by this means. We elaborate on this point in Sec. V.

Software Integration Needs Improvement

The ability to share information, applications, and processes is a function of software decisions as well as hardware choices.9 Technical

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9These issues are not unique to DG equipment. They would arise with almost any hardware-specific operating system and applications programs targeted so far in advance—especially during a period of very rapid technological change (for example, see McDonough, 1988).

9Sometimes these are interdependent factors whose effects are not easy to separate. For instance, interview responses suggest to us that engineering applications are run on
representatives as well as subject matter specialists in both regions cited the need for better integrated and more compatible software systems as an important future information technology objective. As one forest supervisor put it, “strategic planning” is necessary to “maintain national integration.” Said another, more than anything new, “we need to integrate what we have.”

Interestingly, the call for improved integration comes equally from microcomputer-using units and units primarily using the network of terminals and minicomputers. Many microcomputer users, for instance, think that microcomputer decisions have become “too decentralized” and that “standardized applications” are needed; others regard “interchangeability” as the chief need. One unit had, in fact, standardized on a word processing package and a spreadsheet for its microcomputers, but its other microcomputer applications (e.g., those used in silviculture or road design) remained diverse and self-contained. On the other hand, even the most committed DG users and system operators contend that its applications are not fully integrated; the need to integrate resource management applications on the agency-wide system, for example, received special emphasis in several interviews.

We gave careful attention to software integration issues within the agency-wide DG environment since they would remain even if problems of portability, interoperability, file conversion, and the like were resolved; further, they pose the greatest challenge to effective use of “corporate” information. In this context, we distinguished three kinds of integration difficulties:

- It is not always possible to move data between relevant applications (e.g., “the FORPLAN [forest planning model] process should be able to tie its results directly to budgets to show the implications of different decisions”).
- Databases are often incompatible, so that aggregation of data becomes difficult within resource areas (e.g., combining timber data from different ranger districts has been mentioned as a problem) or between resources within the same Forest Service units (e.g., it is not possible to use CEO-PRESENT to generate...
a combined report about range and timber data in a forest, although this report generation program can be used to produce separate reports about each resource).  

- Some applications are uniquely linked to particular databases (e.g., the R1R sediment analysis model is tied to the INFORMS database).

As the Forest Service moves further toward its goal of uniform information structures and access procedures for organization-wide resource data, many of these integration problems will be alleviated. Their resolution should be given high priority, according to most respondents, to set the stage for the next wave of technological innovation—geographic information systems (GIS) that will enable spatial display of resource data.

SYSTEMS-IN-USE

By “systems-in-use” we mean the diversity of hardware and software that an organization in fact employs to carry out its missions. In the Forest Service, systems-in-use are highly adapted to local contexts while participating in the overall information structure and communications network. Each of the units we visited had incorporated a number of different systems, evolving a distinctive pattern of use to meet its needs.

Local diversity, however, has to be balanced with overall organizational needs for a common information environment. This can create tension between local autonomy or decentralization and centralized planning, budget direction, and control. Such tension, reported in our first study, still exists. We see even greater local divergence now, in late-stage implementation. Internalization has resulted in the emergence of diverse “computing subcultures,” although there continues to be a need for centralized agency roles in the resolution of issues concerning connectivity, software integration, “corporate” applications, and system-wide database management. Preceding sections provided evidence of the diverse nature of systems-in-use in discussions of hardware and software internalization; this section supplements those discussions and calls attention to their implications.

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10The difficulty of combining information from different functional areas is exacerbated when the databases are updated on different or irregular schedules.
Centralized Systems and the New Information Technology

Issues of whether and how to embed new microcomputer technology within the agency-wide DG infrastructure were described in previous sections of this chapter. It is appropriate to recall, however, that similar kinds of issues arose with respect to the implementation of DG minicomputer technology in environments formerly characterized by heavy dependence on centralized systems at FCCC for data processing and data analysis tasks. When the earlier study was conducted, it was not clear just how the two systems would work together to support local tasks, but the aim was to provide for greater unit-level capabilities and responsibilities related to data-intensive work. Consequently, it was of interest in the present project to learn in what ways these old and new technologies have merged within the Forest Service's systems-in-use.

While the two regions we studied make very different use of microcomputers, they make quite comparable use of the older FCCC system (see Table 3 above). We also observed that fairly comparable proportions of employees across major occupational categories work with FCCC (see Table 4). FCCC continues to be used primarily for data-intensive applications in land management planning in general and timber management in particular (e.g., FORPLAN, TMDB, STARS, TRACS). However, the manner in which it is used has changed considerably.

Throughout the units we visited, the distributed system serves as the infrastructure for using FCCC in at least three ways. First, data may be accessed and analyzed remotely, with the agency-wide network serving essentially to provide dumb terminals to FCCC; this is the only feasible option for running some very large applications (e.g., growth simulation). Second, data may be accessed and downloaded directly to CLI applications for local analysis; this is the preferred option, for example, for unit-level timber database managers doing tasks that are narrower than full-scale land management planning. Other users, however, are more likely to rely on CEO-CONNECT for accessing and downloading data for local analysis. While most databases housed at FCCC are still centrally created and maintained, some changes are noteworthy; for instance, ranger districts enter their own data for timber sales tracking and reporting into STARS, where it subsequently may be accessed by other levels (e.g., regional offices).

Technical representatives in all units were asked what impact the distributed system was having on their use of FCCC. The short answer

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seems to be that units are using it more but liking it less. On the one hand, local units make more frequent use of FCCC data because of online access provided by the agency-wide infrastructure. Formerly, most local units requested analyses from FCCC, which sent printouts in response; the present procedures represent a major improvement. On the other hand, these procedures seem quite cumbersome in comparison with local computing arrangements. The following comments are illustrative of reported difficulties:

Hardware connections are never smooth.
You sometimes lose items of data accessing Fort Collins databases.
Conversion of data for use with DG applications is difficult.
The biggest problem is the interface to Fort Collins.
Working with the FCCC is like an art form.

In general, most of the sites we visited prefer to download data and run applications locally whenever feasible. So, while units are doing more with FCCC data than they did before, remote use of the centralized system is declining in favor of local use.

It would appear, then, that the initial aim of providing a means for units to access and analyze centrally stored data has largely been realized. However, the interface between the new and old systems is seen as needing considerable improvement—users like it less the more they deal with it. In part, the dissatisfaction with existing connections to FCCC probably reflects changing expectations of the sort noted earlier. That is, as newer and more flexible technologies become available, users’ standards change and older technologies become commensurately less acceptable by contrast. The dissatisfaction undoubtedly also stems from the need to learn (and remember) how to use multiple systems and applications that lack a consistent user interface.

While we did not direct research attention to the National Finance Center (NFC), it nonetheless became clear in the course of our interviews that similar findings would apply to that centralized system as well.\textsuperscript{12} Purchasing and budget data for the Department of Agriculture as a whole are maintained at NFC. Forest Service units report making more use of these data than before, because of the access its networked system provides. However, those databases are still underused because NFC applications are generally so difficult. More importantly, while

\textsuperscript{12}We did not examine relationships between the Forest Service's agency-wide system and the NFC system since the latter serves the entire Department of Agriculture and is not controlled by information technology decisions at any level of the Forest Service. However, interviews with administrative officers and with program development and budget staff often evoked comments about NFC.
the NFC budget reports are not particularly difficult to use, many sites are unable to base decisions on them because the data are too old; one administrative officer, for example, says that NFC output is regularly out of date by three weeks. Consequently, Forest Service units often maintain their own financial data in parallel using BMA.Notes, an application that allows for direct data entry and manipulation—with immediate updating of budget reports—locally. In these cases, BMA.Notes output is the de facto basis for local decisionmaking, even though it does not constitute an official budget record. In fact, its use is officially strongly discouraged.

The picture of systems-in-use within the Forest Service, then, is a very complex one: the agency-wide minicomputer-based system supports electronic mail and a variety of administrative and substantive applications; in addition, it provides an infrastructure for accessing older centralized systems on the one hand and connecting with newer microcomputer systems on the other. Taking full advantage of the information technology mix requires knowing how to navigate through a number of systems and understanding what tasks are best done with which tools. To make this happen, according to one respondent, “you need a local guru with up-to-date knowledge about how to get around [in the systems].” According to another, what is needed most is “more transparent access” to the different systems.

Probably it will continue to be necessary or desirable for the foreseeable future to have some databases and applications centralized and standardized in the Forest Service; budgets, for example, are a likely candidate in any government agency. Such systems are nevertheless apt to pose difficulties for the Forest Service for a number of reasons. First, as uniform and mandatory, they seem to conflict with the high value placed on local autonomy. Second, as older systems, they suffer by contrast with the more flexible tools available in the distributed system environment. But even if they did not, having to cope with a number of different interfaces is itself problematic for users. Consequently, it is worth a serious effort to determine what needs to be

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13Interestingly, interviewees most favorable to the NFC reports are those who have not used BMA.Notes. It would seem that being able to access corporate budget data online and generate reports remotely is viewed as a major improvement over the old way of doing business—until a more flexible and responsive new technology appears.

14We should underscore that these are late-stage implementation issues. Most large organizations—including those where end-user computing is well established—have not introduced media for making centralized corporate systems and databases directly available to and manipulable by low-level units, and so have yet to address many of these questions.
standardized or centralized for the agency, and why.\textsuperscript{15} Databases, applications, and processes that fall within this category merit special attention at the national level to assure their functionality and usability. Development of easy access mechanisms, consistent interfaces, usable formats, timely and coordinated update procedures, conversion programs, and the like should be given high priority for any centralized or standardized systems. Finally, the Forest Service needs to keep re-evaluating its approach to agency-wide versus local systems as relevant technologies (e.g., storage media) change. Otherwise, corporate information systems are likely to be routinely devalued.

**Data (Mis)management**

Our inquiry into systems-in-use found that Forest Service sites are heavily dependent on multiple kinds of information as well as information technology. In earlier sections of this chapter we described database problems that arise when users attempt to combine information about different resource areas (e.g., range and timber data) or even information about the same resource area drawn from different data tables. These are problems of software integration and compatibility that need not be reviewed here.\textsuperscript{16}

Other issues about the effective use of information resources surfaced in the course of the study that are better treated as data management problems—or, data (mis)management. Currently these problems are perceived by most users as relatively minor inconveniences in comparison with database integration issues; however, as database integration proceeds and increasing numbers of users are sharing pooled information resources, these problems will be exacerbated. The most commonly cited difficulties in this category are summarized below.

1. Too many duplicate files are created and saved, taking up scarce storage space and slowing system processes. In part, according to technical interviewees, this represents inadequate

\textsuperscript{15}For instance, if development of corporate information resources is the aim, the agency might choose to promulgate data interchange standards, stating exactly what format data must have for transfer to higher levels or to shared facilities; how data are to be mapped into that format (e.g., by using applications that meet the standard or by acquiring conversion programs) could remain a local option.

\textsuperscript{16}Media incompatibility was also mentioned when there is a need to combine on-line data with information still maintained in paper files. For example, fire management specialists use many on-line inventories, but the fire cache inventory is still paper based. This is an almost inevitable aspect of the long-term implementation process, since it is not feasible to convert all information resources from paper to electronic media concurrently. Such mixed media systems are likely to be in use for some time to come, particularly for tasks that require bringing very old as well as recent data into consideration.
understanding of the information architecture and of efficient ways to search for and use files in shared space.

2. Even more problematic is the inability to find needed data files, even with an efficient search strategy. Often, data files from different locations must be merged. Different locations may use different terminology for the same data, or, as a recent Forest Service study pointed out, may collect different data for common components, such as resource areas.\(^\text{17}\)

3. A third issue has to do with data updating. According to users, databases are not updated promptly or on regular schedules, and often data that need to be merged are updated on different schedules. As one user put it, “There is not enough stability in updates.”

4. A final issue has simply to do with the magnitude of information with which Forest Service employees must deal. Many report “information overload,” an experience that is intensified by the preceding practices.

That users undergo the difficulties outlined above is not surprising. Very few Forest Service employees have formal training in database management. Even for those who do, as a timber database manager commented, “keeping up with database maintenance is hard—you have to get the right people to do the right kind of job with maintenance.” As yet there are no established answers to questions about how to enable subject matter specialists to make effective use of shared distributed information resources.

Part of the answer lies in the introduction of higher-level query languages (as exemplified by the agency’s Structured Query Language [SQL] efforts) and other software that will assist users in locating, merging, and manipulating distributed data files. More importantly, however, the agency needs to conduct regular, careful studies of file management in systems as actually used, identifying the most frequent practices and problems and suggesting alternative information management strategies. The Resource Information Project study is a step in that direction. Finally, to the extent that meeting resource area objectives requires facility in the management and use of distributed databases, more advanced training in these procedures should be provided to subject matter specialists. It would be appropriate to initiate such activities now, since the store of on-line information is growing and since efforts are underway to enable even broader pooling of information over substantive domains.

As we mentioned, no critical obstacles to Forest Service work appear to be created by data (mis)management. On the contrary, inefficiencies in the use of on-line databases are small in comparison with the benefits of such information resources (for corroboration, refer to the preceding discussion of missions, tasks, and tools). But while these difficulties may not hinder ongoing work at the level of any particular system-in-use, they present definite impediments to the vision of broadly shared information, pooled across systems to comprise agency-wide resources. As one respondent put it, “The information may be highly functional, but it isn’t corporate.”

Emergence of Different Computing Subcultures

Differences in early implementation strategies have resulted in even greater diversity as the system was internalized. Although all Forest Service units received essentially similar hardware and software, as documented in our previous study, regions adopted different policies for the transition from old to new working procedures. One studied region, for instance, pushed for rapid adaptation to the new technology but gave users a great deal of latitude in accomplishing this objective within their own task areas; the other region aimed for a slower and more structured transition, and emphasized the implementation of the most widely used applications first. These differences in approach translated into quite different systems-in-use. Subsequently, as reported above, one region continued to promote the common technological infrastructure, investing more of its resources in DG equipment and compatible software; the other pursued an alternative course, supporting the acquisition and use of a wider variety of technology (e.g., microcomputers and PC-compatible software packages) to meet individual task needs. Another way to characterize the diverse orientations is to say that one region puts emphasis on making the same tools available to everyone, the other on allowing people to have individual tools.

While regional differences are most salient, computing subcultures vary along other noteworthy dimensions as well. Our first study, for example, reported the frequently mentioned concern that only skilled programmers would be able to operate in the CLI/IS environment. While this fear was not well founded, there does appear to be a split between CEO and CLI subcultures. For instance, in the CEO subculture, users do their own word processing; in the CLI subculture, this is resisted. In the CLI subculture, on the other hand, users run (and often write) their own applications programs; “organizational macho” was a phrase used by one interviewee to characterize their systems
stance. Electronic mail seems to be the major bridging technology being used in both subcultures.\footnote{These characterizations are intended to be suggestive only; a more focused study would be required to do justice to variations in computing subcultures. Since this construct did not guide but rather emerged from the research, it was not specifically targeted in interviews.}

Another dimension on which subcultures vary pertains to system security. Some sites have internalized serious safeguarding procedures. Responding to an interview question about such protections, for instance, a technical representative in one unit said, "We have strict password controls and rules, and they are closely followed." At other sites, in contrast, the same question elicited responses suggesting the existence of similar rules but not as careful observance. For example, a technical representative in one such unit said, "Staff and line management don't recognize the problem. . . . They share access, passwords, files, whatever—without regard for security issues."

Still another dimension has to do with management practices. Some districts still centralize typing; others encourage universal keyboarding. Some exercise tight control over incoming "junk mail," while others have no central control. Some allow individual users to bring up their own applications; others do not. In short, the same basic system can turn into many different kinds of work environments.

These dimensions are indicative of the kinds of differences that can be found among systems-in-use. It is not clear what the long-run effects of variation in computing subcultures will be. At present such differences appear to have greatest impact on employees who encounter them in transferring from one site to another. For instance, some employees who had transferred between regions reported significant "culture shock" at having to learn new computing practices to accomplish their jobs. Said one respondent, "Region [ ] is two or three years ahead of my previous region—it's much more in a doing mode." We would also expect to observe similar differences in the transferability of information tools. For example, standardized software developed at the national level might be readily assimilated within one region but not another.

It is possible that variation in computing subcultures could work against centralization and standardization of information tools even when it is desirable. On the other hand, it could lead to new alternatives for thinking about how agency-wide systems should be organized. In response to an interview question about next steps with information technology, for instance, one respondent suggested that systems be "stratified" by purpose or type (general office versus corporate databases versus dedicated applications, and so on); hardware and software
acquisition as well as training, support, and maintenance could be organized accordingly. Such policies might have the effect of generating uniform horizontal strata rather than wholly centralized and standardized approaches. Another respondent answered the same question by recommending the organization of information systems around resource areas, to be administered and managed through special resource offices rather than through the existing Forest Service hierarchy. In fact, there appear to be regional differences in opinion about the relationship between information technology and organizational hierarchy. A forester in one of the regional offices we visited reported that the current system “has certainly had a centralizing effect on the Forest Service.” His counterpart in the other region told us that “it makes decentralization much easier.” While such comments shed little light on centralization and decentralization per se, they provide evidence that when information technology is internalized, its effects are likely to be manifested, not necessarily in consistent or predictable ways, in the broader organizational culture.\textsuperscript{19}

HUMANWARE

In all our studies of the use of information technology by organizations, a central theme recurs: it is the skills, knowledge resources, and technical support provided by and to individual people, as much if not more than the hardware and software, that makes a system work well or poorly. Accordingly, we have coined the term “humanware” as a way of reminding those who work with systems that properties such as maintenance, basic and advanced training, and the cultivation and encouragement of user competence need to receive equal attention in the design, planning, and implementation of information processing technology.\textsuperscript{20}

The Forest Service has encountered a good many humanware problems over the course of the implementation of the agency-wide system, a number of which were noted in the earlier RAND report. Since then, the situation has improved in many ways. However, with the passage of time a number of new humanware issues have come to the fore, in spite of the assumption widely held in organizations that “training” is a

\textsuperscript{19} Effects of computer-based information technology on centralization and decentralization in the Forest Service are discussed in Sec. V.

\textsuperscript{20} It is worth noting that the implementation process is inextricably bound up with “people” issues. Since the technology works only to the degree that it is used by human beings, the human end of the equation is as least as critical as the machine end. Humanware issues should be regarded as opportunities to contribute to resolution of overall technological concerns, not as a separate and unfortunate corollary.
one-time, early-stage implementation requirement. Humanware needs systematic upgrading along with the hardware and software. This area thus remains one to which careful attention needs to be devoted, particularly as the Forest Service moves toward even more complex and powerful technology (e.g., through GIS implementation). More technology will not “solve” humanware problems, but it may exacerbate them. Our primary findings are:

- Employee computer skills continue to improve.
- Advanced training opportunities are lacking.
- “Gurus” are an endangered species.
- Human resources cannot be readily replaced.
- Current human resource policies are inadequate.

Uneven Computer Skills

The first major area of concern is the patterns of learning about the system that have characterized Forest Service units over time. In general, employees have moved relatively rapidly up the learning curve—and in fact are still gaining. There is, however, wide variation across and even within units in terms of the skills available to use the system effectively. Moreover, the arrangements for cultivating and encouraging individuals to expand their system use skills are highly ad hoc, and often can be accomplished only at significant cost to the users and to the missions of their units.

Basic Training and Advanced Learning

Basic training in CEO core applications (word processing and electronic mail) is generally adequate in most units. It appears to be carried out largely through one-to-one tutoring—a few hours spent with each new employee coming on board, usually provided by the system manager or another staff person. Since most units have relatively few new employees at any given time, this arrangement is generally satisfactory. The core applications are easy enough to learn that a limited briefing, supplemented with the ability to ask questions of systems staff and others freely in the first months of use, can get employees into the system quickly. It has been noted by many staff that new employees entering the Forest Service today, particularly younger people recently out of school, already have an orientation toward computers that allows them to assimilate the technology more easily than employees without this kind of background. In general, acquiring a basic “comfort level” with the generic agency-wide tools, either prior to
joining the Forest Service or shortly thereafter, is relatively easy and is effectively carried out.

The problem becomes increasingly acute, however, when employees become able to and want to make more advanced use of the system’s capacities. Training beyond the initial stage is generally provided at the forest level (some courses are run by the regions, particularly in the most specialized applications, such as computer-assisted design [CAD]). Training is generally focused on particular applications such as spreadsheets or data tables; only rarely does it focus on a mission area as such, or on system processes, information resources, or database management. Further, this training is often difficult to come by for busy professionals; it is very common for individuals to try instead to teach themselves more advanced applications for which they have perceived a need. Very few districts appear to have any systematic strategy for training their staff on domain-relevant applications, or to do much to assist individuals who self-identify training needs.

Self-teaching can lead to “reinventing” applications, a process that has both benefits and costs. For example, in one forest with two adjoining ranger districts, we identified five separate budget spreadsheets being used by five different individuals. The existence of each was unknown to the others. Users were keying in their own data—often data that were available elsewhere. Two of the users had had basic spreadsheet training; one had attended a Lotus 1-2-3 course at the local community college; and two had simply figured out the program on their own from the manuals. There was no effective sharing of either data or expertise among these staff. While the individuals involved had clearly learned a lot about spreadsheets in the process of setting up their programs, that effort could have been considerably enhanced if they had not had to figure out everything by themselves.

Another area where substantial reinvention efforts take place is fire cache inventories. We identified numerous examples, ranging from simple lists of equipment kept in a word processing text file to elaborate data tables and spreadsheets. These were generally created by fire management officers—occasionally by summer staff who had computer expertise—with very little help from others.

In sum, at present the process of learning applications beyond the introductory level is largely an individually directed effort, driven by immediate needs rather than organizational strategies. The fact that so many individuals have identified their own learning needs and sought out opportunities to fill them speaks highly for their motivation. However, this fact also points out that a wide range of needs is essentially being left unmet by the laissez-faire training and staff development policies currently in effect in most units. The more the Forest
Service moves toward a complex shared-information environment, the more important it will be to have systematic procedures in place to cultivate and support the skills needed to operate effectively in that environment.

**Gurus Are an Endangered Species**

A key element in humanware is the local “computer guru”—the individual who by virtue of talents and interests, as well as understanding the organization’s work, becomes significantly more informed about the system and its uses than his or her peers. The guru assumes a consultation role, helping others to use the system better. These individuals are the source of a significant proportion of informal advanced training, and take up much of the slack in applications modification or development, system maintenance, general user support, and technical assistance.

Unfortunately, our study indicates that gurus are fast becoming an “endangered species” within the Forest Service. At site after site, we were told of the local guru who had just left the office, sometimes for another position within the Forest Service (generally at one of the research stations), sometimes for private business, or occasionally to return to school. These gurus often held relatively low-level formal positions (e.g., forestry technicians) and had simply taken to the technology. It appears particularly hard for district-level units to retain gurus; those who survive in the role are more commonly found at the forest level. In practice, this means that it is often difficult for personnel in the districts to get quick and informal access to the help they need.

This is certainly an area where the Forest Service can adjust its policies with high expectation for significantly improving the situation. Provisions can be made to recognize and reward individuals for becoming local experts and to facilitate their retention. To some degree, this involves recognizing the role explicitly rather than expecting these people to perform all their regular duties in addition to the guru role. There is a distinct tendency toward burnout among these individuals, a factor that contributes significantly to their mobility out of the system. If this humanware component of the evolving systems-in-use fails, it will be ever more difficult to maintain consistent levels of use and performance across the agency.

**Expertise Is Not Easily Replaced**

Humanware is a perishable and scarce commodity, and cannot readily be replaced once lost. This is equally true for senior staff
members with extensive experience, "junior" gurus, or secretaries who have become competent system operators. Whenever a person moves on, there is always lag time before the replacement—assuming a replacement can be found—comes up to speed. When, as in the case of most Forest Service units, the knowledge is highly concentrated in a few individuals rather than broadly shared, the problem is compounded.

Current human resource policies generally do not give adequate attention to these issues. In very few cases, for example, are system-related duties made an explicit part of the job. (An exception is the system operator job, but even in this case the position is not infrequently filled by a person on a general forestry technician job sheet.) Titles and pay are generally based on criteria wholly unrelated to the use of the information system, and vary widely from region to region and forest to forest. System responsibilities are generally considered to be "collateral duty," an open phrase that covers a multitude of tasks. While this device provides an admirable degree of flexibility to the agency, it also makes the systematic cultivation and support of humanware significantly more difficult.

In summary, the Forest Service has yet to bring its humanware components and support up to the level represented by its hardware and software. The systematic development of individual knowledge and skills, and encouragement for sharing these skills among staff, deserves careful consideration by Forest Service management.

\[21\] The collateral duty policy is frequently used for short-term job assignments, when, for example, a job becomes vacant and cannot be immediately filled. Individuals are assigned to fill in and perform other job functions on a collateral duty basis, until the vacancy is filled. With the implementation of the agency-wide system, collateral duty has also been used to conduct system-related training activities or to perform regular system-related tasks.
V. CONCLUSIONS AND RECOMMENDATIONS

At the end of our initial implementation study, we concluded that the Forest Service had developed a system concept—an agency-wide network of generic tools and shareable information resources—that was ahead of its time. It was and is innovative in design, informed by insights into the organizational culture and mission, and unprecedented in scope. Essentially, the Forest Service has put into place a technology that fundamentally reshaped and conditioned almost all aspects of its work. It has done so in an atmosphere not without conflicts and controversies, but in general characterized by a high degree of efficiency and goodwill. In short, the Forest Service has succeeded in internalizing the new technology to a startling and gratifying degree, while maintaining its mission focus and essential organizational culture. We come away with four major conclusions.

CONCLUSIONS

1. Skeptics and Enthusiasts Camp Together

Perhaps the most striking aspect of this internalization process has been the degree to which those who were initially system enthusiasts and those who were initially skeptics have come to share the same general vision of the technology and its place in the Forest Service. This has entailed compromises of vision on both sides. The impact of the agency-wide system remains far short of what some expected to achieve with it; in particular, the data management function is still in many ways essentially unchanged (although more automated). On the other hand, the technology pervades the daily work of rangers and other personnel in a far-reaching yet largely unconscious manner. Communication patterns have been particularly affected. The phrase "to DG it," meaning to transmit something on the electronic network, has become widely used.\(^1\) Real foresters do use keyboards. And there is an

\(^1\)Our favorite example of the internalization of electronic mail was provided by an interviewee in the Washington office. He related that two Forest Service employees, traveling from out of town, were expected at his home for dinner. Weather slowed the travelers, who stopped at a forest supervisor’s office along their route to send him a message saying that they would not arrive in time for dinner. Our interviewee responded automatically by attempting to forward the message to his wife, forgetting for the moment that they had no computer at home.
appreciation of what the next wave of technology might bring that is considerably facilitated by an understanding on the part of staff of what they have achieved thus far.

2. Computing Has Been Internalized

Our data also indicate that the Forest Service has internalized computing, not computers. That is, it is the process of using the technology, not just the machines per se, that has diffused throughout the organization. Even in the more remote districts, use of the tools is a daily occurrence for people at all levels of the hierarchy. The technology has been built into so many different kinds of Forest Service processes, from timber sale preparation to fire management, that it is literally difficult for staff to remember how things were done in the old days.

This internalization is also evident in the emergence of computing subcultures—the sets of more or less implicit assumptions, beliefs, and values about computers and computing that we described above. Since the Forest Service permitted widely divergent implementation strategies to be pursued in different regions, distinct computer subcultures flourish in different places. In fact, even within forests there are differences between districts in terms of practices for mail handling, staff keyboarding, microcomputer use, and the like. In general, the identifying characteristics of any computer subculture seem to be more a function of the implementation strategy than of the technology per se.

3. Late-Stage Implementation Gives Rise to New Issues

Over the years the issues facing the Forest Service in the quest for effective use of its computer technology have changed. At the time of our initial report, issues of internalization were still live. Would the technology be accepted by diverse people of different ranks and educational backgrounds? Could adequate tools be developed to support major Forest Service missions? Could existing manual processes be successfully converted to new automated formats? As these questions have come increasingly to be answered affirmatively, new questions have taken their place.

Later-stage implementation issues are systematically different from earlier concerns. The Forest Service now faces the need to make full use of its tools by actively redesigning products and processes to operate in the electronic milieu, rather than merely making direct translations from the manual realm (e.g., screen versions of paper
forms). Tools that are newly developed in the electronic environment need to be shared and maintained, not just created and used. And the computing environment itself needs to adapt to an atmosphere of continuing change, in which there is never any technology state that, if achieved, means the information system is "done" or "completed." On the contrary, during periods of rapid technical advance, there is the danger that system plans can obsolesce even before they have been fully implemented. In short, the issues today are much less those of how to make the early moves into the electronic environment; much more concern now focuses on how to keep moving steadily forward within that environment on all fronts of work.

4. Healthy Tensions Still Exist

The Forest Service has maintained a healthy and stimulating tension between centralization and decentralization in its computing applications to date. The centralized nature of the original procurement was balanced by a pluralism in implementation strategies between regions and forests that allowed local needs to be taken into account; a range of different governing assumptions guided the process. Thus the essentially decentralized nature of Forest Service administrative practice has been preserved and reinforced by the technology, not undermined by it. The balance of functions and responsibilities has not remained unaffected by the tools. While some functions have become more centralized, and while the communications system allows a much closer degree of interaction between central management and the field, there has been a parallel delegation of authority and responsibility to the field in other key areas. (e.g., some position classification authority formerly reserved to the WO has been delegated to lower units).

It remains to be seen how the next wave of technology procurements—geographic information system (GIS) tools—will affect this balance of authority and responsibility. Certainly the initial direction will be set at the Washington office level, if only because that is where the core hardware procurement process must by law be managed. The regions, forests, and ranger districts must develop their own patterns of initiative to bring the technology into their environments in creative and useful ways consistent with local needs and practices. The WO procurement strategy needs to be as open and flexible as possible, recognizing that once again the balances may shift, but that it is in the interest of the Forest Service to maintain an essential distribution of responsibilities. The emphasis must continue to be on the functionality of the GIS, on the creation and sharing of a vision of work that
continues within the Forest Service patterns but adds new and useful technical dimensions. The tools are secondary; the work, primary.

In conclusion, the Forest Service remains at the leading edge of government, and other nationwide organizations as well, in the implementation of large-scale distributed communication and information processing technologies. The bad news is that the Forest Service has very few role models and remarkably little received wisdom to guide its progress into the future. The good news is that the Forest Service can become a model in its own right, and has the potential to gain advantages from the technology that will elude latecomers to this arena for some years.

RECOMMENDATIONS: THE TECHNOLOGY

At this stage of the implementation process we see a need for new policies to govern hardware and software acquisition and use. These policies must aim toward developing the current mixed technology environment in ways that take advantage of technological advances on the one hand, and agency needs and capabilities on the other.

Developing a Mixed Environment

A critical late-stage implementation issue for the Forest Service is how to define a strategy for developing, interconnecting, and supporting a mixed hardware and software environment; its users should, in the future, be able to say yes to multiple alternatives rather than learn to live with trade-offs. Restriction to a single-vendor environment served the early-stage technology implementation aims of building a consistent agency-wide infrastructure and bringing a critical mass of users up to speed on a common set of information tools and practices. But now it is unlikely that vendor-specific technology dependence is in the agency's best interests as its users' skills and expectations increase and as diverse technically advanced products continue to appear in the marketplace. Practically speaking, all units are coping to some extent with heterogeneous systems in spite of the initial plan for a common environment.

There are a number of reasons why today's trade-offs will probably not remain viable. First, there is an evident need for stand-alone CPUs. For handling very large applications, both current (e.g., road design) and future (e.g., manipulating geographic information), powerful workstations are required. But a number of other processing tasks should probably be done off-line as well (e.g., budget analysis), even
though they may not require special hardware. As more and more analytic tasks are performed at forest and district levels using locally controlled databases, these needs will mount. Such considerations argue for hardware policies that include a range of options. However, at present microcomputer acquisitions seem to occur without an overarching strategy for their eventual integration or evolution into the larger environment. As a technical representative in one of the sites now pursuing the microcomputer alternative told us, "PCs haven't really been treated as an information system issue"; they have been purchased with specific applications in mind.

Second, there is an equally evident need for initiatives to expand networking capabilities and to support text and data interchange between varied types of hardware. Sites pursuing the DG alternative have begun to experience this need in relation to authorized and fugitive microcomputer use, and future generations of GIS technology will require that such steps be taken. Additionally, such initiatives are important in view of the agency's interest in potential gateways and interchange with other organizations in the United States and Canada; in some functional areas, electronic interagency interactions have already been established (e.g., the Idaho Panhandle National Forest has on-line communications with the Idaho State Department of Forestry). And the Forest Service has to be able in the future to transmit its official electronic record material to the National Archives.

Providing effectively for a diverse but interconnected hardware environment is a significant challenge and one for which there are not yet adequate precedents. While some pieces of the solution are available (e.g., gateways, local area networks, conversion programs), they do not operate consistently across varied hardware and software. For example, PCs may lack straightforward ethernet connection mechanisms, and interchange programs do not always work suitably for microcomputers and workstations or between microcomputers with different operating systems such as PCs and Macs; and even the CEO connection to FCCC, according to users, is not graceful and not always reliable. Such between-system transfers become even more formidable when they involve complex databases, text documents in which the original presentation must be preserved, or compound documents comprising text, images, graphs, tables, and the like. That is to say, there is not yet a marketplace solution for the problem as a whole. However, it is desirable to get a head start on the problem before the next generation of powerful workstations joins the Forest Service's technology milieu.
A mixed environment strategy probably requires leadership and support at the national level, for at least two reasons. First, it is an agency-wide issue, given the continuing need to share files and transfer information horizontally and vertically between units as well as the growing need for interorganizational exchange. Second, it will call for technical development efforts likely to outrun local resources and expertise. It was appropriate to relax centralized restrictions on hardware acquisition after the initial installation phase. But there is an important late-stage role for national-level policies, less in providing vendor-based hardware standards than in promoting system-independent interchange standards. Specific steps in this direction, for example, might include: exploring available interchange programs and testing likely candidates in Forest Service environments (or developing them where suitable programs are lacking for anticipated agency needs); developing and supporting gateways between the agency infrastructure and other networks; monitoring the activities of national and international standards bodies as well as other large U.S. agencies, with a view to assuring the Forest Service’s ability to interact electronically with other organizations that share its domain interests; and assisting regional evolution toward diverse but integrated hardware milieux.

**Buy First, Borrow Second, Build Last**

Like hardware, software policies are in a state of flux reflecting the vastly increased complexity of the software environment in the years since the original distributed system procurement. Acquisition of software suitable to the variety of Forest Service tasks has not always been easy. The original set of “generic” DG software tools (word processing, spreadsheet, data tables) has proved remarkably flexible and capable of being used in diverse ways, but not always to best effect.

Forest Service personnel have succeeded in using their generic tools to build a great many different specific applications. But in the “buy or build” decision, it may now be better to “buy,” particularly with the variety of commercial software applications available. Off-the-shelf software purchases can save scarce resources currently spent on software development and support services. Commercial software comes with training manuals, help and support capabilities, and compatible updates that often increase capacity or flexibility. One region already makes extensive use of off-the-shelf spreadsheet and word processing packages on its microcomputers.
A second option is to “borrow” applications from other units or functional areas. While there are many examples of borrowing, it is probably altogether too infrequent. Most borrowing takes place strictly on a person-to-person basis, usually across organizational (and frequently regional) lines. For instance, employees who come into a new setting remember an application that was available in their former location and try to import it. Other applications may be found at conferences or workshops. While the agency-wide system supports this sharing, its implementation is totally ad hoc, without strategy, and frequently without consideration for the new information environment. The reliance on informal, interpersonal networks for information about potentially useful applications means that there is little systematic search for electronic tools available elsewhere in the agency. The Forest Service should explore ways to encourage and assist borrowing, beyond having “application libraries” that do not seem to be used. It might, for example, institute a standing, on-line “conference on applications” that would let users put their programs/applications on an electronic bulletin board for others to download and use.

While the option to create customized software needs to be available, there is a tendency on the part of competent people who are highly invested in their missions to feel that only they are capable of designing and creating applications that will effectively meet their needs. This belief needs to be treated gently, since it is a sign of commitment and pride in one's work and capacities. On the other hand, it consumes resources and takes the time of professional specialists away from their primary missions. In general, arguments for in-house development of applications must be seriously weighed against other available options.

**RECOMMENDATIONS: ORGANIZATION AND MANAGEMENT**

Every analysis of the impact of technology on organizations, and ours is no exception, eventually comes to the conclusion that the specifics of the technology are far less critical to its effective use than are the organizational arrangements for managing, supporting, and assessing results of system use. Our study indicates that the Forest Service has made major strides in coming to terms with these issues, but that a number of areas remain critically sensitive and in need of careful attention in the immediate future. In particular, we believe that issues of training and personnel management, centralization, and dissemination need emphasis.
Develop New Human Resource Policies

While the Forest Service has been generally successful in its development and retention of information system expertise, current human resource “policies” appear to be primarily a set of default options that at best have thus far not resulted in any catastrophes. While there are warning signs on the horizon, many agency personnel, especially at higher levels, do not realize the scope of the problems or the urgency of the need to resolve them. The issue is simple: how to reward and therefore reinforce the development of expertise.

As new computer-based technologies have spread throughout the Forest Service, considerable learning and adaptive performance by many employees at all levels has ensued. In many cases the employees had jobs that did not necessarily include system operation and maintenance (e.g., secretaries), complex applications development (e.g., silviculturists), logistic simulation (e.g., fire protection), or the like. Forest Service employees by and large have rallied to the challenge and risen to the new task demands. Many have become local “experts.” At present, however, the agency does not have a way formally to recognize, support, and reward individuals who give considerable time and effort toward developing and sharing their expertise.

Organizations that do not provide proper incentives take the risk of losing their experts. In this case, as the Forest Service becomes increasingly bound up with the technology, it risks losing those on whom it most depends. We found substantial evidence that this is already occurring in the two regions we studied. These vital human resources cannot readily be replaced either at the same level or at higher levels. Incoming secretaries hired as replacements, for instance, will not know how to be system operators.

Alternatives are available. An outgoing secretary/system operator might be replaced with a new system operator trained from the start as a computer professional. However, such new system operations people are not likely to know much about the practices of the Forest Service, its information architecture, and so on. In addition, new hires into these positions would likely ask for formal recognition, support, and reward for their task functions from the outset. Turnover simply

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2A recent RAND study of computer use in mathematics and science education, for example, identified the “vanishing computer-using teacher” phenomenon: Teachers nominated as successful in educational applications of microcomputers disappeared from their classes to become “computer coordinators” in their districts or software developers in the burgeoning information technology industry (Shavelson et al., Teaching Mathematics and Science: Patterns of Microcomputer Use, The RAND Corporation, R-3180-NIE/RC, March 1984).
results in the continuation of the problem, as well as turbulence in the work unit while newcomers attempt to internalize procedures.

A longer term solution might be to develop policies to recognize local experts from the start, by assuring that they are allocated time and resources for the information system activities they perform (e.g., self-teaching, applications development, and giving assistance to other users). Good foresters, wildlife biologists, and the like can use the tools to carry out their professions with greater effectiveness; they cannot be replaced simply with computer technicians who have a passing interest in forestry. The bottom line is that good foresters have to know more than ever these days, including how their jobs are affected by technology—a fact that should be recognized and reinforced by the agency.

In addition, the agency needs to replace the current overreliance on “collateral duty” as a basis for system involvement with policies that reflect more careful attention to job descriptions, career paths, and human resource needs in the computerized Forest Service. Although collateral duty is a useful transition policy, it cannot satisfy the agency’s needs over the longer term for a special cadre of trained systems people. The Forest Service might consider, for example, how to build system participation into jobs without losing the flexibility of present general job descriptions and broadly functional titles (e.g., forestry technician). In general, then, personnel policies need to take increasing and increasingly explicit account of the technological component that has been introduced into virtually every job in the Forest Service.

Monitor and Balance Organizational Tensions

The centralization/decentralization balance issue has been noted earlier. In terms of the management of technology, the issue translates into the appropriate balance of authority and responsibility among the different levels of the Forest Service in relation to information system configuration design, connectivity, and data structures. The movement toward GIS capability and the need to tie this analytical resource more effectively to the ongoing data inventory of the agency bring this issue into sharp focus. The recent efforts to identify core terminology for databases and to create a “corporate data structure” that is compatible with both central coordination and local management and maintenance are steps in the right direction.

Disseminate Lessons Learned

Finally, strategies need to be developed and strengthened for disseminating the lessons learned about system implementation and use both
within the Forest Service and outside its boundaries. The graduated path of implementation has meant that some units of the agency are far in advance of others in experiencing and coping with key problems. There need to be mechanisms for sharing knowledge between units in systematic ways, not just as a byproduct of personnel transfers and scattered personal ties. Historically, the Forest Service has depended on internal transfers (referred to as “cross fertilization”) as a way to spread expertise throughout the agency. However, the diversity of “computing cultures” described earlier suggests that such interregion transfers of computing personnel and even the transfer of applications from the region that developed them to potential user regions could be problematic. Users reported experiencing some culture shock concerning the computing environment when they transferred. Although culture shock may be temporary during an initial period of adjustment, the agency needs to be sensitive to the issue and perhaps to discover adequate methods for promoting computer-related knowledge transfer.

Similarly, we believe the Forest Service can benefit the public by disseminating what it has learned to other governmental organizations in a timely and accessible way.

RECOMMENDATIONS: IMPLEMENTATION

Our results clearly show that the Forest Service needs to improve its training and support capabilities in future implementation efforts. Development of humanware and long-term learning support should be part of system budgets; training should be redesigned. Furthermore, steps should be taken to better monitor the implementation process itself.

Improve Training

The long-term key to effective continuing implementation of information technology in the Forest Service is an opportunity for beginning, intermediate, and advanced learning. Initial training is accomplished almost entirely by on-the-job briefing; while this works reasonably well for rapidly giving people entry-level skills, it does not particularly facilitate the development of the more sophisticated systems skills needed for full utilization. With higher-level training, regular users will continue to improve in competency and local experts will continue their skill development. These steps will be increasingly important as ever more sophisticated systems (e.g., the GIS) enter the agency’s technology repertoire. Continuous training capability is also
necessary to insure that the cohort that replaces current personnel (as
the latter are promoted, transfer, or retire) is adequately prepared for
the jobs they will assume. As one interviewee said, "There's a need for
well-trained people in the pipeline." The new training coordinator posi-
tion in the WO is an excellent step toward more effective training pol-
cies.

Learning needs to focus on functions rather than applications. What
this means in practice is that instead of teaching each application
(e.g., spreadsheet, electronic mail, word processing, or use of a
specific program) as a separate tool, the training should be organized
around the collection of applications that a user might be likely to need
in accomplishing a broader functionally defined task. There has been
movement toward this philosophy of functionally based training in the
budget and personnel areas; such approaches should be generalized so
that all Forest Service professionals receive training on the "kit" of
computer-based tools most relevant to their work. Training should
include how to use the tools effectively, and how to move between
them efficiently. In addition, training should result in a broader under-
standing of system architecture. Finally, training should stress how
the tools and data used by one specialty overlap with those created or
used within relevant others.

**Develop an Ongoing Self-Evaluation Capability**

Another critical component of effective implementation policy is the
ability of the Forest Service to understand in systematic terms what is
happening with its technology. As we have noted, the impact of com-
puters has been substantial. Information/communication tools have
become an integral part of the performance of Forest Service missions.
Employees are doing state-of-the-art work in fields as diverse as land
management and fire protection, with reduced staff. But key questions
about the direct relationships between the technology available and the
nature of the work performed remain defined largely by anecdote and
impression.

Recognizing this challenge, the agency should attend to improving
its methods for fairly representing benefits in relation to costs. Our
research suggests that traditional approaches to cost-benefit analysis
may underestimate value-added outcomes (see App. A). Although it is
not easy to quantify mission-related outcomes, the temptation to select
outcome measures simply because they can be quantified—e.g., number

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3These staff reductions were mandated by Congress coincidental to (though not as a
direct consequence of) the early stages of system installation.
of pages/screens produced or minutes saved—should be resisted. In addition to hard-to-measure mission-related benefits (e.g., fast and efficient turnaround on budgets per Congressional request), there are equally elusive organization-wide benefits, such as interactivity. The ability of different parts of the organization to share information, and to move it where it is needed, when it is needed, affects every functional area. Availability of local processing power yields another hard-to-measure yet crucially important benefit.

Ideally, the Forest Service should develop an ongoing self-evaluation capability. This might include some form of system instrumentation (e.g., having the system automatically log when and by whom certain applications are used) as well as routine documenting of mission-related outcomes. At present, the agency and outside evaluators often rely on retrospective reports comparing the “old” and “new” ways of doing the job. Systematic ongoing evaluation would permit self-monitoring and enable midcourse adjustments as new procedures or tools were being implemented. Finally, this capability would give external evaluators a data set to start with, avoiding the necessity to design evaluation methods ad hoc when third-party assessment is desired.

**Build Technology Scanning and Flexibility into Late-stage Implementation Plans**

Interconnected organization-wide systems for an agency as large, complex, and decentralized as the Forest Service will require a guiding plan that is extensive in breadth and also in temporal scope. A review of the schedule for the system discussed in this report—from initial needs assessment and requirements development through acquisition, installation, and training—indicates that even when nothing goes wrong with the process, such large-scale efforts will require many years. In this instance, the time line spanned about five years.

The difficulty of making such far-sighted design plans during periods of rapid technical change cannot be underestimated. In its plans, for example, the Forest Service made accurate judgments about the future importance of an interconnected organization-wide information system and the role for minicomputers in that infrastructure. At the same time, however, the agency did not foresee the hardware and software advances that would potentially permit microcomputers to become powerful and versatile components within such an infrastructure. Thus, not surprisingly, microcomputers and off-the-shelf software were left out of the initial design.
What seems surprising is that even at much later stages in the implementation process, these technologies remained outside of the overall organizational systems approach. On reflection, it is likely that such design rigidity is related to conditions of the procurement process. That is, Congress would not be expected to approve an open-ended or flexible plan for a procurement involving many millions of dollars; thus the procuring agency probably has to make too detailed and relatively fixed system design commitments over too great a time span.

Insofar as possible within these procedural constraints, then, we recommend the development of long-term system "strategies" or design "skeletons." Without a comprehensive design schema, there would be no way to move toward integrated organization-wide systems. But without some room for indeterminacy, there is no way to take advantage of major technical improvements that may develop. The optimal solution would seem to lie somewhere in between. That is, ideally, detailed design and procurement plans for particular system components should not be made many years in advance of their acquisition. Instead, centralized advance planning should focus on generic requirements (e.g., communication, interface, and capability requirements), allowing their specific realization to be contingent on subsequent technical opportunities and local needs. Such a strategy should be coupled with periodic scanning of the technical environment.

Just as we recommend periodic self-monitoring, we recommend regular assessment of emerging technologies and their likely influence on current and planned Forest Service information system designs. Such assessments will be independently useful in times of accelerated change. They will be even more valuable if they can provide input into a flexible and continuous system planning process for the implementation of organization-wide systems over long periods.

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4A modular approach along the lines suggested is probably more feasible now than it was before adoption of the government OSI profile (GOSIP), for which the Forest Service provided strong support (see Information Week, April 4, 1988).
Appendix A

COST-BENEFIT EVALUATION IN 
THE FOREST SERVICE

In 1984, as the implementation of the agency-wide information system was proceeding, the Forest Service determined that a broad-gauge cost-benefit analysis of the system would be helpful both in assessing the impacts of the current level of commitment to the technology and in planning future investments. Accordingly, a contract was let to LABAT-ANDERSON, Inc. (LAI), to design and carry out such a study. The study’s fieldwork was carried out in 1985 and 1986, and final reports were submitted in 1987.

In the course of our project, we reviewed both the LAI reports and a sample of the data on which their findings were based. In the interests of assessing the convergence of our findings with theirs, two of the four forests we visited were selected from the LAI sample. The aim was to determine what light our more qualitatively oriented approach might shed on their more quantitative findings, and to use their results as a base for part of our analysis.

In general, there is a significant convergence between LAI’s conclusions and ours. We both conclude that the benefits from information technology are much greater than the costs (however major those may have been), and that there is wide diversity in how those benefits are experienced among forests and regions. We also agree that these benefits are experienced by and enhance the performance of personnel at all levels of the Forest Service. When we disagree, it is generally to argue that the highly analytic approach taken by LAI—breaking work into small units, then reaggregating—underestimates the interactive effects of the technology, and thus sometimes obscures rather than clarifies the true nature of benefits experienced.

The purpose of this appendix is to offer some systematic comparisons of LAI findings and ours based on selected data from the two forests that were included in both their sample and ours. We believe that this comparison enhances the credibility of both studies. When there is convergence, confidence in the reliability of the observation is strengthened; when there is divergence, it can be used to understand the context within which the observation must be interpreted. Based on this comparison, we also offer some observations about how a more thorough and comprehensive cost-benefit analysis might be conducted in the future.
OVERVIEW OF COST-BENEFIT STUDY

The goals of the LAI cost-benefit study were to measure and track productivity changes occurring with the implementation of the information system, determine the monetary value of the changes in productivity, and compare the value of the system to expected costs. The method required identifying 25 “key products,” defined as units of regularly produced output, contributed to by one or more individuals and requiring significant amounts of time and cost.1 LAI surveyed employees in a sample of 12 forests to obtain estimates of time saved by use of the DG system. Changes in productivity were measured as the average percent improvement in time needed to generate key products (time saved divided by the sum of time spent and time saved) and in the rate of key product generation (units/hours spent in 1985 minus units/hours spent in 1984 divided by units/hours spent in 1984).

The LAI evaluation concluded that productivity improved by 32 percent for the sampled forests. Total savings for the entire Forest Service in 1985 were estimated at $127 million. Total cost in 1985 was $70 million. Thus, the cost-benefit ratio was 1.8.2

LIMITATIONS OF THE COST-BENEFIT STUDY

The cost-benefit study yielded very positive findings for the Forest Service—a projected one billion dollars in savings through 1990. However, a number of its limitations probably have the effect of underestimating projected and actual effects. Our main concerns have to do with data definition and collection procedures, the “key product” concept, and the variable applicability of the model to task domains. These are not limitations of the analysts, but of the approach; every approach has some limitations.

The evaluation procedures, first of all, present problems for determining the generalizability of the sample. For the two forests included in both the LAI evaluation and our follow-on research, the LAI questionnaire reached about 20 percent of all employees; but the 20 percent sample was not random. As Table A.1 demonstrates, data were gathered from twice as many GS-9 employees and half as many GS-3-5 employees in Forest 4 than in Forest 2. However, the two forests have about the same overall grade distribution. Since use of different applications varies by grade level (see below), these discrepancies may well

Table A.1

PERCENT OF RESPONDENTS BY GS LEVEL

<table>
<thead>
<tr>
<th>GS LEVEL</th>
<th>3-5</th>
<th>6-8</th>
<th>9</th>
<th>11</th>
<th>12-14</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest 2</td>
<td>21</td>
<td>22</td>
<td>15</td>
<td>19</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>Forest 4</td>
<td>14</td>
<td>23</td>
<td>33</td>
<td>19</td>
<td>11</td>
<td>100</td>
</tr>
</tbody>
</table>

result in systematic differences between applications reported in use in different forests, reflecting more who was sampled than overall system use.

In addition, there are problems with the retrospective recall method used in the LAI evaluation for estimating time saved. Recall is notoriously subject to bias depending on subsequent experience. In particular, people will generally either overestimate or underestimate time savings depending on their general evaluation of the system and their performance standards. While it is possible that these errors will be balanced and have no effect over the 900 questionnaires, it is important to remember that the quantitative analysis is based on these qualitatively influenced recall estimates.

This is not to suggest that the LAI evaluation overestimates benefits to the agency. In fact, the “key product” approach probably obscures what we believe to be the most significant payoff—namely, the greatly improved quality of output made possible by interconnectivity and expanded analytical capacity. In particular, the approach underemphasizes the highly interactive nature of the work. The main value of the agency’s performance is not just in the production of documents—the major dependent variable in the cost-benefit analysis—but in its interactions within and outside itself. In addition, a large part of the reported savings come under the “general memos/reports” category, which is independent of any task domain and assumes equal value for all paperwork. This makes the results hard to interpret from the standpoint of mission relevance.

The agency performs many different functions; some of them map onto the document production model better than others. Fire management, for example, is an area where the generation of written reports makes up a relatively small part of the total task. What matters far more is working effectively with people and resources inside and outside the agency, and manipulating on-line models in a timely way to support firefighting decisions. Land management planning, by
contrast, is much more oriented to paperwork. But even here the key
contribution of the system appears from our interviews to be improved
communication and analysis, not just better written products. In short,
the “key product” approach does not take into account the real nature
of the Forest Service business. While we agree with the main conclu-
sion of the evaluation—there is a significant advantage of benefits over
costs in relation to the system—we expect that LAI’s benefit figures
capture only a portion of the true “benefit space.”

INTERPRETING LAI’S FINDINGS IN RELATION TO OURS

Our observations and interview responses can be compared in relation
to LAI’s data for the two forests and four districts that were sam-
ped in both studies. From this comparison we conclude that while the
LAI data do illustrate real diversity between forests, the emphases may
be misplaced. While drawing comparisons between forests in the sam-
ple was not a major aim of the LAI study, it is one way to assess the
face validity of the LAI conclusions. In order to understand their find-
ings better, we reanalyzed the LAI data from the two forests in the
sample that we had visited—not to duplicate their efforts, but to see if
there were insights in the contrasts between the kinds of observations
we made and the kinds of conclusions generated from the LAI data.
Tables A.2–A.8 develop some of these findings.

The LAI data (Table A.2) suggest that Forest 2 has notably more
database and special program applications than Forest 4; this is gen-
erally in accord with our observations. By contrast, Table A.3 suggests
that Forest 4 devotes more of its savings to “improved organizational
management” and less to “direct customer service” than Forest 2; this
difference was not apparent to us in site visits or interviews. Accord-
ing to LAI data (Table A.4), Forest 2 seems to be getting more value

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<tr>
<td>Forest 2</td>
<td>56</td>
<td>15</td>
<td>9</td>
<td>4</td>
<td>16</td>
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<tr>
<td>Forest 4</td>
<td>65</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>8</td>
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Table A.3

PERCENT OF APPLICATIONS REPORTING SAVINGS, BY BENEFIT CATEGORY

<table>
<thead>
<tr>
<th></th>
<th>DCS</th>
<th>IPC</th>
<th>IOM</th>
<th>IRM</th>
<th>TOTAL</th>
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<tr>
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<td>Forest 4</td>
<td>54</td>
<td>2</td>
<td>24</td>
<td>19</td>
<td>100</td>
</tr>
</tbody>
</table>

NOTE: DCS = direct customer service; IPC = improved public contact; IOM = important organizational management; IRM = important resource management.

Table A.4

AVERAGE SAVINGS IN HOURS PER APPLICATION, BY FUNCTION

<table>
<thead>
<tr>
<th></th>
<th>GEN</th>
<th>ADM</th>
<th>OTH</th>
<th>ENG</th>
<th>LMP</th>
<th>TIM</th>
<th>AFM</th>
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<td>5</td>
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<td>28</td>
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<td>6</td>
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<tr>
<td>Forest 4</td>
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<td>3</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTE: GEN = general; ADM = administrative; OTH = other; ENG = engineering; LMP = land management planning; TIM = timber; AFM = aviation/fire management; REC = recreation.

out of its administrative, LMP, and timber applications. While this is hard to validate directly, it certainly appeared to us that Forest 2 had a stronger positive orientation toward the system in these application areas than did Forest 4.

It is also possible to use the LAI data to explore some other types of differences, particularly across functions. LAI data (Table A.5) suggest that across functions, higher-graded people tend to get as much or more value (time-savings) from the system as do lower-graded people, a finding that concurs strongly with our observations. Further, Table A.5 suggests that higher-graded people experience particularly significant benefits from telecommunications and spreadsheet applications, in contrast with middle-graded people who get most value from databases and special programs. Telecommunications most strongly benefit the upper clerical (GS-6-8) group and senior managers; all groups benefit just about the same from word processing. These LAI findings in general accord with our conclusions, and are not necessarily intuitive (in
Table A.5

AVERAGE SAVINGS IN HOURS PER APPLICATION,
BY FUNCTION AND GS LEVEL

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>GEN</th>
<th>ADM</th>
<th>OTH</th>
<th>ENG</th>
<th>LMP</th>
<th>TIM</th>
<th>AFM</th>
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<tr>
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<td>0</td>
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<td>15</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: GEN = general; ADM = administrative; OTH = other; ENG = engineering; LMP = land management planning; TIM = timber; AFM = aviation/fire management; REC = recreation.

Table A.6

AVERAGE SAVINGS IN HOURS PER APPLICATION,
BY APPLICATION TYPE AND GS LEVEL

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5</td>
<td>11</td>
<td>30</td>
<td>6</td>
<td>1</td>
<td>39</td>
</tr>
<tr>
<td>6-8</td>
<td>8</td>
<td>16</td>
<td>14</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>20</td>
<td>7</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>12-14</td>
<td>11</td>
<td>17</td>
<td>21</td>
<td>15</td>
<td>31</td>
</tr>
</tbody>
</table>

Particular, the finding regarding word processing would probably be regarded as counterintuitive. Finally, as Table A.7 shows, there are significant differences among functions in terms of the applications from which they derive the most benefit. Not surprisingly, for instance, LMP benefits most from word processing, while fire management benefits most from telecommunications and special programs (presumably such as BEHAVE).

In terms of total system effects on mission performance, however, LAI data diverge sharply from our conclusions. LAI suggests (Table A.8) relatively low levels of benefit across both forests in the areas of
Table A.7
AVERAGE SAVINGS IN HOURS PER APPLICATION,
BY FUNCTION AND APPLICATION TYPE

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>GEN</th>
<th>ADM</th>
<th>OTH</th>
<th>ENG</th>
<th>LMP</th>
<th>TIM</th>
<th>AFM</th>
<th>REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Proc.</td>
<td>11</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>134</td>
<td>18</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Database</td>
<td>18</td>
<td>15</td>
<td>37</td>
<td>6</td>
<td>20</td>
<td>39</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Telecom.</td>
<td>12</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>13</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>13</td>
<td>15</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Special Proj.</td>
<td>8</td>
<td>26</td>
<td>72</td>
<td>6</td>
<td>13</td>
<td>15</td>
<td>7</td>
<td>24</td>
</tr>
</tbody>
</table>

NOTE: GEN = general; ADM = administrative; OTH = other; ENG = engineering; LMP = land management planning; TIM = timber; AFM = aviation/fire management; REC = recreation.

Table A.8
PERCENT OF APPLICATIONS REPORTING SAVINGS,
BY FUNCTION

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>GEN</th>
<th>ADM</th>
<th>ENG</th>
<th>LMP</th>
<th>TIM</th>
<th>AFM</th>
<th>REC</th>
<th>OTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest 2</td>
<td>31</td>
<td>34</td>
<td>3</td>
<td>2</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Forest 4</td>
<td>32</td>
<td>39</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

NOTE: GEN = general; ADM = administrative; OTH = other; ENG = engineering; LMP = land management planning; TIM = timber; AFM = aviation/fire management; REC = recreation.

LMP, fire management, and recreation—three areas where we found a great deal of system-supported activity in both forests. This divergence suggests that either (a) LAI data collection methods missed a lot of applications in use, or (b) a lot of activities got folded into the “general memos” category that should have been more appropriately treated as functional applications, or both. In any case, this comparative exploration suggests that LAI data may not represent the actual functional distribution of system performance and benefits as well as might be desired.

We also find questionable, in relation to our own observations, the “rankings” of the sampled forests on the studied functions. (Again, to provide rankings was not a major aim of the LAI evaluation, but
exploring them is illustrative.) Of our two forests, Forest 2 generally ranks in the top quarter or half of the LAI sample on most of the administrative dimensions, while Forest 4 ranks near or at the bottom. From the perspective of our research, there is a certain face validity to these rankings, since Forest 2 demonstrated considerable facility in using the system for administrative functions. In the LAI data, moreover, both forests generally rank toward the bottom of their sample in timber and silviculture areas. This evaluation, by contrast, does not seem quite so valid from our perspective; Forest 2, for instance, has developed some of the most interesting and innovative uses of the system in timber management that we encountered. It is possible that since both Forests 2 and 4 are very heavy timber forests relative to some of the others in the sample, the marginal advantages of the system show up less. If so, it would again tend to underestimate the actual contributions of the system.

MEASURING COST BENEFITS IN THE FUTURE

Our analysis suggests that although the overall study results are sound, the agency should be careful in interpreting specific quantitative results of the LAI study. LAI's methodology, while thoroughly professional and based on precedents in the evaluation literature, was not well suited to identifying the full "benefit space" of the Forest Service's computing system—particularly the value added by interactivity. Moreover, attempts at generalization across an extremely complex system—in which no forest is a good predictor of the system-in-use in another—make the evaluation exercise extremely problematic. While the order of magnitude of the LAI conclusions is probably correct, the more detailed findings do not stand up to critical scrutiny and may generate erroneous inferences about system effects in different functional areas, on varied job grade levels, or in diverse regions.

What might the Forest Service do in the future to more effectively measure benefits in relation to costs? We have four recommendations:

1. Structure a longitudinal analysis
2. Sample systems-in-use, not necessarily forests
3. Sample intact work units
4. Measure qualitative changes in output and throughput

The first and most necessary step is to plan ahead, rather than to study these kinds of causes and effects retrospectively. We suggest taking one set of measures, followed up by another similar set, perhaps 18 months to two years later. For instance, since the geographic
information system (GIS) will not be widely implemented for a few years, there is ample time to take appropriate baseline measures. Field experiences in the units currently piloting GIS systems provide a good starting point for identifying possible outcome variables and for considering how to measure them. Furthermore, since the GIS will be installed in different units at different times, there is opportunity to collect some data on units with systems versus units without while implementation is proceeding.

Second, the appropriate sampling frame is perhaps not the forest, where many different computing cultures are in operation, but the cultures themselves. One possibility would be to form a profile of the modal systems-in-use and ensure that future evaluations include a balanced representation of them. The units would thus be ranger districts, supervisory offices, and so on. The construction of an appropriate sampling frame would require unit-level data on numbers and dates of installations, nature of systems in place, types of applications, and so on. A typological analysis could be used to group these system properties into modal patterns, and an appropriate number of sites chosen to represent each pattern. While this method cannot incorporate the cultural dimension of systems-in-use, it does offer a relatively easy way to construct a reasonably representative sample of internalized systems.

Third, future research should sample intact work groups, not individuals. This approach allows the interactivities to be charted directly, and the work flows within groups and across groups to be measured. Within each site selected, a specific number of work groups in major functional areas should be identified (e.g., fire, timber sales, budget/management). The kinds of things people use the system for could be measured directly, either by questionnaire, observation, or (where technically possible) by direct review of system logs. These data could be supplemented with interviews to establish an interpretive context. Particular emphasis should be placed on who communicates with whom, and who shares data; to the extent possible, communication networks should be charted and their parameters measured.

Finally, evaluative efforts should measure the qualitative change in activities/outputs, not just quantitative change. Measuring qualitative changes takes into account the fact that the tasks themselves will change along with the technology. Tracking task/process changes will give the Forest Service a better understanding of how information systems affect work. And clients or consumers of USFS activity should be included in assessments of result quality.

In sum, the LAI cost-benefit analysis was a useful and informative look at effects of the current information system. Its limitation is that
the implicit evaluation model does not accurately map against the kinds of computing cultures and task domains that we observed. The discrepancies may be a function of the fact that systems and organizations don't stand still—many changes may have occurred in the years since that study was launched. Although the LAI evaluation had some limitations, new cost-benefit studies of future technologies can learn a lot from this critical exploration of earlier efforts.
Appendix B

DEMOGRAPHIC ANALYSES OF SYSTEM IMPACTS

Below we discuss findings from a series of analyses examining the effects of agency-wide system implementation on the size and composition of the Forest Service work force and on the content and characteristics of individual jobs. We begin by discussing the motivation for these analyses and the specific research questions we addressed. We then review the results of work force analyses conducted for a related study and reported in detail elsewhere (Mittman and Stasz, 1988). Next, we present results of new analyses performed as part of the present study. We conclude by summarizing the implications of our findings for the Forest Service and for organizations more generally.

MOTIVATION AND RESEARCH QUESTIONS

Managers and researchers concerned with the impacts of information technology on organizations recognize a wide range of changes that typically accompany major system implementation efforts such as those associated with the Forest Service agency-wide system. While impact on communications patterns, individual and work group behavior, and output measures such as efficiency and effectiveness are perhaps the most salient changes, effects on work force size and composition—and the nature of specific jobs—are also important outcomes to assess. These effects, which are closely related to efficiency and effectiveness and are therefore of intense interest to managers charged with making system purchase decisions, include the following:

1. overall decreases in employment levels associated with system-related gains in worker productivity;
2. changes in occupational composition such as declines in clerical personnel and growth in programming staffs; and
3. the evolution of job duties and skill requirements to include technological expertise such as the ability to run applications programs and become facile with a wide range of sophisticated hardware.

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Our discussions with Forest Service personnel and our review of relevant research literature led us to focus on four main research questions in our work force (or "demographic") analyses. We review each question below, describing the specific employment effect of interest and our expected findings based on previous research and the experience of Forest Service officials.

Changes in Overall Employment Levels

The first research question addressed effects of system implementation on overall employment levels in the Forest Service. Information technology—like other forms of automation and capital investment—is generally expected to reduce demand for labor, all other factors such as output levels and quality being equal. Thus, we expected to find evidence of system-related reductions in Forest Service employment levels per output level.

Changes in Employee Age, Tenure, and Gender Composition

The next set of research questions addressed changes in the demographic composition of the Forest Service work force. The agency-wide system represented the first exposure to sophisticated computer technology for many Forest Service personnel (particularly older, long-tenured workers who did not have access to such technology in high school or college or in previous jobs). Thus, we expected the Forest Service to show increased turnover among older workers unwilling to learn new ways of performing their jobs, and decreased entry rates among older workers who lacked previous experience with computer technology. As a result of these changes we expected to see declines in the average age and tenure of the Forest Service work force.

We also expected to see changes in the gender composition of the Forest Service work force. The Forest Service has invested considerable effort in increasing the gender balance of its work force in recent years, and the increased turnover and hiring we expected would accompany system implementation should facilitate these efforts. Countering this effect, however, we expected declines in clerical occupations (which are predominantly female) and growth in programming occupations (which are predominantly male) to contribute to the continuing under-representation of women.

Changes in Occupational Composition

A third research question addressed shifts in the occupational composition of the Forest Service work force. As we noted above,
information technology implementation—especially implementation of office automation systems such as the Forest Service’s—are generally expected to reduce the need for clerical workers while increasing demand for technical computer personnel. We expected to find evidence of such changes in the Forest Service.

**Change in the Content and Characteristics of Jobs**

The final research question addressed changes within individual jobs. While the previous question deals with changes in the size of various occupations, the final question concerns changes occurring within occupations and within jobs, such as the tendency for administrative jobs to take on aspects of clerical jobs, or the addition of office responsibilities to field jobs such as Forestry Technician. In this phase of the research we looked for evidence of changes in formal job descriptions and qualification requirements, as well as informal changes in the content (i.e., specific duties and responsibilities) of jobs.

**DEMOGRAPHIC ANALYSIS RESULTS**

**Findings Regarding Changes in Overall Employment Levels**

Our analyses of trends in overall employment levels provided evidence of relative increases in staffing levels for the first six months following system installation, followed by relative decreases. These decreases led to net declines in employment levels in organizational units with systems (compared to those without systems) beginning approximately 12 months after installation. These analyses were conducted by examining six panels of annual personnel data (covering the period 1982–1987) obtained from the federal government’s automated payroll system maintained at the National Finance Center in New Orleans.1 For our analyses we used data for 756 national forest supervisory offices and ranger districts.2

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1 For each organizational unit in each year, these data give the number of full-time, part-time, and intermittent-time employees in each civil service occupational series (GS), listed by sex and ethnicity. The data also give the average age of the incumbents of each series in each organizational unit, as well as the average GS grade (i.e., salary level). The data file contained approximately 10,000 records per year, for a total of approximately 60,000 records.

2 We excluded the the Washington office, regional offices and experiment stations from our analyses due to the small number of organizational units involved (i.e., one Washington office, nine regional offices, and fewer than ten experiment stations) and the fact that these offices are extremely diverse, relative to the National Forest System. In addition, the experiment stations were not originally included in the DG system implementation plan. The 756 national forest supervisory offices and ranger districts in our
Our analyses of changes in overall employment levels were complicated by the general downsizing that began in the Forest Service in 1982. This downsizing was accomplished primarily through attrition, early retirements, interunit personnel transfers, and similar methods. Because of this trend, we examined relative changes in employment declines for organizational units receiving DG systems versus those not receiving systems, and interpreted a decline in the rate of downsizing as a relative increase in staffing levels.

Our findings regarding overall employment levels suggest that, while information technology implementation was associated with net decreases in employment levels in Forest Service offices, these decreases were not immediate. This conclusion is consistent with the literature on implementation of information technology. This literature notes that training needs, initial "shake-down" or "break-in" periods, and the practice of maintaining obsolete systems during the early phases of automated system use all lead to temporary disruptions in organizational routines and productivity. Temporary increases in staffing levels (achieved via accelerated hiring or delays in retirements or other types of attrition) are one means of maintaining output levels in the face of these disruptions, and our analyses suggest that Forest Service units used this approach during the implementation of the agency-wide system.

**Findings Regarding Employee Age, Tenure, and Gender Composition**

Our analyses of changes in employee age, tenure, and gender composition revealed no evidence of DG system-related effects. Both age and tenure increased throughout the period under study, but this is a necessary result of organization-wide downsizing when achieved via attrition. We also failed to detect any significant impacts of system implementation on Forest Service gender composition.

Our failure to detect evidence of system implementation on demographic composition may be a result of overall agency downsizing obscuring any system-related impacts, or may simply reflect a lack of such impacts. Our results for gender may be further complicated by

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sample represented approximately 88 percent of total Forest Service employment during the period of our study.

3See the review by Bikson, Gutek, and Mankin, 1981.

4Under stable employment levels, the continuous aging of existing employees is balanced by the net result of exits of older workers and entry of younger workers. When employment levels decline, entry rates of younger workers decline, thereby eliminating the primary source of younger workers to balance the continuous aging of the existing work force. Average tenure is affected in the same manner.
the Forest Service-wide trends toward gender equality and our mixed results for clerical work force representation (reported below), since clerical workers are overwhelmingly female.

Findings Regarding Changes in Occupational Composition

Our analyses of occupational composition trends revealed that system implementation led to increases in the proportion of professional personnel and decreases in the proportion of technical personnel. We used the federal civil service occupational categorization system as a basis for computing changes in occupational composition. This system classifies each job into one of the following categories: Professional, Administrative, Technical, Clerical, Other, and Blue Collar. Since the latter two categories are rarely used in the Forest Service, our analyses focused on changes in professional, administrative, technical and clerical composition. In the Forest Service the professional category includes jobs such as Forester and Engineer, while administrative jobs include Computer Specialist and Support Services Administrator. Technical jobs include Forestry Technician and Engineering Technician, both of which are junior-level job classifications leading to professional-level Forester and Engineer roles. Clerical jobs include Clerk Typist, Personnel Clerk, and Computer Clerk. Since subprofessional workers are typically younger than professional workers and therefore have higher turnover rates, agency-wide downsizing (which occurred largely through attrition) probably resulted in greater losses of technical workers than professional workers. In addition, relative declines in technical employment may have increased even more following system implementation due to increased demands for clerical workers (see below).

Our findings regarding clerical personnel were less straightforward. Clerical personnel showed significant declines throughout the Forest Service beginning in the first year of DG system implementation—1984. In units receiving DG systems, the declines were even more pronounced during the initial six months following system installation. However, beginning six months after installation, these units showed smaller declines in clerical representation—and some even showed increases—relative to units without systems.

These results were also counter to our expectations, and have no straightforward interpretation. The Forest Service intended to accomplish a large part of its mandated reductions through the elimination of clerical jobs, which are typically the initial focus of cuts during staffing reductions. This strategy seemed especially attractive in light of the new information system, which was seen as a way of achieving clerical
reductions with minimal impact on output. Thus, the finding that units with systems show smaller clerical reductions beginning six months following installation than those without systems is somewhat unexpected. It appears as if the clerical work force was cut back in anticipation of system-related reductions in workloads, but when these reductions did not occur, further cutbacks were slowed or hiring was actually increased. Indeed, 53 units with systems in place between 12 and 18 months by January 1987 actually showed increases in the proportion of their work forces in clerical jobs.

This finding suggests that automation-related changes in employment patterns show only an indirect link to changes in workloads. Instead, the changes appear to be related to managerial perceptions and expectations regarding workload changes. It suggests that analyses of system impacts at the level of individual organizations must pay particular attention to "causes" and "effects" and the temporal order of these phenomena, given the complicated interplay between expectations, actual effects, and the system. The finding also has significant implications for aggregate-level studies of employment impacts, which mask the organizational processes and mechanisms through which employment changes occur. Aggregate-level analyses cannot disentangle expectation-induced effects from actual effects, and such analyses may produce misleading or uninterpretable results.

JOB CONTENT ANALYSIS RESULTS

Changes in Formal Aspects of the Personnel System

Our investigation of changes in formal aspects of the Forest Service personnel system (e.g., formal job titles or descriptions, formal promotion paths, etc.) revealed a striking lack of DG-related changes. Through a series of personal and telephone interviews at all levels of the Forest Service, we asked personnel officials and other Forest Service employees about any changes in formal personnel arrangements. Our respondents noted that system implementation did not result in the widespread creation of new jobs or the elimination or modification of formal position descriptions or other personnel arrangements at the forest and district levels. While Washington office officials are aware of changes in job duties and responsibilities caused by system implementation, they have allowed forests to deal with these changes locally and informally.

We also gathered information on informal changes in tasks and duties associated with specific Forest Service jobs. Our questions about
personnel matters paid particular attention to informal changes. We administered a two-page questionnaire concerning formal and informal job changes to approximately 300 Forest Service employees in the units we studied to obtain further information on these changes. We received approximately 200 returned questionnaires, for a response rate of 67 percent. However, the sample included one of the two regional offices we visited, and this office contributed approximately 80 of the completed questionnaires. To facilitate cross-regional comparisons without the contaminating effects of a single regional office, the results we report below exclude this office. The remaining sample consists of 122 questionnaires.

Job Content Survey Findings

The job content survey yielded numerous interesting findings regarding DG system impacts. First, system use in the regions sampled is extremely high: 99 percent of all respondents reported using the DG system in their work. Approximately 37 percent of all respondents reported using some other form of hardware as well (see Table B.1). As this table shows, Fort Collins (FCCC) use was significant in both regions, while personal computer (PC) use was significantly greater in Region B than in Region A. Further analysis showed that PC, FCCC, and Other Hardware use patterns were similar in supervisory offices and ranger districts, and showed no significant relationship to employee tenure. However, these patterns do differ by occupation (Table B.2): PC use is greatest among technical workers, followed by professional and administrative workers. No clerical workers reported using PCs in their work, suggesting that PCs are used for tasks other than word processing. Use of FCCC is similar across all occupations, including clerical. However, results for individual jobs within these

<table>
<thead>
<tr>
<th>Hardware Type</th>
<th>Any Non-DG Hardware</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>FCCC</td>
<td>Other</td>
</tr>
<tr>
<td>Region A</td>
<td>6%</td>
<td>32%</td>
</tr>
<tr>
<td>Region B</td>
<td>37%</td>
<td>23%</td>
</tr>
</tbody>
</table>
occupational categories show that some types of clerical workers, namely Clerk Typists (GS 322), show no use of FCCC at all, while others (e.g., Computer Clerks, General Business and Industry) show rates of FCCC use as high as 50 percent. Finally, Other Hardware is used only by professional and technical workers. According to our interviews, this hardware includes specialized engineering workstations or minicomputer systems, as well as hand-held programmable calculators used in silviculture, fire suppression, and other functions. Engineering Technicians (GS 802) showed very high levels of computer use across all categories, including Other Hardware.

We next examined responses to survey questions addressing changes in jobs, tasks, etc., that have occurred in response to the agency-wide system implementation. One set of questions asked respondents to indicate the extent of general change their jobs experienced, while a second set asked about specific changes that (a) have already taken place and that the respondents (b) expected to take place in the future. We first present results of the questions addressing general change.

Table B.3 shows regional differences in the extent of job change related to implementation. To create this table, we coded responses to questions concerning job changes resulting from the system implementation on a scale from 1 to 3, with 3 indicating considerable change. Table B.3 shows that Region A respondents indicated higher levels of job change than Region B respondents. This difference is statistically significant (p < .05), indicating that respondents in Region A have experienced greater changes in their jobs. Additional analyses of response patterns across ranger district and supervisory office settings showed no significant differences between the two types of offices. And analyses of job change by occupation and by individual job title revealed small and statistically insignificant changes.
Table B.3
SYSTEM-RELATED JOB CHANGE BY REGION

<table>
<thead>
<tr>
<th>Region</th>
<th>Job Change Score</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region A</td>
<td>2.02</td>
<td>62</td>
</tr>
<tr>
<td>Region B</td>
<td>1.81</td>
<td>60</td>
</tr>
</tbody>
</table>

Tables B.4–B.6 present results from a set of questions asking respondents to indicate whether six different aspects of their jobs (a) had changed, (b) would change in the future, and/or (c) should change. The tables show the percentage of respondents indicating change on at least one of these dimensions.

Table B.4 shows that respondents overall felt that their jobs should change to a greater degree than has occurred to date. While respondents in Region A were more likely than those in Region B to feel that their jobs have changed and will change, and less likely to feel that their jobs should change further, these differences were not statistically significant. Administrative workers experienced significantly greater actual job changes than other occupations ($F[3,115] = 4.2; p < .01$) and express greater desire to experience additional changes ($F[3,115] = 2.8; p < .05$), followed by technical and clerical workers and then professional workers (Table B.5). Differences among the four occupations in anticipated changes are not statistically significant, however, suggesting that employees across all occupations expect similar amounts of further

Table B.4
SYSTEM-RELATED JOB CHANGES: ACTUAL, ANTICIPATED, AND DESIRED, BY REGION

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Anticipated</th>
<th>Desired</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region A</td>
<td>27%</td>
<td>23%</td>
<td>29%</td>
<td>62</td>
</tr>
<tr>
<td>Region B</td>
<td>17%</td>
<td>12%</td>
<td>38%</td>
<td>60</td>
</tr>
</tbody>
</table>

NOTE: Entries indicate percentage of all respondents reporting that one or more aspects of their job (a) have changed already (“Actual”), (b) will change in the future (“Anticipated”), and (c) should change (“Desired”).
Table B.5
SYSTEM-RELATED JOB CHANGES: ACTUAL, ANTICIPATED, AND DESIRED, BY OCCUPATION

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Anticipated</th>
<th>Desired</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional</td>
<td>8%</td>
<td>13%</td>
<td>19%</td>
<td>48</td>
</tr>
<tr>
<td>Administrative</td>
<td>57%</td>
<td>29%</td>
<td>57%</td>
<td>7</td>
</tr>
<tr>
<td>Technical</td>
<td>27%</td>
<td>24%</td>
<td>41%</td>
<td>37</td>
</tr>
<tr>
<td>Clerical</td>
<td>30%</td>
<td>15%</td>
<td>41%</td>
<td>27</td>
</tr>
</tbody>
</table>

NOTE: Entries indicate percentage of all respondents reporting that one or more aspects of their job (a) have changed already ("Actual"), (b) will change in the future ("Anticipated"), and (c) should change ("Desired").

change. Finally, Table B.6 provides additional detail concerning occupational differences in actual, anticipated, and desired job changes. The overall table is significant at the 5 percent level (F[17,104] = 1.87; p < .05), suggesting that differences indicated here are probably due to real differences across various jobs.

The next series of tables presents responses to the survey questions addressing changes in jobs, tasks, etc., that have occurred in response to system implementation. These tables indicate the percentage of respondents reporting each type of change. As Table B.7 shows, approximately one-third of all respondents felt that the agency-wide system has increased the efficiency and speed of their work, while fewer than half that many felt the system has caused more work or made their work more time consuming. Respondents in Region A were somewhat more likely to feel that the system has improved efficiency relative to Region B respondents, but were nearly twice as likely to state that it has increased their workload. Respondents in Region B were more likely to feel that the system has improved the quality of their work, however. The differences between the regions are generally small, however, and are not statistically significant.

Table B.8 shows that professional workers are somewhat less likely than other workers to feel that the agency-wide system has increased efficiency, but are significantly more likely to have mentioned their need to perform their own key entry. These data are statistically significant at the 5 percent level and thus indicate that differences across occupations are probably real.
Table B.6

SYSTEM-RELATED JOB CHANGES: ACTUAL, ANTICIPATED, AND DESIRED, BY JOB TYPE

<table>
<thead>
<tr>
<th>Job Type</th>
<th>Actual</th>
<th>Anticipated</th>
<th>Desired</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>203 C Personnel Clerk</td>
<td>25%</td>
<td>13%</td>
<td>50%</td>
<td>8</td>
</tr>
<tr>
<td>332 C Misc. Clerk</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2</td>
</tr>
<tr>
<td>322 C Clerk Typist</td>
<td>50%</td>
<td>17%</td>
<td>33%</td>
<td>6</td>
</tr>
<tr>
<td>334 A Computer Spec.</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>2</td>
</tr>
<tr>
<td>335 C Computer Clerk</td>
<td>50%</td>
<td>25%</td>
<td>75%</td>
<td>4</td>
</tr>
<tr>
<td>342 A Support Svcs Adm.</td>
<td>75%</td>
<td>25%</td>
<td>50%</td>
<td>4</td>
</tr>
<tr>
<td>460 P Forestry</td>
<td>9%</td>
<td>11%</td>
<td>20%</td>
<td>35</td>
</tr>
<tr>
<td>462 T Forestry Tech.</td>
<td>32%</td>
<td>28%</td>
<td>48%</td>
<td>25</td>
</tr>
<tr>
<td>802 T Engineering Tech.</td>
<td>17%</td>
<td>27%</td>
<td>25%</td>
<td>12</td>
</tr>
<tr>
<td>810 P Civil Engineering</td>
<td>0%</td>
<td>9%</td>
<td>9%</td>
<td>11</td>
</tr>
<tr>
<td>1101 C General Bus. &amp; Ind.</td>
<td>0%</td>
<td>0%</td>
<td>25%</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTE: Entries indicate percentage of all respondents reporting that one or more aspects of their job (a) have changed already ("Actual"), (b) will change in the future ("Anticipated"), and (c) should change ("Desired").

Table B.7

CHANGES IN FOREST SERVICE WORK DUE TO SYSTEM IMPLEMENTATION, BY REGION

<table>
<thead>
<tr>
<th>Region</th>
<th>Work is Faster, More Efficient</th>
<th>Perform Own Key Entry Now</th>
<th>More Work/Tasks Time-Consuming</th>
<th>Higher-Quality Work, Better Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region A</td>
<td>38%</td>
<td>19%</td>
<td>19%</td>
<td>9%</td>
</tr>
<tr>
<td>Region B</td>
<td>29%</td>
<td>27%</td>
<td>10%</td>
<td>14%</td>
</tr>
</tbody>
</table>
Table B.8

CHANGES IN FOREST SERVICE WORK DUE TO SYSTEM IMPLEMENTATION, BY OCCUPATION

<table>
<thead>
<tr>
<th></th>
<th>More Efficient</th>
<th>Perform Own Key Entry Now</th>
<th>More Work/Tasks Time-Consuming</th>
<th>Higher-Quality Work, Better Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof.</td>
<td>29%</td>
<td>38%</td>
<td>3%</td>
<td>10%</td>
</tr>
<tr>
<td>Admin.</td>
<td>43%</td>
<td>14%</td>
<td>14%</td>
<td>0%</td>
</tr>
<tr>
<td>Tech.</td>
<td>42%</td>
<td>19%</td>
<td>11%</td>
<td>14%</td>
</tr>
<tr>
<td>Clerical</td>
<td>30%</td>
<td>4%</td>
<td>0%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Additional analyses show that job tenure (including tenure in the Forest Service, tenure in the organizational unit in which the employee is currently employed, and tenure in the specific position the employee currently holds) bears no relationship to any of the three groups of measures of system-related job change described above. However, employees who made use of one or more types of non-DG hardware (PCs, FCCC, etc.), in addition to the agency-wide system, tended to report more positive impacts of computerization (e.g., Improves Quality \( t = 2.72, p < .01 \); Increases Efficiency \( t = 2.50, p < .01 \)) than employees who used only the DG. To the extent that users of multiple types of equipment are more skilled and knowledgeable about computers, this suggests that increased familiarity leads to more positive perceptions of computerization.

OTHER WORK FORCE ANALYSES

We examined employment data for Computer Specialist and Computer Clerk personnel to determine if system implementation led to changes in their prevalence in forests and districts. As Table B.9 shows, employment of individuals in the 334 (Computer Specialist) series increased in Regions A and B and in the National Forest System overall between 1982 and 1987. In addition, the number of Computer Specialists per organizational unit in the sample units and the two regions was significantly greater than the number per unit in the National Forest System overall, throughout the period of study. Table B.10 shows that employment levels in the 335 (Computer Clerk) series more than doubled (in absolute terms and on a per unit basis) in the National Forest System overall between 1982 and 1987. The increase in Region A was significantly smaller than that in Region B and in the
Table B.9

COMPUTER SPECIALISTS IN SAMPLE REGIONS AND IN THE NFS
(Ratio of Number of Computer Specialists per 6 Organizational Units)

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1982 1987</td>
</tr>
<tr>
<td>Region A Sample Units</td>
<td>3/6 4/6</td>
</tr>
<tr>
<td>Region B Sample Units</td>
<td>3/6 4/6</td>
</tr>
<tr>
<td>Total, National Forest System</td>
<td>0.8/6 1.3/6</td>
</tr>
<tr>
<td></td>
<td>+33%</td>
</tr>
<tr>
<td></td>
<td>+33%</td>
</tr>
<tr>
<td></td>
<td>+62%</td>
</tr>
</tbody>
</table>

NFS overall, but this region began with a much higher level of Computer Clerks in 1982 than other regions.

CONCLUSIONS AND IMPLICATIONS

The findings presented in this section have numerous implications for the Forest Service and for organizations more generally. Our demographic findings suggest that system impact on organizational staffing levels can be quite difficult to detect, even with highly accurate and comprehensive data. These findings also suggest that system influences are far from straightforward and linear, but follow a time-path in that net effects change significantly over time.

Our findings concerning changes in formal personnel arrangements highlight the difficulty of effecting major changes in large, bureaucratic systems that have evolved over long periods. In addition, the presence

Table B.10

COMPUTER ASSISTANTS IN SAMPLE REGIONS AND IN THE NFS
(Ratio of Number of Computer Clerks per 6 Organizational Units)

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1982 1987</td>
</tr>
<tr>
<td>Region A Sample Units</td>
<td>7/6 8/6</td>
</tr>
<tr>
<td>Region B Sample Units</td>
<td>2/6 6/6</td>
</tr>
<tr>
<td>Total, National Forest System</td>
<td>1.3/6 2.6/6</td>
</tr>
<tr>
<td></td>
<td>+14%</td>
</tr>
<tr>
<td></td>
<td>+200%</td>
</tr>
<tr>
<td></td>
<td>+123%</td>
</tr>
</tbody>
</table>
of a mechanism for making small, incremental changes (the collateral duty rule discussed in Sec. V) further militates against the likelihood of significant change in formal arrangements.

Finally, our results concerning job content were notable for the lack of change they revealed. While the Forest Service used a wide variety of computer equipment before the installation of the agency-wide system, the old equipment was highly specialized and limited to only certain groups of professional and technical workers. While the new system created numerous novel demands and needs, these were generally small relative to the primary tasks and duties of Forest Service personnel.

The results described above, which we view as preliminary and suggestive rather than conclusive, highlight several avenues for further research:

- The need to apply more sophisticated statistical techniques to better understand the contributions of agency-wide downsizing and information system implementation on the Forest Service work force.
- The need to utilize employee-level personnel transaction data to explore the mechanisms and processes behind job-level and organizational unit-level changes.
- The need to use rigorous techniques of job analysis to better understand system-related evolution in the tasks and duties associated with individual jobs.
Appendix C

SAMPLE INTERVIEW GUIDE

SUBJECT MATTER SPECIALIST INTERVIEW GUIDE:
LAND MANAGEMENT PLANNING (LMP)

OPENING REMARKS
1. Introduction:
   a. Exchange of names (confirm interviewee’s job title)
   b. At the request of the Forest Service, RAND is conducting a
      follow-on study of the Data General (FLIPS) system and
      other computer-based information technologies (e.g., PCs).
      We’re interested in its effects on information work at all four
      levels of the Agency and are focusing on three task/mission
      areas—Land Management Planning, Protection (fire suppres-
      sion), and Business Management (i.e., Program Develop-
      ment and Budgeting)—and also on general patterns of com-
      munication.
   c. The information you give us in this interview will be held in
      strict confidence. You should feel free not to respond to any
      particular question. Information in the final report will not
      be identified with specific individuals or organizational units.
      Do you have any questions? Can we go ahead?

2. Organizational context:
   a. Can you summarize the objectives of Land Management
      Planning within this unit?
   b. And your role in LMP?

3. Technology Orientation:
   a. We are interested in how information technology has been
      incorporated into the Agency’s work. When we ask about the
      computer system, we mean primarily the DG system—
      especially the equipment and software with which you and
      other users involved in Land Management Planning directly
interact. But, of course, we’re interested in the other computer technology you use as well.

b. When we ask about changes in work or impacts on the organization, we’re referring to what has happened in this unit since you have gained experience using interactive computer systems, and what the effect on the organization has been as a result. We’re particularly interested in effects specific to Land Management Planning and to the activities that involves.

4. Probes (for all topics):
   a. Expected (as well as actual) effects, unanticipated effects.
   b. Potential key actors not yet identified.

5. NOTE: Below, “unit” is used as a substitute for region, forest, or district as applicable.

THE MISSION

1. Has this forest prepared and filed a Forest Plan with the Region?
   Yes ____  No ____
   a. If yes, how far has it progressed (e.g., approved by the Region and sent to Washington, approved by Washington, some provisions under appeal, etc.)?
   b. If no, where is this Forest in the LMP process (e.g., verifying data, modeling, environmental impact assessment, etc.)?

2. What are the main tasks that this unit has to do in Land Management Planning in the course of a year? (Probe for the current year, if this is problematic. If this is a large unit with too much to record, focus on timber management. In any event, be sure that timber management is recorded and get details; ideally, get a few tasks that recur at least annually.)

3. We’re particularly interested in how computers are converted into work tools. Can you tell me how the DG system is used to get the job of Land Management Planning done? (As before, use timber management as a focus.)
   a. Is this process any different from what you did before the DG system was implemented? Explain. (Probe for process differences related to information tools at hand.)
b. How about the people who work on it—any differences? Do you need less or more clerical support? How (if at all) are clerical staff involved? Do you rely more or less on computer specialists? (Probe and record in detail.)

TECHNOLOGY-IN-USE

4. First I’d like to know about the hardware in use for LMP by this unit. (Probe for at least the following and record responses.)

<table>
<thead>
<tr>
<th>Type</th>
<th>Main use</th>
</tr>
</thead>
<tbody>
<tr>
<td>DG terminal</td>
<td></td>
</tr>
<tr>
<td>DG portable</td>
<td></td>
</tr>
<tr>
<td>microcomputers</td>
<td></td>
</tr>
<tr>
<td>minicomputer</td>
<td></td>
</tr>
<tr>
<td>FCCC (mainframe)</td>
<td></td>
</tr>
<tr>
<td>other computer:</td>
<td></td>
</tr>
</tbody>
</table>

How is hardware purchasing handled, i.e., what’s the policy if you think that for LMP you need something in the way of hardware that you don’t now have? Who makes the decisions? What is your role?

Does this differ at all from how it was when the DG system was first installed? If so, explain.

How do these equipment policies seem to be working out? As a Land Management specialist, do you think you have the hardware resources you need? (Probe.)

5. Now I want to know the same kinds of things about the software in use for Land Management Planning. Can you tell me about the applications you use for LMP? (If there are too many, focus on timber management.)

<table>
<thead>
<tr>
<th>Application</th>
<th>Function</th>
<th>Source</th>
<th>Modifications</th>
</tr>
</thead>
</table>

What kinds of policies govern software acquisition and use for LMP in this unit? For example, if there’s an application you need for LMP that you don’t now have, what’s the process for getting it? Or if you want to modify an existing application?
Or get non-DG software? What's your role in this? (Probe in detail if there are locally generated applications or major modifications.)

Does this differ at all from how it was when the DG system was first installed? If so, explain.

How do these software policies seem to be working out? As a Land Management specialist, do you think you have the software resources you need? (Probe.)

6. How easy or hard is it to get the different kinds of hardware and software you use in LMP to work together? (Probe for trade-offs in the multivendor environment.)

7. We've heard a great deal about the many kinds of data the Forest Service collects and about a common information architecture that lets units keep what they need at the unit level but access other information when they need it. And the same is said for individuals within units. From your perspective, how well is this working? (Get examples.)

How hard or easy is it to transfer LMP data to others, or to download data from other sources for your own use?

How hard or easy is it to locate what you need for LMP in shared storage?

How are databases important to you for LMP maintained and updated? Can you be fairly confident about data integrity?

In general, how do you evaluate the common information architecture approach the Agency has taken, relative to LMP?

8. Last but not least in the technology area, we'd like to know how electronic mail is involved (if at all) in the work of LMP? (Get a general description.)

In the electronic mail environment, are there any differences in whom you communicate with? Or how often? Or how fast? (Get and record the specifics.)

<table>
<thead>
<tr>
<th>Who (by position)</th>
<th>Location (vertical, horizontal)</th>
<th>Changes (frequency, speed, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What about communications outside the Agency (e.g., with Bureau of Land Management, with state forestry agencies, etc.)?
Do you see any differences in the way that LMP work is organized because of the availability of electronic mail? (Probe for: ad hoc teams, changes in interdependencies, reporting or power structures.)

Everyone talks about the likelihood that with fast communications and easy widespread distribution, there will be nuisance costs: lots of junk mail, angry people sending thoughtless messages to their bosses, too-hasty decisionmaking, lack of personal warmth, and so on. Have you experienced any of these things? What's your view? (Probe for why flaming, etc. does or does not happen; get examples, if any.)

TRAINING

9. Did you receive any specialized training to use the DG system for Land Management Planning?

   IF YES: Get a description of who/where/how the training was provided.

   IF NO: Find out how the user developed skills in this area.

10. When you run into problems, or when you want to do something new and can't quite get it to work, what do you do? What are your best sources for solutions? (Note responses and if possible rank order the first 2 or 3: e.g., user manual, local "expert" in the same unit, another subject matter specialist [e-mail? phone?], online documentation, etc.)

11. Do you have access to people—either here or in another unit—who are especially skilled users of LMP software applications? (Probe for and note how they are accessed.)

   Do these "experts" receive any informal (e.g., recognition) or formal support for providing technical assistance?

12. Overall, do you think you and other LMP specialists have the skills and resources you need to take advantage of new information technology in the Forest Service? (Explain.)

IMPACTS

13. What, in your view, are the most important ways the DG system affects the way Land Management Planning tasks are done here?
14. Where do you think the biggest payoff lies for LMP in the use of this new technology? What are the biggest benefits for Land Management?

15. Now I’d like you to consider the impact of this technology on your own job specifically.

a. Are there any tasks you do now that you didn’t do before? (List.)

b. Are there things you used to do that you don’t do now? (List.)

c. How about effects on where you work (e.g., field vs. office) or when you work or whom you work with? (Describe.)

d. Does it affect the sheer quantity or speed of your work? How, if at all, does it result in TIME SAVINGS for the kind of work you do?

e. Have any of the following changed for you as a direct result of computer technology becoming a part of Land Management Planning? If not, will they? Should they?

<table>
<thead>
<tr>
<th>Has changed</th>
<th>Will change</th>
<th>Should change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job title</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GS level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GS classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Career path</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16. More broadly, I’d like to know what you think the effects of this kind of technology might be on the Forest Service as an organization.

Do you think the agency will become more centralized/decentralized?

Do you think it will change anything about the way the agency is organized and managed?

Do you think it will affect the quality of working life for you or your own satisfaction with being a member of the Forest Service?
In your view, what are the most important challenges to be faced as the DG becomes internalized into the Agency?

17. Overall, how has the Forest Service's information technology in use compared with your expectations?

18. Where do you think the Forest Service should be going next with information technology?

THANKS VERY MUCH FOR YOUR TIME AND YOUR HELP.
BIBLIOGRAPHY


