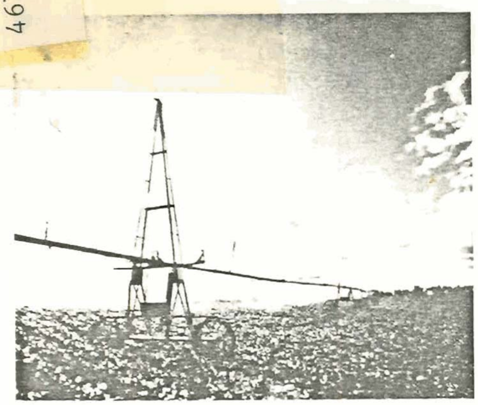

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Resources

Technology development and transfer for natural resources management

K. E. SAXTON

CONSERVATIONISTS, engineers, and planners are experts in applying technology to achieve efficient natural resource use and safe, dependable structures. The technology they use represents years of experience and research. But as these professionals know, current technology must be refined or replaced with improved concepts and procedures if we are to achieve and maintain a cleaner environment, economical farming with sustained high yields, and effective conservation practices.

Technology is the systematic application of scientific knowledge. The development of applied procedures and techniques is a unique, continuing process that requires the deliberate accumulation of knowledge to solve well-defined problems. Technology development, therefore, requires an effort apart from seeking knowledge through research or applying technology in practice.

Today, more professionals apply technology to conservation, farming, resource management, and environmental control than at any time in the past. Research in these areas accounts for many scientist-years. But how many scientists are dedicated to the task of developing technology from new research knowledge and transferring this technology to users? Unfortunately, there are far too few, and the gap is widening.

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When scientists were fewer and problems less specialized, researchers and professionals were better able to communicate and assimilate new knowledge and experience. Today, with larger, more separate organizations and more diversified, specialized jobs, this personal and largely informal technology development and transfer process has diminished, just when the increase in scientific knowledge and the demand for sophisticated technology require an expanded role.

Technology Development & Transfer

To gain a better view of this system of seeking knowledge (research), assimilation (development), and application (production and practice), let's review some recent literature. A few writings concern water resource findings, but more has been written about the management of private industry. The need to disseminate technology from major federal projects, such as the space program, has been researched and reported also. A common theme appears in these studies—the findings of research (basic) must be assimilated into a workable solution (applied research and development) for the benefit of production (field practice).

In September 1972 directors and representatives of the State Water Resources Institutes met to assess technology transfer (9). Their concerns included (a) the state of water technology transfer, with views from researchers, extension personnel, federal agencies, state agencies, consulting engineers, and regional water planners; (b) what is being done about technology transfer; (c) ways to overcome barriers between researchers and users; (d) procedures for developing effective technology transfer programs; and (e) ways to involve the user in the design and conduct of research.

Several significant statements emanated from the meeting:

- Research producers should try to eliminate well-documented voids in knowledge. Further, there is a great need to inventory information already available and to apply it successfully.
- Researchers and users should be brought together as a team in the problem definition stage. A communications expert to facilitate the transfer process might be useful at this point.
- Multidisciplinary input is needed to guide the user as he tries to determine research needs.
- Mobility of personnel between producer and user organizations should be encouraged.
- Research results must be explained clearly and demonstrated to the user.
- Mere information dissemination is not sufficient because technology must be packaged in a form palatable to the user.
- Effective translators (professionals who can bridge the gap between the users and researchers) are in short supply and urgently needed.
- Water research organizations should engage committed professionals in the technology transfer task. The job cannot be left to researchers and users alone.

Couplers

That 1972 conference ended on the note that intermediaries are needed between research and application. We might term these people synthesizers —professionals who can link disciplines and users to problems and who will command sufficient respect by both users and researchers.

Lesher and Howick (*5*) noted that traditional means of transferring technology, while extremely important, are no longer adequate. They concluded, "This results in a need for intermediaries or couplers who can operate effectively at the interface between knowledge and need and who can communicate effectively with those at both ends of the pipeline."

Technology transfer is a complicated process, interlaced with communication strings, shaped by an undulating continuum of knowledge, and pulsating with research findings and user demands. The process is constantly stirred by innovation, and those involved are educated.

Vertical and Horizontal Transfer

Technology transfer can be both horizontal and vertical (*6*). Horizontal transfer is largely directed to equal constituents and peer groups, for example, technical reports of research results. Such reports usually do not supply adequate information for direct application of the results. They must receive considerable interpretation before they can be used.

Vertical transfer is directed from research toward application. The reverse of this communication line supplies research needs.

Myers (*6*) explained one way to organize for vertical transfer. He noted that the route from general to specific is long and requires management control over the interfaces between basic research, application, engineering, and production. It is management's task to provide common goals on which innovators can focus their efforts. This requires effective communication. Little information will be transferred, horizontally or vertically, unless there is a purpose.

Elements of Successful Transfer

Most people would agree that the goal of technology is to meet the needs of the market place (the user). But the market rarely expresses its need for a new product. Because the market reacts to innovations critically rather than creatively, the risks of innovating for it are inevitably high. On the other hand, the market represents the most powerful force in stimulating innovation because, if goals are specified and backed with dollars, the necessary technology will be developed. This is the major pattern of innovation (*6*).

Role of the Entrepreneur

Hollomon (*3*) considered the entrepreneur a key element in the process of innovation and technology transfer. Technology, he said, develops in three overlapping steps: (a) invention, (b) innovation, and (c) diffusion. The process of innovation involves a degree of risk. Someone must accept that risk to provide the possibility of greater return for the investment. That someone is the entrepreneur.

Innovation follows invention. The time lag is determined by the ingenuity of the people who exploit the invention and the requirements of the market for it. The successful entrepreneur is willing to innovate and to undergo the difficulties of change, and he is ingenious enough to bring it off!

Charpie (*1*) echoed the need for entrepreneurs to champion the cause of innovation, but he also cautioned that they too are only human. Many turn out to be good managers; some are successful in production roles; and some are even good inventors. But none are good at everything, nor can they work in a balanced way on all the problems that arise. Therefore, it is always necessary to identify and shore up the weak spots.

Role of Management

Rosenbloom and Wolek (*8*) brought the role of management solidly to the forefront. They showed that the manager must be concerned with measures that complement and interrelate with the usual patterns of information flow. To do so, the manager must build and maintain within the organization an effective interface between information systems concerned with advancing bodies of knowledge and those concerned with operational systems.

Where there is no effective interface, research will build on information obtained from literature and contacts with professional colleagues, with the feedback resulting in a closed system. Similarly, operations will draw upon experience-based information largely derived from sources within the same firm. Again, the system closes on itself.

Research and application organizations can share in the mission-oriented task—learning relevant, new knowledge and applying it. The problem common to both activities is one of maintaining the link between the possibility of new knowledge and the needs of operations. The central question for management thus becomes how to maintain fruitful links between the sources of knowledge and the needs for knowledge in operations (*8*).

Jackson and Spurlock (*4*) classified the spectrum of research to production as (a) fundamental research, which establishes the true character of a phenomenon or concept; (b) applied research, which extends the understanding of the basic phenomenon, determines its practical significance, and directs this new knowledge toward the creation of a feasible idea for a useful application; (c) developmental research, which creates the methods and tools for the production of any resultant product; and (d) production, which actually generates the item for market. Management in many organizations downgrades the role of applied research in the overall effort of generating a new product. Similarly, the role of developmental research must not be underrated because it, to a large extent, determines whether prior research will be profitable (*4*).

Organization for Technology Transfer

Organizing for technology transfer within and among companies and governmental agencies is a difficult task. Numerous approaches have been tried. Each probably can be effective, given the proper setting, resources, and commitments. Selecting and using a specific approach thus becomes a management decision.

Several organizations for technology transfer include task-force groups, corporate development units, outside companies, staff groups at the corporate level, a top executive with multifunctional line authority, a research group with a special budget, individual entrepreneurs, multilevel committee responsibility, an entrepreneurial group, and a transfer team (*2, 7*).

The criteria presented for the transfer team are indicative of those required for most schemes of technology development and transfer (*2*). Participants should be specialists from both research and operations. Their assignment is to move the new product (knowledge) from research to operations in the most efficient way. It may be either an ad hoc team assigned to just one product or a permanent team.

A critical factor is the functional status of the members. The participants must have both the authority and the technical knowledge to make scientific decisions. Low-level technical people would have to call in their managers to authorize decisions, and high-level management probably would not be familiar with the technical problems. First-level managers perform well as team members. The team should be as small as possible.

There are some problems with the team approach, however. First, each team member represents a specific interest that may conflict with the interest of another representative. To be successful, team members must be willing to discuss their differences openly until some understanding is reached.

Second, absenteeism, changing membership, and inadequate understanding by members can limit the team's effectiveness. For continuity, managers should assign team members and expect them to perform consistently.

Third, communication among team members, between the team and researchers, and between the team and production people are key elements, particularly because most technology transfer must flow through these communication channels.

Communication

Although people communicate in different ways, personal contact is important. Geographical arrangement often determines how these contacts are made. The geographic domain may be a single company's operations, several interconnected agencies, or a series of federal agencies. Most contact and communication is accomplished in the vicinity of the individual, regardless of domain size. A scientist is more apt to see or call a fellow scientist in his own building or agency than a scientist farther removed, even though the latter contact may obviously be a better choice (2, 8).

Also, scientists use different resources for information, depending on their interests. Researchers draw heavily on sources more external to their organizations, such as literature and professional contacts. Those whose principal focus is operational rely heavily on information available within the employing organization. These two communication attributes, geography and interest, bear heavily on technology transfer. Managers of both research and operations must recognize this fact and organize to assure good communication among their technical leaders.

Examples and Recommendations

Much can be learned by reviewing successes in conservation research and practice that were not available in 1960. A few examples include the universal soil loss equation, the laser guided tiling machine, computer hydrology models, and computer scheduling of irrigation.

A striking observation is that each of these successes was championed by an entrepreneur who made an effort to communicate his new-found technology to users. And each represented an assembled package of knowledge ready for application to fulfill a scientific need.

Not all technology development and transfer must be a striking success or a unique package. Most will be small improvements or new combinations of existing methods. The primary ingredients needed for effective transfer are the available knowledge, a defined need with a receptive receiver, and someone with the incentive to implement the combination.

All scientists, whether performing research or concentrating on its application, must ask themselves if they are participating fully in an effective transfer procedure. Today, this primarily constitutes reading and writing in appropriate scientific journals and maintaining personal contacts. However, new methods are being developed, such as computer literature searches, that scientists should readily adopt.

Work schedules often preclude the technology transfer aspect of a scientific position, or this aspect is not a spontaneous part of a scientist's work habits. But scientists must play a role in technology transfer if they are to perform their assignments efficiently. Each scientist must review his or her own effectiveness. Does he or she read the latest scientific literature, know and readily communicate with contemporary researchers, evaluate current techniques and try to seek new knowledge, actively participate in the development of procedures and research needs, and advise supervisors of concerns and needs for improved techniques and technology transfer?

Managers and supervisors must insure that each scientist is given the incentive and freedom to participate adequately in technology transfer. Many methods can be used — seminars, workshops, scientific meetings, special assignments, organized literature sources, and temporary transfers. In addition, management must not just approve or disapprove requests to participate, but aggressively seek or organize the right types of activities to bring new technology and research needs to its organization by participation of its scientists. Although all scientists must perform some technology transfer, management should designate certain staff members to assume this task as a primary responsibility.

Increased effectiveness of technology tranfer will benefit both those in practice and in research. The results of new knowledge and techniques brought into practice will enhance our efforts for sustained high crop yields and effective conservation. And the two-way communications will more clearly define relevant research needs. We will all gain by increased efforts in technology development and transfer, or we will lose with continued neglect.

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