

CENTER PIVOT IRRIGATION IN NEBRASKA:
AN INSTITUTIONAL ANALYSIS CASE STUDY

Thomas E. Nutt-Powell and Stewart Landers

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Abstract

This paper is one of a series resulting from institutional analysis of photovoltaic (PV) acceptance. It reports the results of a study of institutional factors influencing acceptance of center-pivot irrigation in the Nebraska agricultural community. Center-pivot irrigation (CP) was an interesting topic for study because (1) it was a major recently introduced technological innovation in agriculture which (2) had potentially detrimental attributes--water and energy intensity. A brief historical review of the introduction and acceptance of center-pivot irrigation in the Nebraska agricultural community is presented. Institutions which were a likely part of this institutional arena relative to CP introduction and acceptance were identified. Their likely responses were hypothesized, then data collected regarding actual response. Three broad conclusions are drawn. First, there were definite, even controlling institutional influences in the acceptance of CP in the Nebraska agricultural community. Second, acceptance was facilitated in the Nebraska agricultural community because the innovation differentiation process yielded secondary attributes of CP that met prevailing social orders--productivity, automation, and felt need. Third, the innovation differentiation process for CP in the Nebraska agricultural community yielded both transformation and disconnection of detrimental attributes, creating the circumstances for attribute redefinition in the first instance and another innovation in the second instance.

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This paper is one of a series resulting from institutional analysis of photovoltaic (PV) acceptance. These studies are undertaken with sponsorship of the US Department of Energy (DOE) as part of its Photovoltaic Program. In addition to institutional questions, DOE is interested in economic, marketing and technological issues, and is sponsoring a series of studies and field tests on these topics. Institutional analysis studies have typically been undertaken in relation to particular PV field tests although in some cases studies have focused on comparable technologies and institutional forces influencing their acceptance.

The agriculture institutional arena was investigated in connection with a field test of PV agricultural applications for irrigation and grain drying. The field test, initiated in July 1977 and located at The University of Nebraska's Field Laboratory at Mead, Nebraska, is being conducted by MIT's Lincoln Laboratory, in collaboration with the University's Department of Agricultural Engineering.

This working paper grew out of data collection efforts for institutional analysis of PV acceptance in the Nebraska agricultural community. [Nutt-Powell et al., forthcoming.] Data collection for that purpose involved comparison of PV with a recently accepted innovation. Center-pivot irrigation (CP) was chosen as the comparison innovation. Preliminary research on CP suggested that it presented an interesting case of institutional factors influencing innovation acceptance. For that reason it was decided that a special working paper would be prepared on the topic. This paper is the result of that effort.

Among the many questions raised by CP, one in particular captured our attention: Why did institutions in Nebraska lend overwhelming support to

an innovation that is extraordinarily water and energy intensive, circumstances that would suggest opposition. Even the groups involved in rectifying the problems occasioned by the widespread use of CP have not voiced opposition to CP per se.

In this study we briefly present a chronological history of the acceptance of CP, then identify and analyze those factors which contributed to its initial and continuing acceptance.

CENTER-PIVOT IRRIGATION: A BRIEF HISTORY

Center-pivot irrigation (CP) has been described as the most significant advance in irrigation in four thousand years. Irrigation had always been a highly labor intensive process. In gravity flow irrigation, the most extensive irrigation system previous to sprinkler system designs, a great deal of labor was required to move the pipes that carried the water to the trough, and to open and close the valves that controlled the amount of water flow. With CP, only one-tenth to one-eighth of the labor used for gravity-flow irrigation is needed. On the other hand, capital, energy, and water usage are all increased. In the 1960's, when CP systems began to come into general use, energy and water costs were far below current levels, and capital was available.

Recent studies show that the groundwater level in Nebraska is dropping at an increasing rate. From fall 1975 to fall, 1976, water levels declined in ninety-one of the state's ninety-three counties. In fifty-six of these counties the decline in water level was greater during that period than in the preceding year. Since the 1950's, six areas in the state have experienced significant declines in water level, some in excess of fifty feet. In each of these areas the decline is attributed primarily to the development of deep well irrigation methods. [Ellis and Pederson, 1976.] The technology that now dominates the use of deep wells for irrigation is CP.

In a part of the United States characterized by small government, extreme controls have been enacted to prevent the rapid exhaustion of groundwater reserves. In 1972, a system of Natural Resource Districts was established to monitor environmental problems. In 1975, the Groundwater Control Act gave the locally elected directors of the Resource Districts the power to control

groundwater use. Measures of control may be as drastic as the total prohibition of the drilling of deep wells.

The Early Development (1949-1966)

Center-pivot irrigation was conceived in 1949 by Frank Zybach, who obtained a patent in 1952. In that year, he and a partner, A.E. Trowbridge, manufactured nineteen units, some of which were operated by Trowbridge's nephew, Bill Curry, on land in Columbus, Nebraska. An article in The Nebraska Farmer about Curry's CP units first brought CP to the attention of the Nebraska agricultural community.

CP is a system of sprinkler systems mounted on a long pipe. The pipe is supported by mobile towers and is attached on one end to a deep well. The pipe and sprinklers move around the well like a hand of a clock; water is pumped from the well through the sprinklers to irrigate the field.

The majority of CPs in operation are a quarter-mile long. Thus, they irrigate a circular field that occupies 133 of the 160 acres in a quarter section (a square quarter mile). A CP can circle that size field in as little as twelve hours; most complete a circuit once in three or four days. The average depth of a CP well is 180 feet; an average of 900 gallons of water is pumped per hour. Most CPs are powered by diesel engines; others are driven by natural gas-powered engines; and still others by electric motors. In an average circuit a CP deposits one inch of water into a field. Over the course of a summer, a CP uses enough water to supply a town of one thousand people for one year.

Due to its design, CP allows much previously non-irrigable land to be irrigated. Gated pipe systems require extensive leveling of land to allow gravity to move the water. By comparison, CPs can climb inclines up to thirty

degrees, though it is recommended that CPs not be used on inclines greater than ten degrees, due to erosion problems. Thus hilly land can be irrigated by CP with little preparation. A similar situation exists with sandy soil. Gravity flow irrigation methods could not be used on sandy soil because water applied through troughs would pass through such soil too quickly. By allowing precise water application, CP systems put down only as much water at a time as sandy soil can hold and plants can use. Thus, because of CP this land is also made productive.

Among its other advantages, CP guarantees a crop. Irrigation systems that depend on water diversion from streams or rivers do not guarantee a crop in years with very low precipitation. By comparison, as long as groundwater is available, CP will assure a crop each year.

CP is an energy intensive innovation. In applying twenty-two inches of water over a season, a CP consumes ten times the fuel needed to till, plant, cultivate and harvest a crop such as corn. Currently, forty-three percent of the energy used by the Nebraska agriculture industry is used to pump water for irrigation purposes. [Splinter, 1976.]

However, water and energy were not the concerns of the Valley Manufacturing Company (Valmont Industries after 1966), which bought Zybach's patent in 1953. While further improving and refining the technology, the marketing concerns of the company centered on the public's perception of the device. The barriers to acceptance were seen as three-fold:

1. The seemingly poor logic of trying to put a circle inside a square field;
2. The inefficiency of having corners left over;
3. The reluctance on the part of the technical community to endorse CP. It was feared that water application would exceed soil capacity [Howard, 1978].

Valmont thus became involved in seeking proof that CP would work. By supplying universities with CP systems at little or no cost, it encouraged research. Arrangements of this kind were made with the Universities of Kansas, Texas, Minnesota, and Maryland, and Ohio State University. The particular means by which CP came to be studied by the University of Nebraska were a combination of chance, Valmont's efforts, and the University's own process of choosing research projects.

In October 1966, the University of Nebraska's Institute of Agriculture and Natural Resources (IANR) was planning an irrigated pasture system at the North Platte Experiment Station. (The IANR is an umbrella including the University's agricultural school, the Agricultural Extension Service, and the Agricultural Experiment Stations.) The system was to use a tow-line irrigation process. At the same time, Alfred Ward was completing the purchase of several CP systems with Al Wahl, then general sales manager of Valmont Industries. Ward suggested they stop at the North Platte Station, as he had heard about research work being done there in which he was interested. Once there, Wahl found out about the planned irrigated pasture system and suggested that the station "go modern" and use CP instead of tow-line irrigation.

One of the concerns, cost, was met by Wahl's offer of the use of a CP system as a research grant. The other concern was whether CP should be tested at all. Traditionally, research priorities are decided by the superintendent of the Agricultural Experiment Station, on the recommendation of the University's faculty within a specialty. Their decision, in turn, is based on "felt need." That is, are farmers interested in knowing what they are studying? Apparently, by 1966 enough CPs were in use to have generated some interest, as Valmont's offer was accepted. The use of CP was initiated in fall 1967. Although this may have been the first time CP was used at an

experiment station, it was somewhat incidental to the main concern of the research being conducted, specifically comparing the effects on cattle of irrigated pasture versus dry-lot feeding. Thus, though not a primary consideration, the study did prove that CP worked. The support of center-pivot by the University system began at this time and continued throughout the next two periods of CP diffusion. [Sheffield, 1978.] As will be shown, this support, was critical to the acceptance of CP in the Nebraska agricultural community.

Before the Boom (1967-1970)

From 1967 to 1970, the number of CPs grew steadily, across the state. Data are available about the number of CPs in a nine-county region in southwestern Nebraska from 1965 through 1970 [Sheffield, 1978.] Table 1 presents the cumulative annual totals for this region.

TABLE 1

Cumulative Total Center-Pivot Irrigation Systems 1965-1970
Nine Counties, Southwestern Nebraska Region

Year	1965	1966	1967	1968	1969	1970
Cumulative Total of CP Systems	14	29	71	161	296	349

Source: Sheffield, 1978.

While this growth was occurring, the University was beginning to publish research results on CP. The increased production resulting from CP was confirmed. Research was also undertaken comparing the economics and energy consumption of various irrigation systems, and on the proper application of water, herbicides, and fertilizer. The results of these research efforts were disseminated to the general population through the Agriculture Extension Service.

Beginning in 1965, the Nebraska Rural Electrification Association (REA), representing thirty-two of the thirty-six rural electric districts, engaged in activities that encouraged the acceptance of CP. The REA was especially active in 1970-1971. In 1965, peak electric loads in Nebraska were in the winter. Increased electric use for nonpeak times was encouraged; a variety of electric appliances were supported, including CP. At non-peak load times, rural electric districts had to pay a minimum of sixty-five percent of peak load to whomever they purchased their electricity from. Thus it seemed efficient to level peak load amounts as much as possible.

The spread of CP was also seen as fostering rural development by making it profitable for more farmers to keep operating. In this way the rural population would remain the same or, hopefully, increase. To support CP, REA conducted tours of CP systems for bankers, farmers, and newspaper editors. Ads were placed on radio and in the REA magazine. Speakers were sent to 4-H groups and chambers of commerce. The most effective tactic was showing the cost-benefit relationship of CP to bankers. [Anderson, 1978.]

The connection to the finance community was a most critical one, as the support of lending institutions was crucial to CP acceptance. Few, if any, CPs were financed before 1967. However, it is estimated that currently ninety-five percent of all are financed in some manner. [Sheffield, 1978.]

The Production Credit Association waited to lend to the "practical" innovators--those who had learned from the mistakes of the early innovators who might have lost their shirts. [Jamison, 1977.] The Farmer's Home Administration held off until 1967, after which it would lend to farmers who had satisfactory soil and water conditions, [Waldo, 1977.] Private banks and insurance companies waited until the devices were in the field for ten to fifteen years, [Shick, 1978.] Dealers, associated with Valmont Industries, would invite local bankers to Valmont where they could learn about CP and the company.

In 1969, the exclusive patent on CP held by Valmont expired, and many firms began manufacturing CP systems. As many as forty entities were producing CP systems in the early 1970's; there are currently approximately ten CP manufacturers operating in Nebraska.

The Boom Period (1971 - Present)

The growth rate for CP has been incredibly high during the 1970's. Diffusion of CP has been particularly extensive in the sandhills of the north-central (Holt County) and south-western (Dundee County) parts of the state. Table 2 shows the growth of CP in Nebraska from 1972 to 1976.

TABLE 2
Center-Pivot Irrigation Systems in Nebraska, 1972-1976
Yearly Additions

Up to 1972	1973	1974	1975	1976	Total
2,665	1,119	2,232	2,501	3,164	11,681

Source: Remote Sensing Center, 1977.

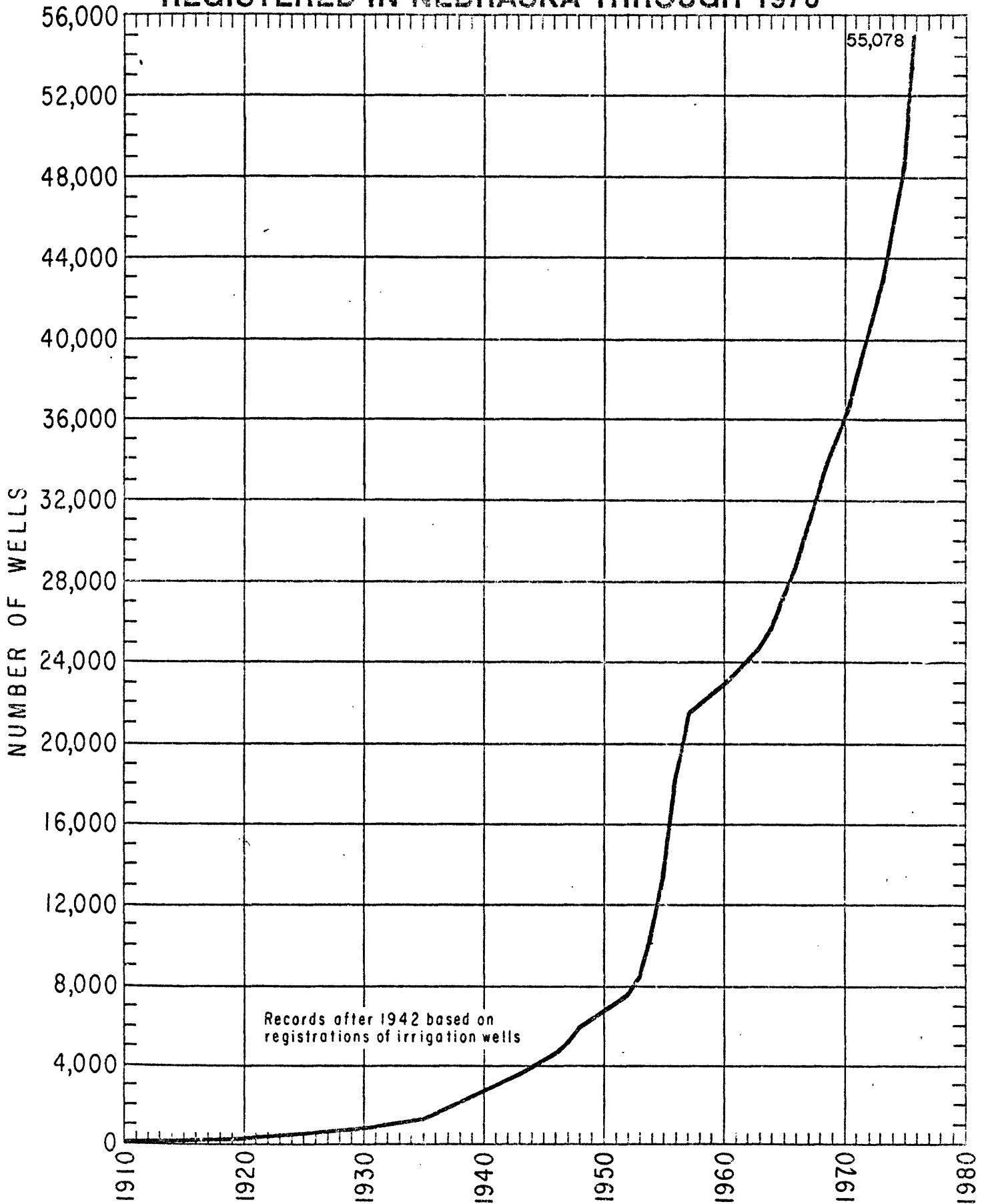
The number of irrigation wells being dug is increasing at an equally rapid rate. [See Table 3.] Yearly additions of center pivots and deep wells increased at a rate ranging from 115 to 180 percent. Since 1965, approximately 98 percent of all new irrigation utilizes groundwater, as opposed to surface water. CP systems are currently irrigating 1.5 million acres of land in Nebraska; this represents half of all newly irrigated land since 1969, and 75 to 80 percent of newly irrigated land in 1974 and 1975. Center-pivot systems are now found in such diverse locations as Colorado, Minnesota, Texas, Florida, the Pacific Northwest, Libya, Australia, Hungary, France, and the Middle East among others, [Splinter, 1976.]

With widespread use of CP, problems involving groundwater control, energy use, and land management began to emerge. A number of domestic wells have gone dry due to the use of many CPs in the same aquifer. Though most of these cases have been settled out of court, two cases that did reach judicial decisions resulted in the landowners of the deep wells being held liable, and ordered to compensate those whose wells ran dry.

These cases have spurred a series of activities regarding underground water rights. In 1972, the Nebraska Unicameral (the State Legislature) set up a system of twenty-four Natural Resource Districts (NRDs) to sponsor data collection, economic efficiency studies, and educational functions. Thus, groundwater depletion would be monitored and set in the context of economic development. In 1975, the Groundwater Control Act was passed, which allowed the NRDs to establish groundwater control districts. In these districts, controls of many kinds can be implemented, including a complete ban on the drilling of deep wells.

The Conservation and Survey Division (CSD) of UN-L modeled the water system in a western Nebraska district. This and other work done by the CSD

CUMULATIVE TOTALS OF IRRIGATION WELLS REGISTERED IN NEBRASKA THROUGH 1976



has contributed to the declaration of two groundwater control districts, the Upper Republican (on August 1, 1977) and the Upper Big Blue Natural Resource Districts (on December 9, 1977). Controls implemented in the Upper Republican control district include the allocation of groundwater among users (to be measured by meters which must be installed by 1980) and a minimum spacing requirement between wells.

In the area of energy use, shifts in electricity demand and perception regarding energy resource availability have altered the market for CPs. CP growth has coincided with shifts in patterns of electrical energy use. Widespread use of air conditioning changed peak electrical loads from winter to summer. The oil embargo in 1974 switched energy producers from an expansion to conservation mentality. The REA no longer campaigned for electricity demanding devices but for mechanisms such as time clocks and radio signals to control when a CP operates. CPs would be shut down when peak loads were about to be exceeded. Customers would receive a discount on their electricity in exchange for the inconvenience. However, even with such a scheduling plan, a waiting list for CP has been established.

Land ownership and usage has been altered by CP. The rise of CP has been accompanied by an increase in investor- as opposed to operator-owned farms. A study conducted by the Center for Rural Affairs (CRA), a private research center concerned with the status of the family farm, reported that investor ownership of CP in Dundee increased from 17 percent to 33 percent in 1975 alone. [CRA, 1977.] By making agriculture capital intensive, CP enable speculative investment in agriculture.

The CRA and others have voiced concern about bringing marginal land into production with CP. Marginal land is land considered unsuitable for crops. (Definitions and grades of land are provided by the USDA.) Most of the

concern centers on land unsuitable for irrigation due to susceptibility to wind erosion. Though such land may be productive and financially successful over the short term, severe damage to the land from cultivation made practical by CP may eventually make it completely unsuitable for use.

Summarizing the history then, one finds that the early development of center-pivot irrigation was concerned with the refining and producing of the device. Institutional involvement occurred at the second stage, in the form of testing, then support for the aspects of CP that were productive and a boost to the economy. Later, institutional action was concerned with controlling the negative aspects of the device that became magnified upon large-scale diffusion. Figure 1 presents a chronological summary.

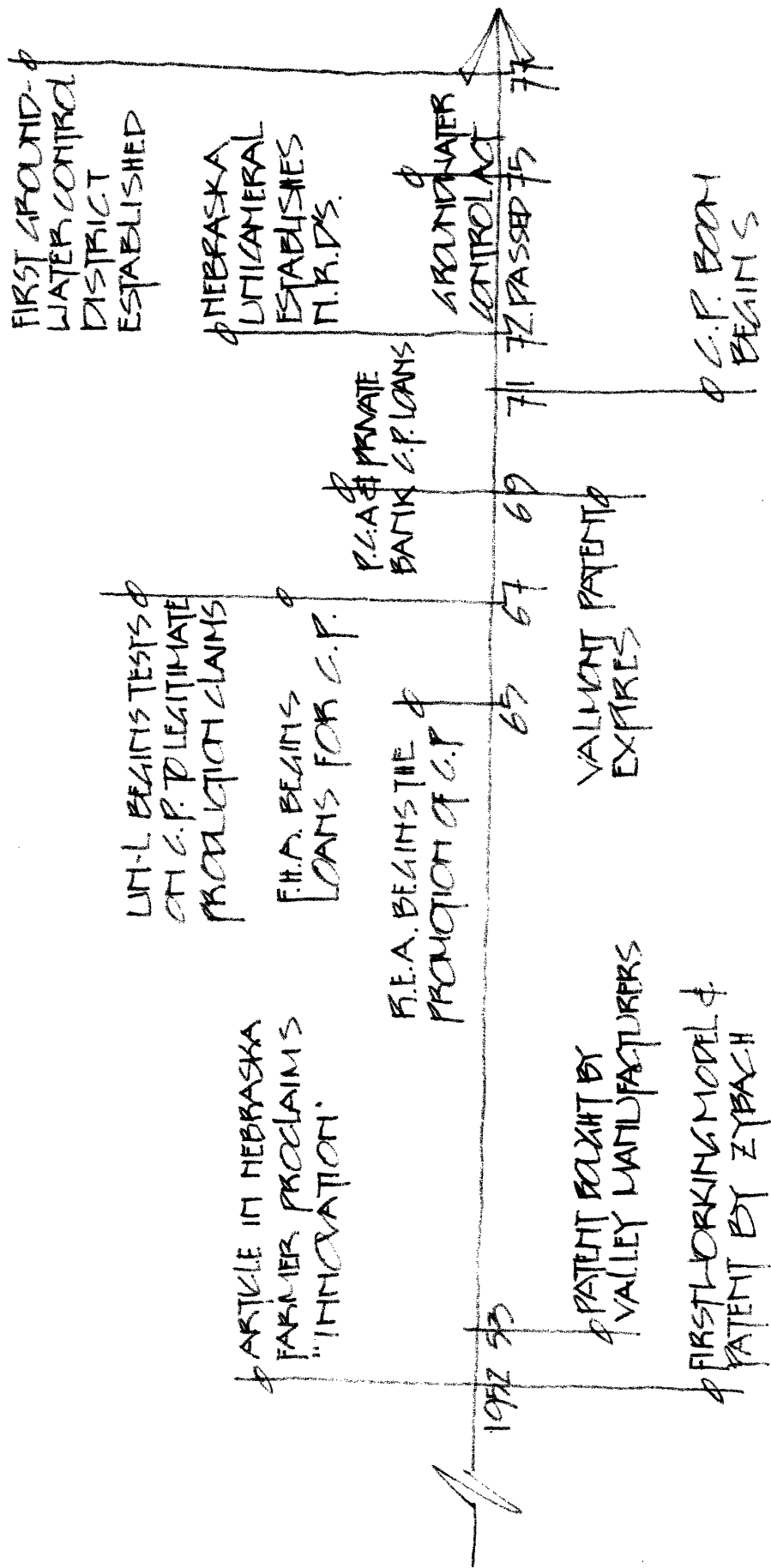


FIGURE 1: CHRONOLOGICAL SUMMARY OF ACCEPTANCE OF CENTER-FLOW IN NEBRASKA

ANALYTIC FRAMEWORK

This section describes the analytic framework used to study center-pivot irrigation as an innovation and the influence of institutions on its acceptance. This framework has three parts. First, innovation is defined and described. The concept of innovation differentiation is introduced as a critical part of innovation diffusion. Recent studies are described that indicate a growing awareness of the impact of institutional action on innovation diffusion. Second, institutions are defined and described. The dimensions of institutions—function, activity, and role—are useful to understand and interpret the part institutions play in innovation acceptance. Finally, the details of this particular research design are elaborated.

Innovation Differentiation

In discussing innovation, H.G. Barnett [1953] distinguishes between "configurations" and "innovations." A configuration is the linkage or fusion of two or more elements not previously combined in this way. An innovation is this fusion on a mental plane, that is, the linkage between ideas. An idea may be an "idea of a thing with substance" or an "idea of some intangible." An innovation always has antecedents; it is always a new combination of previously existing ideas.

The process of innovation adoption over time is called diffusion. A central premise to this analysis is that diffusion is characterized by innovation differentiation. Differentiation entails, at least, the following four phenomena:

1. Different perceptions of the same innovation by different users.
2. Different perceptions of the same innovation by a single user at different times.

3. Corollaries to an innovation resulting from increased diffusion or broader applications.
4. Effects from an innovation necessitating an innovative response from the environment. (The environment refers to the entire array of institutional entities.)

Nuclear fission can be used to illustrate each of these concepts:

1. Nuclear fission is viewed by the Department of Defense as a source of new weapons (bombs, submarines) but by utility companies and the Department of Energy as a generating source of electricity.
2. Oppenheimer worked on the Manhattan Project and had a positive vision of what nuclear fission would mean. Years later, he testified that the dangers of this technology outweighed its benefits.
3. With expansion of nuclear energy use came the formation of the Nuclear Regulatory Commission to monitor and control its application.
4. An effect of nuclear generating plants is the heating of water used in some cooling systems. An innovative response is needed to find a way to dispose of this water without upsetting the ecological balance of localities where nuclear plants are situated.

Thus the differentiation found in innovation diffusion occurs in relation to different actors, different times, different outcomes and different responses. In each case the innovation is differentiated because the different actors/times/outcomes/responses prompt different linkages between and/or among ideas. In effect, differentiation occurs when the meaning attached to the innovation is refined. [For a related discussion on this point see Nutt-Powell et al., 1978, pp. 25-27.]

While it is difficult, if not impossible, to recreate the factors contributing to the differentiation process of any given actor in relation to any given innovation, it is possible to identify, in a simplified way, the linkages which occurred, whether the result of exchanges in relation to different actors, times, outcomes and/or responses. Take, for example, three possible center-pivot irrigation linkages:

1. Inventor-- Sprinkler system > deep well > center-pivot > patent > profit

2. Farm equipment manufacturer-- Center-pivot irrigation > efficiency > sales > profit
3. Farmer-- Irrigation > center-pivot > guaranteed crops > increased production > profit

Surprisingly, the literature on innovation has tended to treat the attributes of an innovation as fixed, an approach rendered inadequate by the concept of differentiation. In this analysis a broader view of innovation is used, based on the innovation differentiation concept. An innovation differs according to actors, time, outcomes and responses, and the interaction of these factors. This concept sets innovation in a larger environment, recognizing that innovation acceptance is not separate from its environment, its elements and ongoing processes. The attributes of an innovation, be it a process or product, are not fixed, but are the result of the meanings realized in the linkage between ideas.

One analytical construct is particularly useful in studying differentiation. Downs and Mohr [1976] distinguish between primary and secondary attributes of an innovation. A primary attribute is relatively stable, thus less subject to change due to the perception of the observer. To any observer an automobile is an automobile, not a subway car or airplane. A secondary attribute is one which can vary substantially according to the perception of the observer. A Volkswagen is not a Cadillac but may be equally a luxury for someone at sometime. Innovation differentiation tends to occur mostly in relation to secondary attributes.

Thus, the attributes of an innovation such as center-pivot irrigation are not simply defined. The primary attributes are clear--CP is a long pipe sprinkling water as it rotates around a field. But what are the secondary attributes? They can be named and questions can be asked relative to them, but they can only be determined by proposing hypotheses and then testing

them. The following secondary attributes and questions illustrate the four types of innovation differentiation:

1. CP is labor saving. Is CP for use by family farmers who wish to farm more land, but whose sons and/or daughters have moved away? Or is CP for use on corporate farms that are characterized by absentee owners, farm managers and employees?
2. CP increases production. What about the dangers of over-production? If corn prices drop low enough, will CP price itself out of the market? If increased production is no longer a primary goal, will the view of CP change?
3. CP uses large quantities of groundwater. Will use of CP drop groundwater levels significantly? Can groundwater be recharged naturally or could technology find a way to replenish it? Will groundwater have to be regulated? Can groundwater be regulated in a non-discriminatory manner?
4. CP can irrigate sand hills and very hilly land. What happens to land, especially fragile land such as sand hills, after it has been irrigated by CP for 15 or 25 years? What happens to land improvement contractors if the need for their services is significantly reduced? What happens to the supporting services of the rural agriculture economic community (small businesses, health providers, and so on) if corporate farms increase and provide these services in-house?

A substantial proportion of innovation research deals primarily with questions concerning the decision to adopt, that is the adopter-innovation exchange. However, as the differentiation discussion suggests, many factors controlling this decision are influenced by the actions of individuals or organizations other than the adopter or producer. These actors may not directly purchase or use the innovation, but may perform some other activity which influences or is influenced by it. Until recently, innovation diffusion was considered to be determined solely by producers and adopters, with information as the intermediary. In a true free enterprise economy this would constitute satisfactory theory. However, as our society has experienced growth and become aware of the limits to growth, the free enterprise system has been increasingly regulated by institutions. Selznick [1960] has dubbed

institutions "the regulators of change." Another writer defines institutions as "collective action in control, liberation, and expansion of individual action." [McDermott, 1971.] The wide range of activities that may influence innovation includes legislation, court decisions, published research, media coverage, public demand, political necessity, and so on. In short, institutions are a major contributor to the process of differentiation.

Institutions and Innovation

Studies of innovation are increasingly reflect the variety of concerns that impinge upon the relationship between producer and adopter. In developing criteria for determining the success of an innovation, White [1978] found that government regulation is likely to prevent the success of super-sonic transport (the SST) and likely to guarantee the success of automotive microprocessors. A recent newspaper article by columnist Jack Anderson [1978] cites the structure of the automobile industry as preventing the marketing of a tire that is stronger, longer lasting, and more efficient than those currently being used. Indeed the term "regulation" is now routinely used to describe a part of the innovation process through which an innovation must pass. [Myers and Sweezy, 1978.]

Here we use institutions to refer to an entity that is a repository for social meaning. [Nutt-Powell et al., 1978.] There are six institutional entities. Three are organizational--formal organizations, informal organizations, and members-- and three are not--social orders, collectivities and persons. The defining dimensions of institutions are function, activity, and role. Function broadly defines the area of an institution's concern. Activities are undertaken to support that function. Roles represent strategies taken in a particular situation to implement a functional

activity. Any given institution will have a resource configuration, by which we mean the way in which its resources are allocated to fulfill its role(s) in support of its functional activities.

Institutions establish exchange relationships with various members of the environment to form an institutional network. The exchange may involve information, services, goods, or personnel. An institution will respond to an innovation in either a routine or innovative way. The difference between these responses is as follows:

1. Routine--The innovation establishes routine linkages with the institution, enabling the institution to utilize a standard procedure, structure, or set of guidelines.
2. Innovative--The innovation, either from its primary or secondary attributes, creates new linkages and therefore provokes an innovative response.

The process of differentiation is one which moves the response from innovative to routine; the tendency of institutions is to routinize the non-routine.

The four response categories that will be used in this analysis are intended to describe the nature (routine or innovative) of the interaction between the institution and the innovation, and the impact on the institution's resource configuration. The categories are as follows:

1. None--This indicates that the innovation has no impact on the institution, in either primary or secondary attributes. It is not part of the institutional network.
2. Routine response--The innovation is supported by the institution in a routine manner.
3. Cooperative response--The innovation is perceived as potentially strengthening the institution's resource configuration, and thus is supported, resulting in institution-innovation cooperation.
4. Conflict response--The innovation is perceived as potentially weakening the institution's resource configuration, and thus is opposed, resulting in institution-innovation conflict.

The first two responses are routine in that there is no disruption in the institutional arena. The latter two are innovative in that resources are reallocated to first comprehend, then either support or oppose the innovation.

Research Design

Understanding the influence of institutions on innovation acceptance entails a simultaneous focus on each, in a specific situation in which innovation appears. The following steps provide a structure for such a study:

1. Define the innovation, by primary attributes.
2. Determine the particular institutional arena for study.
3. Identify those institutions likely to be part of the institutional arena.
4. Identify the functions, activities, roles and consequent resource configuration of each institution in order to assess institution-innovation interactions(s).
5. Identify the institutional responses to innovation.
6. Analyze the direct and indirect effects of such responses on attributes of the innovation, and how those attributes effect diffusion possibilities.
7. Analyze the effect of such responses on the institutions (function, activity, role and resource configuration) and the institutional arena.

This study focuses primarily on two of the six institutional entities—formal organizations and members. This choice was made in part because, as McDermott notes, specific organizations are necessary as a vehicle for the institutions, and the performance of the organization is one determinant of the effect of the institutions, [McDermott, 1971.] Within the context of a larger study [Nutt-Powell et al., forthcoming], an hypothesized institutional arena for the Nebraska agricultural community was developed. Organizations likely to be part of the institutional network impacting CP were specified, based on function and activity.

Information exchange was chosen as a key focus for data collection. Data were collected through personal interviews conducted in July–August 1977 and February 1978 with key members of the organizations determined to be central to the institutional network. A semi-structured open-ended survey instrument was developed. (A list of those interviewed is included as Appendix A.) Questions about the attributes of the innovation were asked to balance questions concerning information channels, and the nature of the organizations and members and their activities. Attributes of the innovation will be conveyed by information, but the weight given various attributes, and therefore the determinant of the activity, will vary with the type of information received by the organization and the functional activity or role of the organization. The role of the individual in effecting institutional action is also considered briefly. In many cases, an individual can build an institution and control its activities. Powerful individuals can substantially block or support an innovation.

A particular focus in the analysis is on the roles adopted by the institutions studied. Several, such as translator, linking-pin and legitimator, have direct relevance to the innovation–institution interaction. The data are structured according to the roles adopted by organizations and the consequences for institutional action, both in general and specifically related to CP.

ANALYSIS

The following analysis considers the interaction between an innovation (center-pivot irrigation) and institutions in a given institutional arena (the Nebraska agricultural community) from two perspectives. Analysis from the first perspective focuses on the development of the innovation and how its diffusion influenced the Nebraska institutional arena. Briefly, the innovation was perceived as satisfying a need and fulfilling certain normative values within the community. When it appeared that CP might satisfy these needs, institutions attempted to determine whether CP satisfied the requirements of those normative values. By satisfying both requirements, center-pivot irrigation spread widely and rapidly. In doing so it changed the environment. In the new environment created by CP (as well as other events), new problems became apparent. These problems are related to CP but due to continuing values and institutional roles premised on CP's institutionalization, the institutional perception of CP has not significantly changed. Rather than prompting a rejection of CP, these new problems have spawned a new innovation, groundwater control.

The second perspective focuses on the institutions and roles that they have played in the diffusion of CP. A controlling social order—felt need—has affected the roles of industry, the university, and the finance community with regard to center-pivot.¹ The prevalent institutional responses to center-pivot were routine and cooperative, viewing CP as a labor-saving and productive innovation. These reactions were facilitated by encountering the innovation through routine exchange relationships enabling the organizations to respond to CP in routine ways.

Innovation Diffusion and Differentiation in an Institutional Context

The overriding concern of the agricultural community in the 1950s and 1960s was production. Any product or process that supported or increased production was viewed positively. New products or processes were tested and, if results were positive, spread rapidly. A good example is hybrid corn, which went from a single application to almost universal acceptance in only a few years.

In view of the concern with production, technology and its various manifestations in farm equipment have become highly valued. The development of new technology has made agriculture increasingly capital, rather than labor, intensive. This was especially true during the 1960s, when the availability of capital was very high and technology was perceived as a primary solution to any problem.

Another factor that encouraged the development of certain kinds of technology during this period was the increasing availability of electricity in rural areas. The Rural Electrification Associations (REAs) were operating below peak load capacity, especially during the summer months. The REAs encouraged the use of many electrical appliances by farmers, center-pivot irrigation included.

Thus, at this time the central questions concerning an innovation such as CP were: Does it work? Does it improve production? Is it economical? Not surprisingly the research done on CP by the University of Nebraska's Agricultural Experiment Station focused on these issues.

At the onset CP was characterized as the most important step in the mechanization of agriculture since the advent of the tractor. After the rate of rotation and water application is set, a CP practically runs on its own. Abundant power sources and groundwater were available to operate CP. The device could increase production on existing farmland as well as increase the amount of land in cultivation.

At initial encounter these attributes would appear to match the agricultural community's norms, notably increased production and automation. Thus the initial response was routine, namely research to confirm the appearances. Research on CP, done primarily by the Experiment Station, focused on the performance ability and on the production that could be expected under various conditions. Among the aspects studied were the proper scheduling and amounts of water application, various soil compositions, and the application of herbicides, pesticides, and fertilizer. Economic analyses focused on prices, expected production, and costs of production.

The research, a routine differentiation process, showed that CP would increase production by allowing precise control of water, herbicide, pesticide, and fertilizer application. It also showed that, due to its application control, CP could be used to irrigate sandy soils. Because it utilized a sprinkler system rather than a series of gravity powered troughs, CP could also be used on very hilly ground. Thus CP met the prevailing norm of increased production. It did not require an innovative response, such as restructuring of the agriculture business. Rather, its use by farmers was routine (mechanized water delivery → seeded land → harvest → increased production) as other technology had been (tractors → seeded land → mechanized harvest → production). There was no apparent need for any innovative response on the part of farmers or researchers.² Thus, CP was legitimated³ and its diffusion keyed to the increase in land that could be irrigated and the productivity of irrigable land.

However, with the passage of time, a new set of problems confronted the Nebraska agricultural community. In 1973, the embargo on oil by the OPEC nations put the term "energy crisis" into the American vocabulary. Until then, cheap and abundant fuel was taken for granted. With the advent of air

conditioning and the spread of electricity-dependent irrigation technology, peak load times for electricity occurred in the summer months, reversing the earlier situation. Center-pivots in particular are highly energy intensive. The REAs began limiting the number of wells and/or the total horsepower they would provide in any area. Scheduling programs were proposed so that peak load capacity would not have to be increased. Natural gas distributors also limited the amounts of gas they would provide for irrigation due to limited supply lines and reserve gas supplies. [Sheffield, 1978.]

The energy crisis was only the first of several challenges to the prevailing normative structure of the Nebraska agricultural community. Increased production and productivity prompted concerns about overproduction and, to a lesser extent, land use and farm ownership. Overproduction causes a drop in prices potentially beyond the capability of federal price support programs to balance. A drop in cash flow, especially if sustained and pervasive to the agricultural community, poses a real threat to its present capital intensive economic structure. Simply, if prices fall low enough, CP systems are no longer economical. Crop prices, however, are partly determined by such institutional externalities as the level of price supports offered to farmers and the amount of exports allowed by the government. With institutional controls such as these, producing as much as possible is no longer the obvious goal. Instead of increased production, efficiency in achieving optimal outputs is now the highest value as far as production is concerned.

The biggest problem connected with CPs is the drop in groundwater levels in the state. With groundwater dropping at a rate of one to three feet annually in many parts of Nebraska, the norm is no longer that water can be pumped indiscriminately. Controls of some kind were determined to be

necessary by the Nebraska Unicameral. The Ground Control Act of 1975 gave the Natural Resource Districts (NRDs) the power after public hearings, to declare irrigation control areas. The law authorized NRDs to register wells, increase well spacing, allocate maximum well withdrawals for various crops, order rotation pumping and, as a final resort, declare a moratorium on further well drilling for up to one year.

The differentiation which accompanied CP diffusion over time is reflected in the chronicling of CP by the Omaha World-Herald, the state's major daily newspaper. The stories that ran on CP evolved thusly: From 1967 into the early 1970s, the stories concentrated on production benefits of CP. At first the stories were about the use of CP for corn and then later on its use with specialty crops such as sugar beets and potatoes. In 1971-1972, the articles centered on land erosion in western soils due to poor management. Finally, in 1973-1975, the concern focused on underground water supplies and the passage of the Groundwater Control Act.

In the differentiation of the secondary attributes of CP, the qualities of the innovation that came to be viewed as negative were disconnected from CP and treated as a second and unrelated issue. Thus, groundwater depletion became a new problem, necessitating an innovative response. For example, in keeping with the high value of technology in the Nebraska agricultural community, one informant expressed hope that ways of recharging ground water could be developed. However, in the absence of such a technological solution, there was still no reaction against CP, but rather the establishment of government controlled management solutions. This avoided any need for re-evaluation of the positively primary and viewed secondary attributes of CP.

Critical to the separation between CP and groundwater control is the role played by the Conservation and Survey Division (CSD) of the Institute of

Agricultural and Natural Resources at UN-L. Vince Dreezen, director of the CSD, may be seen as a linking-pin⁴ in the institutional structure connecting groundwater to irrigation. As head of the CSD he helps prepare studies of groundwater supplies that are used in the determination of control districts. As an ex-officio director of the Nebraska Welldrillers Association, he has had extensive involvement with the people who drill wells for irrigation development. He has intervened and kept out of court a number of disputes in which deep water wells have caused smaller domestic wells to go dry. Yet he sees no connection between what he does and the diffusion of CP. [Dreezen, 1977.] His inability or disinclination to make that linkage illustrates the separation of the two innovations (CP and groundwater control) and the extent to which CP is now routinized, while groundwater continues to provoke innovative response.

The creation of Natural Resource Districts and the passage of the Groundwater Control Act of 1975 may be looked at as the creation of a second innovation--government control of groundwater. Until the passage of this act, there was no formal structure of ownership rights concerning groundwater. Indeed, the act itself will probably be tested with regard to its constitutionality. If it survives such a test, the act will probably be the basis for further legislation clarifying who has what rights with respect to underground water. Thus this innovation is still in its early phases, with its primary attributes as yet undeveloped.

The Effects of Institutions On Innovation

The companion analysis to a consideration of an innovation's differentiation in an institutional arena is the manner in which particular institutions responded to the innovation. Analyzing the particular

institutional reactions to CP is like putting together a puzzle. To understand the roles each organization adopts, it is helpful to have an idea of what the broader institutional environment looks like. In this instance, a knowledge of normative behavior within this arena helps explain the diffusion of center-pivot irrigation.

Industry in Nebraska has traditionally been the source of innovation in agriculture. Within the agricultural community, the free market tradition reserves the right to initiate to those who are the most entrepreneurial. This industry has as its primary goals the making of money and increased efficiency in production. Valmont's role as the producer of CPs is that of a vendor and as such must convince the controlling institutions as well as the consumer that its product is needed.

Valmont acted to convince the consumer population by first identifying and influencing two key institutional actors, the University of Nebraska at Lincoln (UN-L), and the finance community. While industry does conduct a great amount of research in Nebraska, it is the research activities of the University which possess the critical roles of legitimator and translator⁵ regarding new products or processes.

The critical roles of UN-L as a legitimator and a translator grow out of the historic concern of the federal government for education and research. This concern resulted in the 1862 Morrill Act which established land grant colleges in every state in the Union. In 1887, the Hatch Act established Agriculture Experiment Stations and in 1916 the Smith-Lever Act completed the basic functions by establishing Cooperative Extension Services, both to be operated in conjunction with the land grant colleges. McDermott [1971]

describes the presence of both research and extension to be essential as extension was considered as the extending of information that presumably was produced by the research activity.

In serving the agriculture community, the Extension Service acts in response to "felt need." Felt need is identified by extension agents based on questions that are raised by farmers in the area they serve. In their role as linking-pins, county agents connect farmers to information which meets their felt need. If no such information exists, the linking-pin county agent conveys the need to extension specialists. (The University has specialists in over twenty fields.) Specialists are the translators, taking available research results and providing needed information. Alternatively, if no information exists at all, specialists translate the need into a research need. At this point, products and processes (innovation) which might meet this need are identified, and research is conducted which determines whether the innovation(s) legitimately meet the need.⁶ Only infrequently is more basic research undertaken.

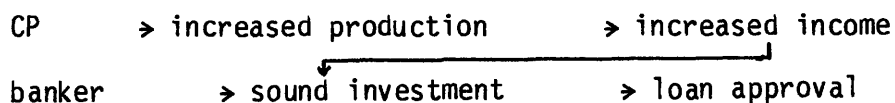
The translator role has been critical in supporting the legitimator powers of the research system. McDermott [1971] notes how "extension" served an almost evangelistic function in promoting science and rationality in farming. This effort reinforced the validity of the role of the academic entity as the legitimator, since its existence and practices are based on science and rationality.

A limitation of this system is that innovation must make itself known in some way before questions from farmers ("felt need") will occur. For the producer this entails making a connection between its innovation and prevailing norms, at least among the early innovators. Valmont promoted CP for its production-raising potential, emphasizing its labor-saving qualities.

Its use by plungers was advertised.⁷ Thus when UN-L was going to test a new system and Valmont approached them with the offer of CP, the felt-need had been created and the University was prepared to respond. Its response was routine, enabling an initially positive attitude.

As farming was becoming more capital intensive and as CPs are expensive, the role of the finance community in supporting CP became the third part of this institutional puzzle.⁸ Approximately 95 percent of CPs are financed. Both private and public finance institutions are involved in lending money for the purchase of CP systems. The availability of capital and the tendency of the agriculture sector towards increased capitalization indicate why the support of CP by finance institutions was so critical to its success. One informant stated that due to the availability and positive reinforcement of financing a farmer was more likely to spend \$50-60,000 in 1977 than \$14-15,000 in 1965.

Public and private banks differ as to roles and method of operation. The private banks are seen as vendors and operate in that way. They are interested solely in making good investments and therefore were conservative in evaluating the worthiness of CP. Only after ten to fifteen years of experience with CPs did they begin to lend money for them. Thus, commercial banks were not interested in CP as an innovation, but wanted it well institutionalized. Indeed, to some banks the nature of the capital investment is not even considered. As one informant stated, "If the farmer is worth it, it doesn't matter what he spends his loan on." In this respect the action of banks with respect to differentiation is corollary:



The bankers do not have to consider the complete set of primary and secondary attributes belonging to CP, only those that enable a routine response, or

(in order of decreasing preference) a cooperative response or a conflict response. Either of these latter two responses necessitate more detailed consideration of the innovation, looking (in a definitionally innovative way) at:

increased income ←——increased production ←—— CP.

The public finance institutions were more specific as to how they considered innovation. The Production Credit Associations (PCA) routine response to innovation is to wait for the "practical" adopters, those who have learned from the mistakes of the plungers. The Farmers Home Administration (FaHA) is labeled an administrator because it primarily tries to process loans to those farmers whose credit is not the best and who have been turned down elsewhere. Surprisingly, this conservative organization started lending money for CP in 1967, about two years earlier than most finance organizations. This is attributed to established institutional connections with the Soil Conservation Service. The FaHA checks on the water levels and soil composition of those to whom it lends money for CP irrigation to see if they are adequate to support such a system. Since such information was available in a way which could be routinely processed (thanks to UN-L's research) FaHA had no need to devise a new resource configuration. Indeed FaHA's existing function, activity, role, and resource configuration were reinforced by the CP information available in the Nebraska agricultural community when FaHA began financing CPs.

Institutional Perception of and Response to CP

The organizations expected to influence CP were categorized with respect to their hypothesized perception of and response to CP (Table 4) and then with

respect to their actual perception of and response to CP (Table 5) based on information obtained from interviews.

The hypothesized table was constructed as follows. Several attributes of CP were identified. An hypothesized response to CP for each institution is determined based on the function of the institution as related to the most relevant attribute. For example, a finance institution is expected to be concerned with the finances of CP. For broad-aim organizations (e.g., the Farmer's Union, which "supports whatever is good for the farmer") an hypothesized response based on a single attribute is more difficult to define. However such hypotheses were made based on the attribute judged to be most dominant.

The expected response to CP was classified according to the categories described in the analytic framework. The "none" response was not included as an hypothesized response because it was expected that all institutions would have a response.

The largest number of organizations expected to have a cooperative response to CP were those thought to perceive the outstanding attributes of the device as either "production boom" or "labor saving." These are closest to primary attributes of CP on which the innovation's success is based. "Water issues" and "land use" are secondary attributes resulting from widespread diffusion. Perception of secondary attributes was expected to vary, with both "conflict" and "routine" responses expected.⁹ For the most part both of these expectations held true.

A major difference between expected and actual response was the large number of organizations with a response of "none." In general those organizations reflect the belief that technology, as part of the free enterprise system, is not something to be "supported" or "opposed" at all. Surprisingly many of the organizations expected to be in conflict with CP fell into the response category of "none."

In fact, of all of the organizations expected to exhibit a conflict response to center-pivot, the only one to do so was the Center for Rural Affairs. The Nebraska Land Improvement Contractors Association agreed that CP was hurting their business since land irrigated by CP requires much less grading than that irrigated by gravity flow methods. NLICA had not, however, opposed CP in any way and saw it positively as "labor saving." In fact, they supported the device in a routine way by advertising for the minimal grading work required by CP.

The Nebraska Association of Resource Districts (NARD), the Department of Environmental Control (DEC), and the Chairman of the Public Works Committee (Senator Kremer), all of whom were expected to conflict with CP on the basis of "land use," were not opposed to CP. Instead, NARD and DEC saw it as a "management" tool, and separated their concern with land use, water, and ecology in general from their opinion of CP. They preferred to see the positive secondary attributes of CP and create a separate category of concern--groundwater control--for what would otherwise be negative secondary attributes of CP. In this way there was no direct conflict with the norms of the Nebraska agricultural community supporting technology and production. The norms could be supported while continuing activities that lead toward control of deep well irrigation.

Management is thus a critical and highly differentiated secondary attribute. It has been attributed to CP relatively recently, representing a time and effect differentiation. Valmont Industries, producers of CP systems, spoke of concern about groundwater conservation and the need to promote CP as a management tool. This reflects a shift in their understanding of the innovation from production in volume to optimizing production. By viewing CP as a management device it is seen as part of a strategy to control resources rather than as a huge resource utilizer.

The Agriculture Experiment Station did not materially benefit from CP diffusion and thus was expected to and did react in a routine way. The usefulness of an innovative response from the University is high, but was not expected and did not occur. The First National Bank (FNB) did have something to gain by supporting CPs at an early stage. The device was highly profitable, and FNB could have made many more loans had it started earlier in time. By missing the chance for an innovative response FNB missed an opportunity. Its institutional connections were not as good as FaHA, which was expected to and did respond in a routine way. However, because of close ties between FaHA and other government institutions such as the Soil Conservation Service, the institutionalized response of the FaHA took place two years before that of private banks.

The Conservation and Survey Division (CSD) should have responded in a conflicting way since it would bring to light the water depletion attributes of CP. By reporting the impact of CP on groundwater, it partially fostered the circumstances that led to the creation of the Groundwater Control Act and new duties for the CSD, the preparation of studies used in the declaration of groundwater control districts. However, the CSD did not link dropping water tables to the rise of CP. It in no way sought to oppose diffusion of CP.

Had it wanted to sell more pivots, Valmont could have worked more closely with private banks in order to elicit their innovative response at an earlier date. The path Valmont took was innovative, but could have been even more accelerated. The Rural Electric Association (REA), which stood to benefit from increased electrical use, was innovative in the campaign it launched to sell CPs. REA was innovative again when circumstance changed and it was forced to optimize the distribution and operation of CP so as not to exceed peak load capacity.

Given the way the sudden and dramatic emergence of the groundwater issue, it is fortunate that Valmont was not more successful in the selling of CP. The failure of the linkage of CPs to groundwater depletion lies primarily in the normative structure of this institutional arena, which did not concern itself with the larger impacts of a new innovation and later chose to isolate the problem as a separate innovation, requiring a separate and innovative response once CP had entered and become a part of the institutional structure.

TABLE 4
Hypothesized Institutional Perception of and
Response to Center-Pivot Irrigation

Perceived Attributes	Responses			
	None	Routine	Cooperative	Conflict
Management			SOPP	DEC
Water Issues		NSIA CNPPID		SC CSD
Production Boom		Ag Builders NCC MFREDA	NSA Valmont Welldrillers FU Farmland NFI/NGFA NFO	
Labor Saving		NSIA AES NCEAA Om W-H Ag Council Ag Exp Sta	REA FSC FB Grange	
Land Use		Neb. Farmer Ex A DA		CRA NLICA NARD Sen. Kremer Sen. Schmidt
Energy Use		NPPD NPC		SEO
Finances of CP		NBF NSFMR DED PCA Sen. Warner NBA FaHA	FNB	
Age of CP		DI		

A listing of these acronyms is found in Appendix A.

TABLE 5

Actual Institutional Perception of and Response
to Center-Pivot Irrigation

Perceived Attributes	Responses			
	None	Routine	Cooperative	Conflict
Management	DEC	NARD	SOPP Valmont	
Water Issues	Ag Builders SC	CNPPID FHA		
Production Boom	NFO FU Farmland		NSA	
Labor Saving	Ag Council NCEAA SEO Grange FB	NSIA AES Sen. Kremer Ag Exp Sta NLICA	REA FSC Om W-H CSD Welldrillers Sen. Schmidt	
Land Use	DA NCC Sen. Warner	NBA Neb. Farmer Ex A		CRA
Energy Use		NPPD		
Finances of CP	MFREDA	NBF NSFMR DED PCA NPC FNB	NFI/NGFA	
Age of CP		DI		

A listing of these acronyms is found in Appendix A.

CONCLUSIONS

The central question of this paper is why the institutions of the Nebraska agricultural community supported an innovation--center-pivot irrigation--certain attributes of which--water and energy intensity--were potentially so detrimental. After presenting a brief history of the acceptance of center-pivot irrigation in Nebraska, we analyzed the institutional factors influencing that acceptance. In particular we looked to see if there were routine exchanges in the Nebraska agricultural community which smoothed the way for CP's acceptance. To the extent that there were such routines, the need for other (presumably more difficult or cumbersome) responses, whether cooperative or conflict, would be obviated.

In order to study the responses of the Nebraska agricultural community we identified those institutions most likely to be part of the institutional arena into which CP was introduced. We hypothesized their probable response to CP, given the innovation's attributes. We then collected data on actual response of these institutions to CP through a personal interview approach.

From our study we draw three broad conclusions:

1. There were definite, even controlling, institutional influences in the acceptance of center-pivot irrigation in the Nebraska agricultural community.
2. Center-pivot irrigation's acceptance was facilitated in the Nebraska agricultural community because the innovation differentiation process yielded secondary attributes of CP that met prevailing social orders--felt need.
3. The innovation differentiation process for center-pivot irrigation in the Nebraska agricultural community yielded both transformation and disconnection of detrimental attributes, creating the circumstances for attribute redefinition in the first instance and another innovation in the second instance.

Institutional Influences

Where the literature of innovation diffusion tends to treat the attributes of an innovation as fixed, the concept of innovation differentiation set forth in this paper holds that an innovation differs according to actors, time, outcomes and responses, and the interaction of these factors. These elements of diffusion are manifest in institutional entities. Thus rather than innovation acceptance being a matter of innovation-adopter interaction (which is the general premise of the innovation diffusion literature), innovation acceptance is the result of institutional influences. Though this view was the basis for our analytic approach, it was not taken uncritically. Indeed the study, in many respects, took this as an hypothesis to be tested.

Based on the evidence presented here, that hypothesis is confirmed. There were definite, even controlling institutional influences in the acceptance of center-pivot irrigation in the Nebraska agricultural community. The innovation did undergo a differentiation process, in which both the innovation and the institutional arena changed as a result of the exchanges between and among institutional entities. The elements of innovation diffusion through differentiation (which we called the routinizing of innovation) were traceable based on which actors were involved at what times with what outcomes prompting which responses.

Perhaps the clearest evidence of institutional influences on CP acceptance is found in the time period we labelled "before the boom," 1967-1970. Though the basic CP system did not change between 1966 and 1967, the nature of institutional exchanges did. In 1967 the UN-L Experiment Station began the first systematic testing of CP. Soon thereafter the results were published, and spread throughout the state by Ag Extension agents. The upward swing in acceptance of CP began almost immediately, clearly the result of the

University's legitimator, translator and linking-pin roles. For example, the 9-county cumulative totals of CP reported in Table 1 show a 227 percent increase from 1967-1978, a 417 percent increase from 1967-1969 and a 496 percent increase from 1967-1970.

Clearly the University was not, by the conventional use of the term, an adopter. It did not purchase CP systems for its private farming business. Similarly CP systems did not change in primary attributes between 1967 and 1970. What did occur was the involvement of critical institutional actors--the University research facility, and the Ag Extension specialists and agents--at a point in time. The Experiment Station served the legitimator role. Claims heretofore made by the manufacturer were now confirmed (or disconfirmed) by a trusted source. (In this case the claims generally were confirmed.) Equally important this information was translated by the Ag Extension specialists from manufacturer claims and research findings into "practical" information for farmers, and then disseminated by Ag Extension agents, serving in their linking-pin roles, to farmers and others throughout the state.

The importance of particular actors and timing of exchanges is also revealed in the pattern of acceptance. Though REA had begun its campaign promoting CP in 1965, the boom did not begin until after the University became involved with CP. For example, FaHA initiated its CP lending far in advance of its expected time, because of the information it received from the University. Thus the acceptance of CP by critical institutional influences--Experiment Station, Ag Extension, FaHA, FEA and so on--was a necessary condition for farmers to adopt the innovation.

Differentiated attributes meet prevailing social orders

A social order is an institutional entity defined as a societal disposition without specific members. [Nutt-Powell et al., 1978.] As such a social order is a non-organizational institutional entity. Its importance in any institutional arena depends on the extent and manner in which it is engaged by other institutional entities.

In our study we identified three prevailing social orders which influenced CP acceptance: productivity, automation and felt need. As the innovation differentiation process yielded CP attributes that met these social orders CP became more widely accepted.

A basic concern in agriculture has always been productivity. The Nebraska agricultural community is no exception. Products or processes which increase productivity spread rapidly. The primary attributes of CP directly affect productivity, specifically controlled irrigation of large land areas. Insofar as the differentiation process showed that these primary attributes held up in the interpretive context of different actors (that is, that the secondary attributes also met the productivity social order), CP's acceptance would be facilitated. REA was one of the first to reach a positive conclusion from its differentiation process. CP, which used power at REA's lowest demand time, would even the utility's loading, increasing productivity. The University's testing was the most crucial in establishing that CP met the productivity standard, for land presently or potentially in cultivation. The link of the University and FaHA lending standards meant that once the University had accepted CP as productive, FaHA would also reach that conclusion. By comparison further differentiation was necessary for PCA and the private lending institutions.

A second social order, emerging in the post World War II period, was automation of agricultural practices. To a certain extent this social order

is linked with productivity, though it has developed an existence and strength of its own. The primary attributes of CP clearly met this social order, but acceptance was dependent on the legitimating evidence of the University. CP could and did work, though a 10 degree grade maximum was recommended, given the dangers of soil erosion and consequent loss of productivity.

A third social order, felt need, influenced the timing and manner of the differentiation process. CP had been in existence for over 15 years before the University decided to test it. Clearly, despite its productivity and automation primary attributes, it had not developed the necessary secondary attributes for the University--faculty, extension agents, extension specialists and/or experiment station personnel--to "feel the need." Indeed it apparently took a chance visit in 1966 by a farmer and the Valmont general sales manager to the North Platte Station for the need to be felt. However, once a felt need had been articulated and accepted, the innovation could be dealt with by a routine response. The routine of the University system is testing → legitimating → translating → disseminating. There is an underlying positive presumption of that routine, namely that the University is to help the agricultural community. Thus the tendency is to find out how the innovation (here CP) can help. There is no equivalent routine to explicitly test how it might hinder, or, should it indeed hinder, to ensure that such innovations are actively opposed. What is especially important to point out is the generally positive disposition toward innovation of the "felt need" response. Any innovation, including CP, which prompts this response automatically gains a positive secondary attribute. This positive secondary attribute might be phrased, "The University wouldn't be testing it if it weren't somehow important/good/useful."

Differentiation yields transformation/disconnection of detrimental attributes

The first two conclusions focused on the acceptance process for CP. Neither particularly considered the potentially detrimental aspects of CP—water and energy intensity—which prompted this study in the first place. However the preceding discussion does make clear why the positive aspects of CP were focussed on in the process of acceptance of this innovation by the Nebraska agricultural community.

There are, however, detrimental attributes. Energy is now less available and more costly. Nebraska's groundwater supplies are being depleted. CP's water and energy intensive attributes have contributed to and are influenced by both of these situations. Indeed the pervasiveness of CP as the irrigation system of choice during the 1970s is illustrated by CP being used for 75–80 percent of all newly irrigated land in 1974 and 1975.

Clearly CP could have a negative impact on the Nebraska agricultural community. The innovation differentiation process for CP in the Nebraska agricultural community yielded both transformation and disconnection of detrimental attributes, creating the circumstances for attribute redefinition in the first instance and another innovation in the second instance.

The first potentially negative impact of CP was overproduction. Clearly CP insured productivity of existing arable land by even, controlled irrigation and fertilization. It also brought considerable additional land into cultivation. Too much production could cause a drop in prices, and a consequent reduction in profits. Thus unchecked productivity could be a bad thing. The differentiation process lead Valmont, for instance, to shift its promotional strategy from one emphasizing production in volume to one emphasizing production optimization.

A second negative impact emerged from what had been a positive attribute. REA had promoted CPs as a means of levelling load demand. The acceptance of CPs was so successful that the load demand reversed, with peak load occurring in summer. As a consequence REAs were forced to an innovative response. They could not choose a response which was in conflict with CP, given the manner in which the innovation met prevailing social orders. Thus REAs created another innovation--use scheduling. They promoted time clocks and radio controls. They also provided for shut down when peak capacity was about to be exceeded, with customers receiving discounts in exchange for the inconvenience.

A companion negative impact to the energy intensity is the water intensity. Both attribute transformation and innovation creation responses have been employed regarding this attribute so that CP acceptance can continue. Valmont's promotion of CP now tends to emphasize it as a management tool, a means of controlling the use of limited resources through their efficient application. Perhaps more interesting is the manner in which the Nebraska agricultural community treated groundwater depletion as an issue separate from the increased use of CP. The two were disconnected, such that the innovation which responded to the depletion issue--Natural Resource Districts and their various regulatory powers--would not be in conflict with CPs, which were by now an institutional entity in their own right. Thus none of the institutional entities (save one) we had hypothesized would manifest a conflict response to CP in fact did. What did occur was the creation of a separate (at best tangential) network of groundwater control, set in the public sector, and structured to minimize direct conflict with the CP network.

NOTES

- 1) A social order is defined as "a societal disposition without specific members." [Nutt-Powell, et al., 1978, p. 19.]
- 2) An innovative response in this case would have been for the Agricultural Experiment Station to investigate the impact on natural resources on the extensive use of CP, or the economic consequence of energy dependence.
- 3) A legitimator is defined as "an actor giving status, authority, and/or credibility." [Nutt-Powell, et al., 1978, p. 13.]
- 4) A linking-pin is defined as "a connector of actions among institutions." [Nutt-Powell, et al., 1978, p. 32.]
- 5) A translator is defined as "a conveyor and usually interpreter of information from one source to another." [Nutt-Powell, et al., 1978, p. 33.]
- 6) Research in this context includes assessing the product/process to see if it meets the norms of the institutional arena.
- 7) A plunger is defined as "the ultimate initiator, trying out new ideas/things simply because they are new, generally, with limited regard as to risk." [Nutt-Powell, et al., 1978, p. 32.]
- 8) The first CP cost \$7,000 to build and install. Current costs of a CP range from \$35,000 to \$60,000 depending on the size of the system.
- 9) A secondary attribute such as "water use" illustrates the various kinds of differentiation. The Central Nebraska Public Power and Irrigation District was concerned with water as a corollary of CP. Its concern was with the amount of water needed as the number of pivots grew, and with changing water allotments from a fixed amount to a demand basis as seasonal fluctuations increased. The Farmers Home Administration was concerned with the availability of water before lending to an individual: this reflects a time differentiation of CP--that the economic feasibility of a CP changes with time if water resources run out. Both the Sierra Club and the Agriculture Builders of Nebraska (a group of individuals informally organized to represent the interests of agribusiness) were concerned with the effects of CP as groundwater changed from an abundant resource to a controlled substance. The Sierra Club is concerned with the interrelation between CPs, underground water and stream flow. The Agriculture Builders of Nebraska were going to meet and start reviewing plans for water use. So while water use was a critical component of CP diffusion and the institutional reaction, the exact nature of water concerns and approaches represent an array of secondary attributes that are the consequence of various differentiations.

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Appendix A

Interview List

Each listing includes the name of the individual interviewed, the organization(s) represented and the acronym used in this paper for the organization.

AES

Agricultural Extension Services
Leo Lucas, Director

Ag Builders

Agriculture Builders of Nebraska
Gib Erickson, President

Ag Council

Nebraska Agricultural Council
Paul Grabouski, President

Ag Exp Sta

Agricultural Experiment Station
Dr. Warren Sahs

CNPPID

Central Nebraska Public Power and Irrigation District
R.D. Dirmeyer, General Manager

CRA

Center for Rural Affairs
Don Ralston

CSD

Conservation and Survey Division
Vince Dreezen, Director

DA

Department of Agriculture
Glenn Kreuscher, Director

DEC

Nebraska Department of Environment Control
Jack Subavaty

DED

Nebraska Department of Economic Development
Steve Kale

DI
Nebraska Department of Insurance
Don Deale

Ex A
Extension Agent
Marshall Logan

FB
Nebraska Farm Bureau Federation
Richard Gooding

FaHA
Farmers Home Administration
Bill Waldo, Acting State Director

Farmland
Farmland Industries
Gib Erickson

FNB
First National Bank
Everett L. Shirk

FSC
Farm Safety Council
Rollin Schneider

FU
Farmers Union of Nebraska
Louis Wiebe, President

Grange
Nebraska State Grange
Edward Anderson, President

MFREDA
Midwest Farm Retail Equipment Dealers Association
Don Virgin

NARD
Nebraska Association of Resource Districts
Richard Hahn, Director

NBA
Nebraska Bankers Association
Harry Argue

NBF
Nebraska Department of Banking and Finance
Jack Riley, Director

NCC
Nebraska Cooperative Council
Maynard Ortegren, President

NCEAA
Nebraska County Extension Agent Association
Jane Bierman

Neb. Farmer
Nebraska Farmer
Bob Bishop, Editor

NFI/NGFA
Nebraska Fertilizer Institute/Nebraska Grain and Feed Dealers
Association
Robert L. Anderson, Executive Vice President

NFO
Nebraska National Farmers Organization
Ed Tvrdy, President

NLICA
Nebraska Land Improvement Contractors Association
Ron Gaddis

NNG
Northern Natural Gas Company
Paul Ducharme

NPC
Nebraska Petroleum Council
Donald Crosier, Assistant Director

NPPD
Nebraska Public Power District
Henry Rice, Executive Director

NSA
Nebraska Seedsman Association
Bill Monke

NSFMRA
Nebraska Society of Farm Managers and Rural Appraisers
Doug Duey

NSIA
Nebraska State Irrigation Association
Henry Lange

Om W-H
Omaha World Herald
Don Ringler, Farm Editor

PCA
Production Credit Association
Jamison Lincoln, President

REA
Nebraska Rural Electric Association
Harry Hackbart, Vice President

SC
Bluestem Sierra Club
Gary Lutman, Chairman

Sen. Kremer, Chairman
Public Works Committee

Senator Schmidt, Chairman
Agriculture and Environment Committee

Senator Warner, Chairman
Appropriations Committee

SEO
Nebraska State Energy Office
George Dworak

SOPP
State Office of Planning and Programming
Warren White

Valmont
Valmont Industries, Incorporated
Dean Howard

Welldrillers
Nebraska Welldrillers Association
Vince Dreezen

Also interviewed:

Les Sheffield, Chairman
Department of Agricultural Economics, UN-L

William Splinter, Chairman
Department of Agricultural Engineering, UN-L

Martin Massengale, Vice Chancellor
Institute of Agriculture and Natural Resources, UN-L

Interviews were conducted in July-August, 1977 and February 1978.