Nebraska Natural Resources Commission

Sandhills Area Study

DECISION DOCUMENT

March 19, 1981

Preface

The Nebraska Sandhills region has the distinction of being the largest individual expanse of grasslands in the United States. Closely beneath the surface of this nearly 19,000 square-mile area may be as much as three-quarters of a billion acre-feet of high-quality groundwater.

The region was mainly inhabited by Indians until the 1870's when cattlemen, attracted by the open range, bountiful grass and abundant water, began settlement along the valley of the Niobrara River.

The Kinkaid Act of 1904 brought homesteading farmers with plows and visions of transforming the rangeland. A succession of dry years and little understanding of soil capabilities resulted in crop failures and disappointment. Cattlemen acquired the land and proceeded to operate with fenced ranches. Few changes occurred in the basic cattle centered industry until the past decade when a combination of circumstances brought about large-scale center-pivot irrigation development, particularly on the region's fringes.

The Nebraska Natural Resources Commission (NRC) has given high priority to considering the positive and negative impacts associated with the current development trends. Comparatively little scientific and technical data exist regarding their effects.

A frequent comment concerning data collection and planning agencies is that they are not always aware of what has been done or is being done by some other group. This paper and the process followed in completing it, were structured to alleviate that problem. Because local, state, regional, and federal organizations have been involved in various natural resource activities of the Sandhills, the early and continual involvement of such groups has been utilized in this initial effort.

This paper should serve to inform all concerned about what has been done, what is underway, and what needs to be included in a long-range study plan. It attempts to summarize some of the pertinent information that does exist, to identify data gaps, and to consider certain possible policy positions. It may also serve some purpose in helping to bridge widely divergent views on the current status and to provide guidance in determining whether any immediate action is indicated.

Al Narjes, Chairman
Nebraska Natural Resources Commission

Acknowledgments

This paper reflects the combined efforts of numerous individuals, groups, and organizations. The active cooperation of the seven Natural Resources District Managers for the Sandhills, along with the staffs of the Nebraska Association of Resources Districts and the Natural Resources Commission, in collecting and compiling data for the paper, was commendable. Individuals who contributed are too numerous to mention. Groups and organizations who actively assisted are:

Lower Loup Natural Resources District
Middle Niobrara Natural Resources District
North Platte Natural Resources District
Twin Platte Natural Resources District
Upper Elkhorn Natural Resources District
Upper Loup Natural Resources District
Upper Niobrara-White Natural Resources District
Nebr. Assoc. of Resources Districts
Department of Water Resources
Department of Environmental Control
Department of Agriculture
Department of Health
Policy Research Office
Game and Parks Commission
University of Nebraska - Lincoln
  Conservation and Survey Division
  Water Resources Center
U.S. Department of Interior
  Water and Power Resources Service
  Geological Survey
U.S. Department of Agriculture
  Soil Conservation Service
  Agricultural Stabilization & Conservation Service
  Federal Crop Insurance Corporation
U.S. Army Corps of Engineers

Preparation and publication of this report was supported in part by grants from the U.S. Water Resources Council under Title III of the 1965 Water Resources Planning Act.

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Executive Summary

This document is the Nebraska Natural Resources Commission's first step in a long range study of the Sandhills region. Prior to developing a study design for a Problem Analysis and Area Planning[1/] study, the Commission decided to assemble existing information, identify study needs, consider potential strategies, and list the possible impacts of those alternative strategies. That information is presented in this paper or "Decision Document." In addition to providing a common base for a long range study plan, the information and analysis in this document may have some immediate usefulness to policy officials.

It is not the purpose of this paper to make policy recommendations. Conclusions or ideas on policy changes which may be drawn on the basis of limited available information are left to the option of the reader.

Policy Issue Analysis reports[2/] completed during the 3-4 years required for the Area Planning Study may provide further insight and potential solutions to some of the concerns expressed in this Decision Document.

An Inventory of the Sandhills

The Sandhills Study region covers 19,000 square miles in western and central Nebraska north of the Platte River. In relatively recent geologic time this "sand sea" was blown into dunes and then stabilized by a fragile cover of productive warm season grasses. The soils that have developed--mostly of the Valentine and Dunday associations--are highly erosive. "Blowouts" can develop rapidly if the surface cover is removed or destroyed. Cultivated cropland can have wind erosion losses of up to 300 tons per acre per year.

Land use in the region has been primarily range for cattle, with several notable exceptions that resulted in failures years ago. However, a new wave of cropland development has started. Center-pivot irrigation has increased dramatically in the past decade. For instance, irrigation systems in Wheeler County at the eastern fringe of the region, where the growth has been more dramatic, increased from 50 in 1972 to 385 in 1980. Most of the systems were installed by large scale developers to produce corn. This has produced a trend in the region's economy from ranching toward farming and feeding. Incentives for large scale development appear to include: the abundant groundwater supply, availability of large tracts of land traditionally priced as rangeland, the tax structure, and Nebraska's freedom from land or groundwater use restrictions.

[1/] The State Water Planning and Review Process includes five major activities: Policy Issue Analysis, Problem Analysis and Area Planning, Project and Program Review, State Project Planning and Design, and Base Activities. Problem Analysis and Area Planning is an activity designed to allow study of specific physical water problems in a flexible format tailored to the particular problem area.

[2/] Policy Issue Analysis activity involves studying, analyzing, and recommending alternative solutions on general water policy issues identified by state policy officials.

Estimated groundwater supplies exceed 700 million acre feet. Average annual rainfall produces recharge of about 12 million acre feet per year. Evapotranspiration is the largest factor in water "loss." Average annual streamflow from the region is less than 3 million acre feet. Streamflows in the region are among the steadiest in the world because they are fed by the groundwater reservoir.

Only recently have adverse effects of irrigation been felt. Shallow stock and domestic wells near large scale developments have failed. Artesian wells have been adversely affected seasonally. Declining water tables have reduced the productivity of the "water level sensitive" wet meadows. A planned project has been found infeasible because the flow of the Cedar River will decrease. The Platte River Basin - Nebraska Level B Study projected water table declines of as much as 40 feet in some areas of the Sandhills and further decreases in streamflow.

Water quality is generally very good, but water of poor quality has been found in scattered locations. Water quality effects of fertilizer application, use of pesticides, and conversion of wetlands and wet meadows to cropland have not been determined.

The Sandhills are a unique ecological resource. The region is the greatest unbroken expanse of grassland in the nation. The numerous lakes and wetlands within the grasslands attract a great diversity of shore and wading birds. The effects on the ecological balance of the shift from grassland to cropland habitat, and the loss of wetlands, are difficult to measure.

A list of sources of pertinent data is found in the second appendix. Much general information on the region is available, but very little specific data can be found, especially on irrigation. Considerable research is needed to provide a sound technical basis on which to make political decisions.

Continuation of Current Trends

A certain level of irrigation development would enhance the economy of the region without extensively altering the cultural and environmental resources. The rate and level of development that would balance economic, social, and environmental impacts is unknown.

Economic conditions and current federal and state policies on taxes and regulation generally encourage development. State statutes which might restrict development, including the Groundwater Management Act, land use sections of the Natural Resources District enabling legislation, and County zoning all delegate control to local government.

Additional development and continued irrigation under current conditions would have physical, environmental, economic, and social impacts. Physical impacts on the land resources include an increase in wind erosion as the grassland is converted to cropland. Also, the productivity of the land decreases under continuous cropping, apparently due to the decomposition of the organic matter produced by the grass. If unsuitable land is developed, or any land is not managed correctly, failure can result and abandonment produces substantial increases in erosion, dust, and sedimentation.

The physical impacts on the water resources include changes in the quantity and quality. As the supply is used, evaporation and transpiration increase and the water table declines. Nitrates and pesticides are leached through the sandy soil to the water table. The declining water table can have a significant effect on adjacent domestic and stock wells, lakes and wet meadows.

Intended economic impacts are greater farm income, expressed as returns to land and management. These direct impacts produce substantial indirect impacts on the value and price of land, growth in service industries, employment, population, and income. The economic multiplier effect of investment is not fully realized locally because many production elements are imported from outside the region.

Improvements could be made under current policies and economic conditions. For example, conservation and management methods now available could reduce erosion substantially. Better fertilizer and water management systems could also be used. Planting shelterbelts between the irrigated fields and leaving the corners in native vegetation could help ecological conditions. Improvements in educational and technology transfer programs could help materially in achieving the implementation of these available management methods.

Strategies for the Future

Management methods for reducing the adverse impacts of irrigation development are largely known, but implementation strategies for ensuring their use are needed. This may require changes in state and local policies. Management methods can be classified as: (1) limitations on the area that can be developed; (2) use of proper management practices; (3) reductions in water use; (4) reductions in use of chemicals; and (5) restoration and enhancement of habitat. Implementation strategies are of two types: incentives and disincentives, and regulations. A recent public survey of Sandhills residents found that 68 percent felt that some regulation of the use of Sandhills land and water resources may be necessary.

Taxes could provide both incentives and disincentives. Reductions in property taxes and deductions from income taxes could provide incentives for implementing several of the management practices. Tax increases could be disincentives to ensure implementation of all the management methods. The changes could be an increase in the real property tax, a new personal property tax on items such as irrigation equipment, a tax on the amount of water pumped, or a state capital gains tax on speculative land investments.

Regulations could be either firm and applicable uniformly, or flexible to allow a decision by some agency in every case. A firm regulation might control development on a certain type of soil and allow no exceptions. Flexible regulations might establish a permit system, and permits would have to be denied only where the adverse effects could not be prevented by management.

The topography and the soil largely determine the intensity of management and types of practices required to reduce adverse effects on the land resources. The wind erosion equation developed by the Soil Conservation Service is an example of available, proven techniques for determining management methods required to control soil losses. The amount of residue maintained on the surface is a critical management factor in the equation. Strategies for ensuring that this management method is utilized include cost-share or tax incentives, tax disincentives, or restrictive regulations. State school land management, based on a conservation plan that includes development according to Soil Conservation Service technical guides if approved for irrigation, is a good example of this type of regulation. Another example is a requirement that sprinkler systems not be removed for a given period if irrigated land is to be returned to grassland.

Groundwater supply might be protected by increasing the efficiency of irrigation systems and crops that are grown or limiting the acres irrigated. Incentives and disincentives could promote this; regulations could limit the number of acres irrigated in any given area. Water quality problems could be reduced by: using the right amount and type of chemicals at the right time; proper well and system design and construction; or restricting the amount or location of development. Careful location of irrigation developments could reduce the loss of valuable plant communities and wetlands.

Flexibility might be provided in the regulatory program by establishing a well permit system coupled with one or more administrative mechanisms. For example, a development plan might be required with every permit application. This development plan might include statements on what, how, and where development is to take place and the management methods to be utilized. Also, permit fees could be established to subsidize the widespread private costs of deepening stock and domestic wells if the fees were large enough to cover those costs.

A combination of strategies which would strike a balance between the benefits of irrigation development and the protection of the natural resources is perhaps most realistic. This might require regulations to address the more serious problems and educational programs and incentives to ensure proper management methods. A combination of strategies based on county zoning, the Natural Resources District land use law, and the Groundwater Management Act could be very effective with slight modifications.

Impact of Development with Future Strategies

Management methods and implementation strategies to reduce the adverse effects of irrigation development would have different physical, ecological, economic, and social impacts. In this chapter impacts are only identified by type and direction. Much more study would be needed to judge their nature and magnitude.

Limitations on the areas that could be developed would result in less development and reductions in associated impacts. The use of proper management practices would reduce wind erosion and control some water losses and pollution. The loss of native habitat would also be reduced by these management methods. Economic activity would be reduced as some land would not be developed to its full economic potential. The restoration and enhancement of habitat could have many of these same impacts.

Management methods to reduce water use would have a primary impact of reducing declines in the water table and a number of secondary impacts, including habitat preservation and less groundwater pollution. Wind erosion would be increased and there could be some loss of productivity and profit. Management methods to reduce chemical use would decrease pollution of the groundwater. Production declines could also result.

Implementation strategies using monetary incentives shift costs from individual irrigators to the generatl public. Disincentives reverse the economic impact. The principal economic impact of regulations on state and local governments would be administrative costs. These regulations may be unpopular and additional staff would be required in the enforcement agency.

Prohibiting additional development would prevent increases in wind ersoion, groundwater consumption, loss of native habitat, and water pollution. The opportunity for increasing production and profit would be lost. There would be less social change in the area. Legislation would have to be enacted for this controversial strategy to be enacted.

Summary and Conclusion

A review of this document and the supporting information sources brings to light several facts about the Sandhills region and irrigation development.

1. The Sandhills region is in a period of transition.

This region has traditionally been cattle country and large-scale irrigation development represents a major change in resource use. Irrigation is a recent phenomenon in the Sandhills that is expected to increase in the future.

2. The changes have become a cause for concern to many people.

The change to intensive irrigation is controversial within the Sandhills area and throughout the state due to concerns about the potential for adverse impacts. Several groups with different interests have started promoting the regulation of this development.

3. More information is needed.

There is insufficient detailed, comprehensive information available to properly assess the land and water resources and the economy and ecology of the Sandhills. More study is needed to assess the long term effects of irrigation in this region. Many years and extensive funding would be required to amass all the detailed data needed to answer all the questions that might arise concerning the whole region.

The soils surveys are a basic sources of information on land resources and a new program to accelerate completion of these surveys in the Sandhills counties is needed. The present rates of soil loss and the locations of the problem areas should be determined to provide a better understanding of wind erosion problems. Acceptable yearly soil loss rates for the soils in the area should be studied and the effectiveness of available management methods should be assessed.

Extensive research is needed for a better understanding of the Sandhills water resources system and the potential effects of irrigation development on this system. Basic hydrogeologic data is needed to refine existing knowledge of aquifer characteristics. Additional monitoring is needed to record changes in the water table and the sizes of the lakes. To prepare a water budget, data is needed on precipitation and other climatic factors, groundwater recharge, groundwater movement, evapotranspiration, streamflow, and water use. Additional hydrogeolgic information on the interaction of the lakes and the groundwater is needed. More information is also needed on the effects of draining wetlands on the water table and the effects of lowered groundwater levels on vegetation and rates of evapotranspiration.

Most of the information described above is needed for the assessment of water quality. In addition, the tranferability of information from other areas should be investigated to assist in the assessment of potential water quality impacts of irrigation in the Sandhills. Additional groundwater quality monitoring should be initiated in the region; more detailed sampling in a small study area should accompany a hydrogeologic study in order to determine the movement of nitrates. The effects of management methods, soil characteristics, and other factors on the leaching of nitrates and other chemicals should be investigated. Effects of draining wetlands on surface water quality should also be assessed.

The economics of agriculture in the Sandhills is not well understood and more information, including projections of economic changes, is needed. Information is needed on the economics of ranching and irrigated agriculture; the role of existing tax laws and inflation and speculation should be documented. The economic impacts of wind erosion from irrigated land should also be studied.

Ecological changes brought on by irrigation development in the Sandhills can be better understood with more information on the potential changes of land and water resources. More information is needed on the reestablishment of vegetation in areas lacking grass cover due to wind erosion or the abandonment of cropland.

4. Some adverse impacts can be prevented.

Many of the potential adverse impacts of irrigation can be reduced by the use of selected on-farm management methods. In many cases, reductions can be achieved under existing programs and policies. Where they cannot, implementation strategies to facilitate the use of these practices through governmental action can be developed.

5. Some level of irrigation development can be sustained.

The development and continued irrigation of land in the region with attendant social and economic benefits can be sustained at some level, depending on the degree of management. Irrigation to improve ranching operations can benefit the region without extensive management changes. Greater economic benefits can be produced through the irrigation of row crops with careful management. The level of development that will balance the economic and social benefits with the adverse impacts and the policies that might achieve such balance are unknown.

6. A Sandhills Area Study could provide information needed for establishing sound governmental policy.

The amount of data collection, research, and study needed to provide the information required on all questions for the entire region is overwhelming. A three or four year study of a selected, perhaps representative, area within the Sandhills could provide information and insights on some of the most important questions and help establish state policy. Alternative management methods and implementation strategies can be developed and assessed as part of the study.

INTRODUCTION

The Nebraska Natural Resources Commission is the lead agency in the State Water Planning and Review Process. In considering the future direction of that planning effort, the Commission decided that an examination of the water and related land resources in the Sandhills region should be given a high priority. As a result, a Problem Analysis and Area Planning Study of the Sandhills was scheduled as a part of the Process.

The potential for a study of the area was discussed with many individuals, organizations, and agencies. A number of knowledgeable persons were questioned on subjects needing study and priorities for studies. The results of these actions quickly made it apparent that the area was too large and the potential study subjects too numerous to be covered with the funds and time available. The Commission decided to first determine what is known about the area, what the study needs are, and what potential strategies might be studied. That information is presented in this paper, called a "Decision Document."

This document has been prepared by the Commission staff with the assistance of many people. The Nebraska Association of Resources Districts and the managers of the Natural Resources Districts covering the region have provided research, review, and advice. Many state and federal agencies have also researched sources of information, reviewed drafts, and made suggestions for improvements.

PURPOSE

The purpose of this document is to provide the Natural Resources Commission, its advisors, and the other agencies participating in the Planning and Review Process with a common information base from which to proceed. It is intended to provide a summary of the sources of available information found by the participating individuals and agencies and to summarize the available information on resources, current trends, and projections of future conditions. It also lists strategies for future consideration and the possible impacts of future activities. This is intended to provide a basis for decisions on the direction and scope as well as the length and funding of the Sandhills Area Study.

This document may also present some helpful information for the Natural Resources Commission and other decision-makers deliberating potential research, development, or policy changes in the Sandhills. It should provide a brief summary of information available on the region and give sources of more detailed information if it is needed.

ORGANIZATION OF THE DOCUMENT

The chapters in this paper are primarily concerned with the available information on the area, potential strategies for future activities, and the possible impacts of those activities. The first chapter is a survey of sources of information and a summary of the information. It summarizes the data on the land resources, water resources, economy, and ecology of the region. It also provides information on what is perceived by the residents as problems associated with these resources and their development. It summarizes the few projections of future conditions that have been found, and finally it lists the subjects that need more data and study.

The subject of the second chapter is irrigation development under current policies. It contains a review of current trends, a summary of current policies on development, and a list of potential impacts of development and continued irrigation. It also contains a discussion of possible improvements in impacts that could be achieved under current policies.

The third chapter discusses strategies that could be used to improve irrigation development in the future. It outlines management methods and implementation strategies that might reduce the adverse impacts of irrigation.

The fourth chapter lists the changes in impacts of irrigation development that might occur if the strategies were implemented. It lists what are considered to be the possible physical, environmental, economic, social and legal/institutional impacts of five classes of management strategies and two classes of implementation strategies.

SCOPE AND DETAIL

This document has been limited to researching and using available data to ensure completion within the allotted time frame. In many instances Garfield and Wheeler Counties have been used as examples because the data may reflect trends of development applicable to the whole region. There undoubtedly are other sources, and more information could have been presented if there had been time to compile, analyze, and interpret it. This document shows how much, or how little, published information about the Sandhills can be compiled in a period of months.

The list of strategies in Chapter 3 is not detailed or complete. It presents a sampling of the types of strategies that could be devised in a Problem Analysis and Area Planning Study. It also gives one example of the kind of detailed strategy that could be provided by the study. Otherwise, it provides only a brief explanation of the strategies and the requirements for making them work.

Chapters 2 and 4 provide only a list of the potential impacts. Until the Sandhills Area Study itself is completed, it is impossible to determine the magnitude of the impacts or judge whether the effects will be beneficial or damaging, and to whom.

CHAPTER I. THE SANDHILLS

The region generally known as the Sandhills lies north of the Platte River in central and western Nebraska--19,000 square miles of sand deposited by wind or water that has been shaped by the wind into sand dunes in the recent geologic past. The surface is now stabilized by a grass cover, but any destruction of this cover allows the sand to blow again.

Parts of the Sandhills are dotted with hundreds of lakes and wetlands in inter-dunal valleys. Most of these lakes are exposures of the water table, which marks the upper limit of a vast body of water stored underground.

The climate of the region is distinctly continental with cold winters and hot summers. The weather is characterized by extreme changes from day to day and season to season. The mean annual precipitation varies from about 16 inches at the western edge to about 24 inches at the eastern edge. About 80% of the annual precipitation is received during the growing season from April to September. The prevailing winds are generally from the north in winter and from the south in the warmer seasons. March and April are the windiest months.

The economy of the area is based largely on agriculture, primarily cattle ranching. A vast majority of the land is used for range, though the acreage of cropland has been growing recently. In the past, attempts were made to develop more cropland, particularly with the passage of the Kinkaid Act in 1904. These "Kinkaiders" found it almost impossible to raise crops under the prevailing conditions and were forced to abandon their lands. As late as the 1920's, other attempts were made by landowners in the Sandhills to develop croplands. The drought forced these efforts to be abandoned. Some of the "go-back" lands from these attempts at cropland development still have not been reestablished to fully productive rangeland.

The rigors of the Sandhills region have produced a distinct way of life. Successful ranching requires large areas of rangeland for the cattle, so much of the land has been consolidated into large ranches by the descendants of the early settlers who survived the hardships. Historically, the relatively few people in the region have been widely scattered and have necessarily developed self-reliance and an attitude of independence from outside influence.

RESOURCES, USES, AND CHANGES

The principal natural resources of the region are land and water. Any changes associated with these two resources are, therefore, of vital importance to the region. A public attitude survey of 700 Sandhills residents was conducted in November of 1980 to determine attitudes toward irrigation development and any associated changes in land use. Their attitudes and concerns are referred to several times in this report. A summary of the survey results can be found in Appendix 1.

LAND RESOURCES AND EROSION

The land forms in this region consist principally of sand dunes and intervening flat floored valleys. This inland "sand sea" is the largest in the western hemisphere. The large dunes range in size up to 10 miles in length and ½ to 1 mile in width. Heights of more than 300 feet are common, with slopes of 5^{o} to 8^{o} (8.75 to 14.1%) on the windward sides and slopes of 10^{o} to 25^{o} (17.6 to 46.6%) on the leeward sides. In parts of the Sandhills region many flat-floored valleys contain one or more small lakes or wetlands. Underlying the dune sand are older Quaternary sands and gravels and the Ogallala Group.

Soils

The soils of the region are in the Valentine - Dunday association. Valentine soils make up the majority of this association. The surface layer is dark grayish-brown, loose, fine sand. Beneath this is a tran-- sition layer of grayish-brown fine sand. Published information indicates that only the minor soils in the region are well suited for cropland. However, recent developments have produced good yields of corn in areas of Valentine soils.

Land Use

Most of the region is covered with grass that provides excellent range for cattle and supports the major agricultural activity, cattle ranching. Information from "Rangeland Resources of Nebraska," published by the Soil Conservation Service (SCS) in 1977, shows counties bordering the region had 70% to 80% of their area in rangeland and up to 30% of their area in cropland. Rangeland area in counties primarily located in the region varied from 86% to 98%; cropland for these counties was 10% or less. For example, Wheeler and Garfield counties had, respectively, 89% and 87%, of their land in rangeland and 7% and 8% in cropland.

Acreages irrigated with groundwater in 1980 ranged from less than 1% of Grant County to 5% of Garfield County and 9% of Wheeler County. From 1972 to 1980, center pivots in Grant County increased from 0 to 17; in Garfield County, from 4 to 96; and in Wheeler County, from 50 to 385.

Summary of Available Information and Sources

There are a number of sources of information on land resources, land use, and erosion potential. Comprehensive sources include reports and plans that provide a general survey or summary of information on the region. Included in this category are the Platte River Basin, Nebraska, Level B Study, the Resource Report Series by the Conservation and Survey Division, and the "Rangeland Resources of Nebraska" report by SCS. The second type of source contains specific data developed to provide detailed information on specific topics. The County Soil Surveys are an example of this type of source. Sources of information compiled in the preparation of this report are listed in Appendix 2.

Soil Erosion

Soil erosion is a major land resources problem in the region. In the survey of residents, 24% of those who said they were concerned about the natural resources indicated that soil erosion was their main concern, and another 17% said their main concern was keeping the land the way it is. Water erosion is generally slight because the infiltration rates of the soils are high and very little water runs off. On the other hand, the potential for wind erosion is great. The potential for soil loss for the principal soils in the region ranges from 90 to 310 tons per acre per year.

If the protective cover in rangeland is destroyed by cattle or some other means, the wind can create "blowouts." Blowouts begin as small areas and can rapidly expand to several acres if not stopped. When the wind moves the exposed sand particles, it forms a small depression that creates a partial vacuum as the wind blows over the edge. This enables the wind to move even more sand, and rapidly increase the size of the blowout. Some obstruction generally causes the larger particles to fall and begin the formation of a dune, while the finer particles can be carried for hundreds of miles.

In cropland, entire fields are subject to erosion by the wind if a cover crop is not planted or if sufficient residue is not left on the surface. The wind and blowing sand can uncover and blow away the seed, bury seeds and cover seedlings, and sometimes sandblast the leaves off young plants. In addition, the blowing sand creates visibility problems and in some places has been deposited on adjacent land in drifts deep enough to destroy the rangeland. These problems are generally aggravated if crop production ceases and the land is abandoned. Without production, no residue is left on the surface, and without irrigation it is extremely difficult to reestablish native grass or maintain a cover crop. In recent years, the practice of removing hill tops with earth-moving equipment to permit the movement of center-pivot systems has increased the amount of erosion. This practice removes the topsoil with the little organic material it contains and leaves crops planted in "blow sand."

The available information on the amount of erosion and the extent of the area affected is limited and not very precise. The Platte River Basin Level B Study Technical Report on "Land Conservation and Sedimentation" contains information on the current level of soil loss due to wind erosion. The 1969 report, "Nebraska Conservation Needs," by the SCS contains estimates of the areas in each county needing conservation treatment for cropland and range, but it does not contain any data on the amount of soil erosion. The Platte River Basin Study is the only known source of information on projected soil loss due to wind erosion. The projections show wind erosion decreasing through the year 2020 due to conservation programs. However, this study was done before center-pivot irrigation became prevalent in the Sandhills, and it does not cover the part of the region in the Niobrara River Basin. In short, not enough information is available to adequately assess the severity of the current or future erosion problem in the Sandhills area.

Data and Research Needs

An important data source for erosion management methods is the County Soil Survey. It identifies in detail the soils of a county on a series of aerial photographs. On each photograph the soils are outlined and identified by symbols. The categories most often used are the soil series and the soil phase. The detailed information provided by each survey on the many factors affecting land management is needed for planning decisions that can maximize use of the available land resources while minimizing the problems that can result from misuse of soils. Essential for a meaningful study or inventory of the Sandhills, the soil survey provides basic data needed for determining suitability of uses and potential hazards. It can be used to show the extent and location of (1) lands suitable for irrigation development, (2) lands with high wind and/or water erosion potential, (3) critical areas (e.g., blowouts, steep slopes), and (4) wetlands and meadows. Unfortunately, a large number of the counties in the Sandhills region either have no recent soil survey or have soil surveys in progress, but not ready for publication in the near future. The status of recent soil surveys in Nebraska is shown in Figure 1.

More information is needed to assess the severity and extent of wind erosion. The issues that need to be defined and examined further are the location of present problem areas, their extent, the types of soils generally associated with these areas, the present rate of loss, and the acceptable yearly losses per acre. Also needed is research on the effectiveness of controlling wind erosion through presently available management techniques. Landowners could make more use of the available information on the soils and management methods. Unfortunately, some landowners are not aware of the assistance and information that is available, and some others may be aware, but not convinced that erosion control will provide any benefits. In both cases, programs to educate the landowner and manager are needed.

WATER SUPPLY

The amount of groundwater in the Sandhills is greater than in any other region in the state, and supplies of surface water are very dependable. The quality of this supply is generally very good, but in a few isolated areas is very poor.

Available Resources

Groundwater is the key to the water supply of the Sandhills. The amount of water in storage is vast but the aquifers are so poorly defined that the amount has not yet been measured accurately. The Ogallala Group, which underlies the entire Sandhills, is a thick sequence of permeable rocks, sands, and occasional layers of impermeable materials. Older water-bearing materials are also found in portions of the Sandhills. These older groups, the Ogallala Group, younger alluvial deposits, and the sands below the dunes provide an excellent groundwater reservoir. In the 1960's, it was estimated there were between 700 and 800 million acre-feet in storage beneath the Sandhills. More recent information summarized for the High Plains Study shows that the saturated thickness is as much as 1,000 feet in some locations, so there may actually be more than previously estimated.

The water table (the top of the zone of saturation) is relatively close to the ground surface and intersects the surface in some of the valleys. In other areas it may be 300 to 400 feet below the surface. The quantity of water that infiltrates to the water table has been estimated to average about 12 million acre-feet per year. This rate of recharge is far greater than in any other upland area of comparable size in the High Plains region. The average amount of water discharged annually to streams that rise in the Sandhills is about one-fifth of the average amount that infiltrates. The remainder is returned to the atmosphere by evaporation and evapotranspiration.

The Sandhills region has very few streams for its size, because most of the precipitation infiltrates into the sand and very little runs off. Flows of all streams in the Sandhills show little annual variation. In fact, they are among the steadiest flowing streams in the world. This uniformity is the result of the regulating effect of the groundwater reservoir, which contributes most of the flow in the streams. Although recharge to the reservoir is intermittent, the rate of outflow to streams changes only gradually and within relatively narrow limits.

According to a 1977 report on Sandhills lakes, a total of 1300 lakes, ranging in size from 0.2 to 2,300 acres, have a combined surface area of 78,500 acres. These lakes differ in their connection with the water table, which is generally within a few feet of the surface in those valleys that contain lakes or wetlands. Where a good hydraulic connection exists, the lake surface is continuous with the water table and the two surfaces fluctuate together. Conversely, where there is a poor hydraulic connection due to sealing, changes in the lake level and water table do not always coincide. This latter group of lakes is generally confined to the western end of the Sandhills.

Water Use

Virtually all of the streamflow generated within the Sandhills leaves the region before any significant consumptive use is made of it. Water stored in Merritt Reservoir on the Snake River is conveyed by canal to northern Brown County for irrigation of table lands near Ainsworth. Similarly, water is diverted from the North and Middle Loup Rivers near the Sandhills border and conveyed by canal to irrigable lands southeast of the region.

Groundwater has been used in the Sandhills for many years. Pictures of its windmills are almost as common as the pictures of the hills themselves. Use of this resource through high capacity wells for irrigation started only recently. As of January 1, 1970, there were 1,299 registered irrigation wells in the 16 counties that lie mostly within the region. That number had increased to 4,909 by January 1, 1980. Development has generally moved into the Sandhills from its fringes.

Changes in the Water Supply

The shift to more intensive irrigation has brought about some changes and conflicts. The Water and Power Resources Service (WPRS) found that a planned surface water irrigation project is no longer feasible because streamflow in the Cedar River will decrease. Furthermore, it probably will continue to decrease as groundwater irrigation in the watershed and diversions by pumping from the river increase. This decrease in streamflow is related to another change--the declining water table. The public attitude survey of the Sandhills residents showed a majority are concerned about possible declines of the water table. Of those who indicated they were concerned about the natural resources (89%), the main concern of 58% was a potential lowering of the water table. Water-level monitoring has not revealed significant annual water-table declines, but seasonal declines that may be due to irrigation pumping have occurred in the past few years. There have been a number of reported cases of failure of shallow stock and domestic wells in areas near large irrigation developments. A declining water table also dries up wet meadows, reducing the amount of hay they produce.

In some areas the water table has been lowered purposely. Wetlands have been drained to allow farming operations, including irrigation, and the drainage water has created problems in lower-lying areas. Neighboring meadows and wetlands have been flooded, and the quality of the receiving waters may have been affected.

Summary of Available Information and Sources

The surface water supply is measured by a stream gaging network operated by the U.S. Geological Survey (USGS) and the Nebraska Department of Water Resources. Currently, 36 continuous-record stations record flows within and out from the Sandhills. The Department of Water Resources also measures flows at partial-record stations on canals and makes miscellaneous measurements using portable equipment. The Lower Loup Natural Resources District (NRD) monitors the flow of Beaver Creek in Wheeler and Boone counties on a monthly basis. All the streamflow information is stored in computers by the USGS and the Natural Resources Commission. Analysis of the available records indicates that average annual streamflow runoff is about 2.4 million acre-feet.

There is relatively little published information on Sandhills lakes. The more detailed sources of information include a 1977 report by the Nebraska Game and Parks Commission and USGS Water Supply Papers 1368 and 1371.

The groundwater resources in the region are monitored through water level measurements by federal, state, and local agencies. Measurements are made in a total of 35 observation wells in the Sandhills by the USGS and Conservation and Survey Division as part of the statewide groundwater assessment program. Periodic measurements are made of 61 observation wells on the Crescent Lake and Valentine National Wildlife Refuges by personnel of the refuges. The Crescent Lake wells have some of the longest periods of continuous record of any observation wells in the region. In addition, measurements are made and reported semiannually for 141 wells by the NRD's in the area. A recorder well in Wheeler County is maintained by the Lower Loup NRD. These data are stored in a computer file maintained by the USGS and Conservation and Survey Division. A summary of the water-level changes is published by these agencies in their series of annual reports entitled "Groundwater Levels in Nebraska."

The data from test drilling and aquifer tests, though sparse for the Sandillls, were used with data on irrigation-well pump tests as available from well registrations to develop a series of maps describing the aquifer. Maps showing aquifer transmissivity, saturated thickness, and specific yield have been prepared for most of the state. The first two maps were prepared by the Conservation and Survey Division for the High Plains Study and the latter map was prepared for the Level B Study of the Platte River Basin.

Projections of future surface-water supplies were made for the Platte River Basin Level B Study and the Cedar Rapids Division study by the WPRS. Streamflow analyses were conducted for the Level B Study to assess depletions in streamflow volume caused by present and future pumping of groundwater for irrigation and by potential surface water irrigation projects. Projected average annual streamflows for 2020 based on two levels of irrigation development and potential surface water projects are shown in Table 1. It should be noted that these projected streamflows are for locations outside of the Sandhills region and they reflect development within as well as beyond this region.

The WPRS has shown that intensive irrigation development will decrease streamflow in the Cedar River and continued development can be expected to result in further streamflow decreases in the future. The 1978 study by WPRS showed that the current level of development would deplete flows on the Cedar River at Spalding to 88% of the historic average and to 75% at Fullerton. They found that 25,000 acres were irrigated in the Cedar River basin above Spalding by 1978, and at the present rate of development, all 80,000 irrigable acres will be developed by 2000. This exceeds the total amount of irrigation projected by the Level B Study for 2020. When full development is reached, the average annual flow of the Cedar River near Spalding is expected to be about 79 cfs. The flows would be depleted to 58% of the historic average at Spalding and 38% at Fullerton. As a result of this development, nearly 20,000 acres of wetlands will be converted to dryland or irrigated cropland. This represents a loss of nearly 50% of the wet meadows in the basin, which will result in a reduction of evapotranspiration losses of about 27,000 acre-feet per year.

Table 1

PROJECTED AVERAGE ANNUAL STREAMFLOWS FROM
PLATTE RVER BASIN, NEBRASKA LEVEL B STUDY

Location	Average Annual Streamflow for 1970 Conditions[1]	Irrigation Development Year 2020 Projections	Groundwater Irrigation Development Only		Groundwater Development With North Loup and Cedar Rapids Projects	
	CFS		CFS	Percent of 1970	CFS	Percent of 1970
Middle Loup R. at St. Paul	1006	Low[2]	777	77	-	-
		High[3]	547	54	-	-
North Loup R. near St. Paul	919	Low	738	80	589	64
		High	583	63	449	49
Cedar R. near Fullerton	247	Low	190	77	137	55
		High	146	59	95	38
Loup R. and Power Canal	2154	Low	1662	77	1498	70
		High	1219	57	1086	50

1/Based on 30 year climatic period similar to October 1940 through September 1970.

2/The "low" rate of groundwater irrigation development is based on the average rate of development for the 1946-1972 period.

3/The "high" rate is based on the development which occurred during 1967-1972.

In the Level B Study, projections of groundwater conditions in the Loup River Basin were made for two rates of projected irrigation development. A map of the projected decline in the water table for the high rate of development is shown in Figure 2. The high rate of development shows a maximum decline in the Sandhills of about 40 feet.

Projections of groundwater declines have also been made for the High Plains Study. These show declines of as much as 80 feet in parts of the Sandhills by the year 2020 when no changes in government policies are assumed. Significantly greater declines are projected because the rate of irrigation development is now expected to be much higher than that used for the Level B Study.

Data and Research Needs

Much more research and data are needed before the extent of the changes in the water supplies can be resolved. Insufficient climatological data are being collected to conduct a comprehensive hydrology study in any portion of the Sandhills. More climatological stations would have to be concentrated in a study area to provide needed information relating to evaporation, transpiration, precipitation, temperature, wind, and other factors.

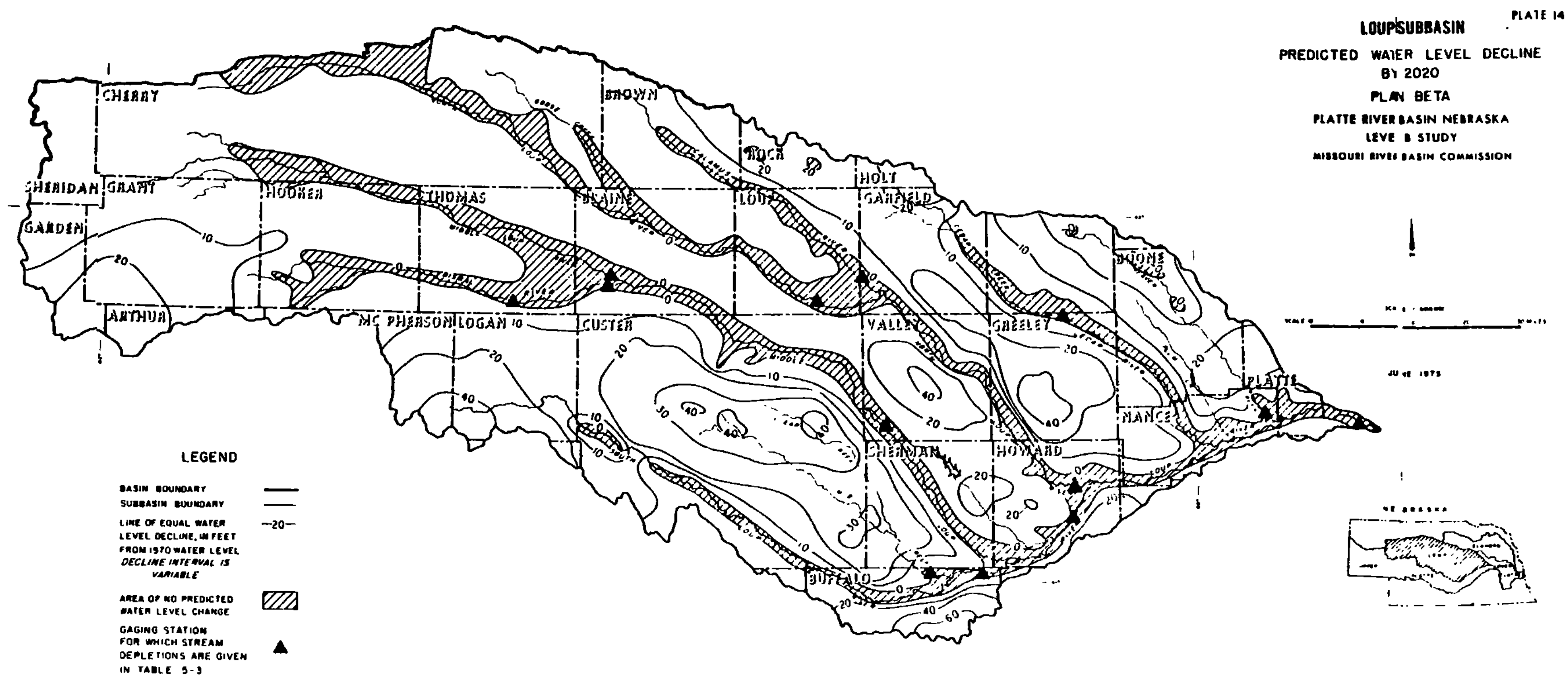
More basic data are needed to refine the existing information describing aquifer characteristics. Additional test holes and aquifer pump tests are required to develop more detailed information on the transmissivity, specfic yield, and saturated thickness of the aquifer. Also, more observation wells are needed to better monitor the variations in the level of the water table, particularly near areas of intensive agricultural development. More recording wells are needed to monitor seasonal variations.

Additional hydrologic research is needed to provide a better understanding of the factors influencing groundwater recharge and groundwater - lake interaction. The practice of draining wetlands and wet meadows to facilitate farming operations should be studied to determine potential effects on the groundwater table. Also, additional information on water use is needed to define a water budget for the area. As most of the water leaving the Sandhills is lost through evapotranspiration, the processes of evaporation and transpiration should be better understood. The effect of a lowered water table on vegetation and the rate of evapotranspiration should be determined.

There is a lack of information about the Sandhills lakes. Much information could be obtained by a monitoring program to measure the depth and size of the lakes throughout the Sandhills. The lakes near areas of existing or potential development would be of particular concern. There is a lack of information on the use of surface water in the Sandhills. More monitoring is needed to determine the actual amounts of surface water withdrawn from streams and lakes for irrigation and other uses.

The Nebraska Water Data Coordination Committee was established at the direction of the Governor to create a more effective and efficient

FIGURE 2


LOUP SUBBASIN
PLATE 14
PREDICTED WATER LEVEL DECLINE
BY 2020
PLAN BETA
PLATTE RIVER BASIN NEBRASKA
LEVEL B STUDY
MISSOURI RIVER BASIN COMMISSION
JUNE 1975
LEGEND
BASIN BOUNDARY
SUBBASIN BOUNDARY
LINE OF EQUAL WATER LEVEL DECLINE, IN FEET FROM 1970 WATER LEVEL
DECLINE INTERVAL IS VARIABLE
—20—
AREA OF NO PREDICTED WATER LEVEL CHANGE
GAGING STATION FOR WHICH STREAM DEPLETIONS ARE GIVEN IN TABLE 5-3
CHERRY
BROWN
ROCK
HOLT
SHERIDAN
GRANT
HOOKER
THOMAS
BLAINE
LOUP
GARFIELD
GARDEN
BOONE
ARTHUR
MC PHERSON
LOGAN
CUSTER
VALLEY
GREELEY
PLATTE
NANCE
SHERMAN
HOWARD
BUFFALO
NEBRASKA

program of data collection, storage, and use regarding Nebraska's water resources. This Committee is identifying and evaluating data programs and data needs. They are also coordinating efforts to fill data gaps in the Sandhills area as well as other parts of the state with the limited resources available for data gathering programs.

WATER QUALITY

The quality of the water in the Sandhills is generally very good. However, there are some exceptions in localized areas.

Summary of Available Information and Sources

Surface water quality is monitored by sampling networks operated by the USGS and Nebraska Department of Environmental Control (DEC). There are 21 stations which are in, or close to the Sandhills. The "1978 Nebraska Water Quality Report" by DEC provided an assessment of the data collected in a 10-year period through 1977. The Sandhills streams were generally reported to have good quality water. The reported changes in quality in the streams were mixed; some showing improvement, some showing slight degradation. For instance, changes in several water quality parameter levels were reported for the Middle Loup River. One parameter showed water quality improvement, while seven showed degradation. It appeared the water quality of the Middle Loup River had become somewhat less desirable, although the stream is still of good quality.

Sandhills lakes generally have good quality water with the exception of the western lakes having poor hydraulic connection with groundwater. These western lakes are partially supplied by runoff and, as dilution and flushing by groundwater is limited, evaporation can concentrate the salts in the lake water.

Information on groundwater quality in the Sandhills is not extensive. Data are collected by the USGS and Conservation and Survey Division, the Department of Health, and some of the NRD's. Data in the USGS files on groundwater quality consist of analyses from almost 350 wells. Many of the samples were taken a decade or more ago and are useful as background information but do not represent existing conditions. Another source of information is the 1978 groundwater reconnaissance sampling of the National Uranium Resource Evaluation (NURE) Program directed by the Conservation and Survey Division.

The chemical quality of the groundwater is generally good to excellent and it can be concluded tentatively that no widespread areas of groundwater contamination exist in the Sandhills region. The total dissolved solids concentration ranges from 100 to 200 milligrams per liter throughout most of the area. Sampling of municipal water supply systems by the Department of Health in 1977 revealed only one violation of drinking water standards in the region. This single nitrate-nitrogen violation at Valentine should not be interpreted to indicate a contaminated aquifer, but may be due to deficiencies in the well or water system. Other isolated wells with high nitrate levels were identified through the NURE Program. Groundwater nitrate data collected by the Lower Loup NRD revealed that the nitrate concentration increased in wells sampled in Loup, Boone, Garfield and Wheeler counties from 1977 through 1979. Groundwater data collected by DEC in the Wheeler County area has not demonstrated a significant change in nitrate concentration over the past two years.

Potential Changes

A great deal of concern has been expressed recently about possible increases in the concentration of nitrates in groundwater. In other areas of the state with sandy soils, such as Hall and northern Holt counties, nitrate concentrations in groundwater have increased dramatically as the amount of irrigation has increased. Recent research in Merrick County indicates that even under the best management practices the concentrations of nitrates could greatly exceed the allowable limits for drinking water. Extensive research is needed to determine whether similar increases may be expected in the Sandhills.

Data and Research Needs

A more extensive groundwater quality sampling network is needed to evaluate groundwater quality changes that may result from irrigation development in the Sandhills. Additional research should be conducted to assess what effect water, fertilizer, and other field-management practices and soil characteristics and other factors have on the leaching of nitrates and other agricultural chemicals.

Data are also needed to establish to what extent the results of research in other areas of the state can be applied to the Sandhills. This research has shown that intensive irrigation on sandy soils with management representative of many operations would, in time, most likely result in concentrations of nitrates in the groundwater significantly above drinking water standards.

Detailed hydrogeologic data and water quality sampling are needed in the area of major irrigation developments and extensive research is needed to determine the movement of the groundwater and nitrates, and the effect of pumping and lowered water tables on this movement. Data are also needed adjacent to areas where wet meadows and wetlands have been drained to facilitate farming operations. The effects of draining wetlands and wet meadows on surface water quality cannot be assessed without additional study.

ECONOMICS OF SANDHILLS AGRICULTURE

The economy of the Sandhills is based on agriculture, primarily ranching. For years, the grass has been used for grazing and the wet meadows for production of native hay. The nature of the ranching operations varies considerably. Some ranchers devote all their resources to the production and sale of feeder calves; others keep part or all of their calves and winter them over; and a few keep no cows, but buy calves and winter them over. Until recently, irrigation generally was limited to producing alfalfa or increasing hay production.

The Current Economic Base and Trends

The situation has been changing in some parts of the Sandhills recently. In Wheeler and Garfield counties, for example, calf production and cows two years old and older declined 13% and 12%, respectively, from 1967 to 1980. Cattle on feed increased 78% and the number of hogs on farms increased 14% in that period. This indicates that the economy of the area, while still dominated by ranching, became more oriented toward feeding.

During the same period, irrigation was increasing in importance. Total acres irrigated increased by 446% and irrigated area harvested increased 445%. The total number of registered wells increased by 704%. Dryland acres declined 22%. Thus, about 38,000 dryland acres were converted to irrigation or went from harvested to a nonharvested classification. There was also a considerable decline in the number of acres of hay harvested.

These statistics indicate that the economy is changing toward feeding and from dryland to irrigated. It is not known how much dryland is being converted to irrigated land and how much irrigated land is being abandoned or reverting to dryland.

This change in land use is causing a great deal of controversy in the region. It is difficult, however, to secure factual economic data to reliably assess the situation. For example, many residents claim that ranching provides a satisfactory economic climate and a good standard of living. However, the available data on economic indicators such as per capita income is mixed, so it does not support any conclusions either way. Research at the University of Nebraska shows that irrigation has a multiplier effect on the economic activity in an area. However, some of the local people say that very little, if any, of the supplies bought by the large developers is purchased locally. Therefore, very little economic benefit is realized in the area from increased irrigation.

Sandhills residents have also expressed conflicting points of view on other subjects. One group maintains that ranching can be improved by using irrigation for raising alfalfa and improving native hay without adverse effects on water quality or soil erosion. Several developers have answered with claims that they have improved the returns from poor ranches by producing irrigated corn. They also claim that, because they are natives of the Sandhills, they have enough knowledge of the area to continue irrigating without damaging the land.

A number of other problems have been reported. Producers have suffered economic losses due to erosion by the wind. It has been reported that, in some cases, it has been necessary to replant three or four times due to wind erosion. Preliminary field data collected in some places also indicates that yields have declined as the organic matter in the topsoil has decreased after several years of cultivation. Lands adjacent to irrigation developments have also suffered economic losses. In some cases, the sand blown from irrigated lands has settled on adjacent rangeland and smothered the grass. Blowing sand and dust could cause greater wear and maintenance on machinery. Pastures and wet meadows have also been affected by drainage water from irrigation developments.

Irrigation pumping causes temporary declines in the water table and may have caused some artesian wells to stop flowing and shallow domestic and stock wells to go dry temporarly. The cost of lowering pumps and replacing flowing wells can be substantial. Such declines could also reduce the production of hay from wet meadows, reducing a rancher's supply of feed for winter.

Intensive irrigation development also causes other economic externalities. It raises land prices, making it difficult to purchase land for continued use as range land. It also increases the value of all property and thus causes an increase in taxes. Whether this increase in taxes is sufficient to offset some of the other costs of development has not been determined. Heavy traffic resulting from intensive developments causes more rapid deterioration of roads. Additions to the population can increase pressure on school districts. The spending lid on local government could make corrections difficult even if the increased revenue would cover the costs.

Summary of Available Information and Sources

Little information is available on the economic situation in the Sandhills. The Department of Agriculture publishes annually, by county, data on the number of acres of crops harvested, the number of acres irrigated, and the number of livestock produced. The Annual Report of the Nebraska Department of Revenue contains data on assessed and actual values of property, income, and taxes on a county basis. No specific information has been published on the net economic returns from Sandhills ranching or irrigation of grain crops. Likewise, no information is available on the regional economic effects of either of these activities.

Projections of future economic conditions have been made by various agencies. The U.S. Department of Agriculture and U.S. Department of Commerce have forecast (OBERS projections) population and demographic variables by river basin and state. The Bureau of Business Research at the University of Nebraska also has a set of economic projections. Both should be updated when the 1980 census results are released.

Some economic projections were made for the North Platte, Middle Platte, Loup, and Elkhorn River Basins in the Platte River Basin Level B Study. They do not cover the entire Sandhills region, however, because they do not include the Niobrara River Basin. The Level B Study did project an increase in the amount of irrigated land in the Sandhills.

Projections of economic activity in the Sandhills have been made for the High Plains Study. The Department of Agricultural Economics at the University of Nebraska has developed a complex linear programming model for analyzing the returns to land and management in agriculture. Essentially, the model is programmed to select the optimal mix of irrigated and dryland crops to maximize the returns to land and management subject to such constraints as prices, costs, and limits on the maximum rate of conversion to irrigated agriculture. The model predicts that irrigation development will continue at a rapid pace for the next 40 years. It predicts much more development than did the Level B Study. It also shows that, without further government restraint, the returns to land and management will increase substantially by the year 2020. This holds true even if the projected energy prices, which are fairly high, are doubled.

Data and Research Needs

No definitive information is available on the severity and extent of future economic changes in the Sandhills. Much more research and data on the economics of the region are required before judgments can be made on the effects of irrigation.

The impact of taxes on development is not known. The normal net returns or profit from marketing corn may not be the only reason for the rapid increase in development. Tax write-offs and sheltering of income from non-farm sources may be the reason for some of the irrigation development. The extent of the incentives that taxes may provide is not clearly known because the tax structure is quite complicated and its effects seem to be mixed.

Inflation and speculation may also accelerate development. Land is a hedge against inflation because it is a real asset and holds its value. Thus, people trying to preserve their capital in an inflationary environment will invest in land as well as other assets which hold their value. This tends to bid up the price of land, making it more economical to develop than to maintain it as pastures and meadows.

Not enough information is available to determine what role speculation plays in development. Often a developer will buy and develop some land for irrigation only to sell it for a quick profit to another speculator or investor. In some cases, turnover in ownership of land is faster than normal and owners may tend to develop very marginal land with the intent of selling before problems develop.

Information on the economic impact of erosion from irrigated land is mostly conjecture. Wind erosion impacts the irrigated area by the loss of soil, loss of seed, damage to young corn, and increased operating costs. These losses are internalized so they are suffered by the developer and the information is not made public, but there are externalities. Neighboring land owners suffer losses because the blown sand may settle on their land in sufficient amounts to significantly reduce grazing. It is a nuisance affecting people, animals, and machinery. These external aspects of erosion are recognized, but monetary damage associated with them is difficult to measure.

A considerable amount of research would be required to secure the necessary data. Extensive study, perhaps with linear programming and input - output models, would then be required to assess future economic conditions with and without potential actions by local, state and federal governments.

SANDHILLS ECOLOGY

The Sandhills are a rare and valuable environmental resource. The region has the distinction of being the largest undivided expanse of grasslands in the United States.

Ecological Resources

The climax plant communities consist almost entirely of grasses and forbs. Plant species in the bunch-grass association occur throughout the region except in recently disturbed areas and wetlands. Some inter-dunal flat valleys sustain luxuriant stands of tall grasses which, for the most part, have a root system that is within reach of groundwater. These valleys are commonly called "wet meadows" or "subirrigated meadows."

The numerous lakes and wetlands are also a valuable asset. The Sandhills region is unique because the abundance of lakes and wetlands in a grassland environment attracts a great diversity of shore-birds and wading-birds. The area is one of the few extensive waterfowl breeding grounds remaining in the United States.

The Sandhills region supports a variety of big game animals, small fur-bearers, rodents, reptiles, upland birds, waterfowl, and fish. In the uplands, the carnivores of most interest include the coyote, long-tailed weasel, and the badger. A number of small grazing and seed eating mammals, including prairie-dogs and jackrabbits, are indigenous to the Sandhills. Numerous small rodents are also found in the region.

Sandhills bird life is well represented on the uplands, but as with plant and mammalian life, it is widely dispersed and composed of fewer species than might be found in a less homogeneous environment. Four game birds and a much larger number of non-game birds frequent the uplands. The wetlands provide the state's most significant waterfowl production area. For example, at the Valentine National Wildlife Refuge in the north-central part of the Sandhills, nearly 80 species of water-birds have been reported.

Approximately 50 species of fish can be found in the Sandhills lakes and streams. Northern pike, yellow perch, black crappie, large-mouth bass, and blue-gill are fairly common in several of the larger lakes. The smaller lakes and ponds are noted for bullheads.

Another asset of the Sandhills region is that it contains several of the state's public lands. Two of the three divisions of the Nebraska National Forest are contained within the region: the McKelvie Division southwest of Valentine and the Bessey Division south of the Middle Loup

River near Halsey. Both divisions were established in 1902 as experimental tree plantings in the Sandhills. Three National Wildlife Refuges are also located in the Sandhills region: the Crescent Lake, Valentine and Fort Niobrara National Wildlife Refuges.

Summary of Available Information Sources

A variety of information is available on the ecology of the Sandhills area, including information on (1) wet meadows, wetlands, and lakes; (2) the native vegetation and plant-community relationships; and (3) fish and wildlife of the area. A detailed list of references on sources of this type of information is included in Appendix 2.

Ecological Changes

One ecological change that has been well documented is the loss of wetlands. At various times in the past, efforts have been made to drain wetlands in the Sandhills to improve agricultural production. A 1972 report by the Game and Parks Commission states that 28,010 acres of wetlands, amounting to 15.3% of the original wetlands, had been destroyed. Most of these wetlands were lost from Cherry, Grant, Sheridan, and Arthur counties.

Several changes affecting the ecological balance of the Sandhills have not been given sufficient study to produce adequate data for proper assessment of their magnitude or severity. In addition to loss due to drainage, wetlands have been, or could be, lost because the water table has been lowered by pumping for irrigation. Loss of wetlands would result in loss of waterfowl. Continued loss of grassland due to increase in tilled and irrigated cropland would result in continued shifts in species of wildlife because of differing habitat requirements.

Data and Research Needs

More information is needed on ways to reestablish vegetation in areas lacking grass cover due to wind erosion or abandonment of cropland. Many examples of such problems exist from two different periods of time when Sandhills land use was changed to cropland. Similarities do exist between the older period of time and the problem that exists now in the Sandhills; the prime difference is that the prior or older land use changes were generally in smaller tracts, located primarily in the low lands. Present development involves the destruction of the grass cover on the steeper slopes as well as nearly flat lands. Some information has been collected by the University of Nebraska - Lincoln Department of Geography relating to land previously disturbed by homesteaders under the Kinkaid Act; the School of Life Sciences also has collected information on this problem.

CHAPTER 2. CONTINUATION OF CURRENT TRENDS

This chapter contains information on current development, including a description of existing governmental policies. It also contains information on the potential impacts of the continuation of current trends in development. Finally, it discusses possible means of reducing the potential impacts under current policies.

CURRENT TRENDS

The Sandhills region is unique in Nebraska and also in the United States. The large amount of native grassland and the small amount of cropland account for this uniqueness and are highly valued by most residents and visitors. However, intensive land use development through groundwater irrigation is increasing in the region. The rate and level of irrigation development in the Sandhills that would be physically, economically, socially, and environmentally best suited to the region in the long run are unknown. A certain amount of development probably would enhance the economy of the area without altering the cultural and environmental resources extensively.

In the past, ranching has provided fairly good economic conditions and an acceptable standard of living for the residents. However, they have always been, and would probably always remain, few in numbers. Development of the land and irrigation of grain crops generally produces greater economic activity and supports a larger population. Current economic conditions encourage such development. The growing world population has increased demand for food and prices have risen accordingly. Irrigation development has increased in response to this stimulus.

CURRENT POLICY ON IRRIGATION DEVELOPMENT

The current policy of most levels of government toward development is permissive, if not encouraging. There are a few federal restrictions on irrigation development in areas that include wetlands and navigable waters. However, the tax structure contains some provisions which definitely encourage development. Another federal program that may apply, though it has not been used in the state yet, is the "sole source aquifer" designation by the Environmental Protection Agency under the Safe Drinking Water Act. There are a few state restrictions also, but it is relatively easy for a developer to secure permission to drill a well and set up an irrigation system. The Sandhills region is most suited to irrigation with center-pivot sprinkler systems utilizing the available groundwater. State laws related to this type of development are confined mostly to requirements for registering and spacing wells and deciding whether an NRD should be allowed to establish a groundwater control area.

The NRD's have several tools at their disposal for regulating the effects of irrigation development: the Groundwater Management Act and the land use sections of their enabling act. The Groundwater Management

Act provides for the establishment of groundwater control areas, allowing the districts to establish regulations that could control the amount of water that can be used for irrigation, the amount of land that can be irrigated, and the total amount of land that can be developed. The land-use law makes provisions for establishing a program to control land use, but only if 75% of the voters in the district approve. No attempt has ever been made to use this authority.

Zoning by local governments, already authorized by state statute, might be used to improve the effects of irrigation development. Advocates of zoning claim that counties have the authority to zone agricultural lands to control the effects of undesirable development. Zoning has never been used in the rural areas of the state as intensively as it has in the urban areas.

IMPACTS OF DEVELOPMENT UNDER CURRENT CONDITION

The impacts of irrigation development in the Sandhills can generally be categorized as physical, environmental, economic, social, and legal/institutional. This last item is a special category relevant to state studies. Under current conditions, impacts on the state's legal and institutional framework would be minor but can be listed in order to contrast them with the impacts of additional management. The impacts described below could occur as a result of development; their magnitude and extent would depend upon the level of development.

PHYSICAL IMPACTS

In this report, physical impacts are defined as the direct impacts on the resources of the region. Environmental impacts generally result from these physical changes.

Impacts on Land Resources and Erosion

The principal impact on the land resource is the increase in cropland and the production of grain, with a consequent decrease in natural grassland and wet meadows. Where row crops are tilled in the conventional manner, the grassland is completely lost. Where the row crops are planted into grass, growth of the grass must be suppressed with herbicides. The practice of leveling the hilltops results, of course, in the loss of the grassland.

Another possible impact of irrigation of grain crops is a decline in the productivity of the land over a period of years. Loss of the organic content in the topsoil apparently reduces the yield of the crops.

An impact associated with the increase in cropland is an increase in wind erosion, which results in more dust and sedimentation. Also associated with the change to cropland is the change in the numbers and species of weeds.

The impacts of a special case of irrigation development--abandonment--are especially dramatic. Discontinuing crop production can result in an invasion of weeds and substantially more erosion. Unless efforts to restore the land to predevelopment conditions are successful, only weeds and less productive species of grass will grow there for many years.

Impact on the Water Supply

The basic impact of irrigation on the water resource is a reduction in supply due to increased evaporation and transpiration. This reduction produces a decline in the water table and may reduce the groundwater contribution to streamflow. This decrease in streamflow may produce a reduction in the number of acres of land outside the region irrigated from streams that originate in the Sandhills. It also might reduce power production at hydroelectric plants on those streams.

Water-table declines can cause some additional secondary physical impacts. As the water table drops, those lakes and wetlands connected with, and supplied by groundwater will become shallower, and eventually they could become dry. This will be especially true of the wet meadows. As the water table declines the number of plants that can send roots down to the water table will continue to decrease until there is no more wet meadow system. Production of hay will decrease proportionately. Paradoxically, this will make more water available for irrigation pumping, because the native grasses transpire a large quantity of water. In fact, they transpire more than they require for optimal growth just because the water is plentiful and available. When the water table declines below their root zone, the water they would have transpired can be salvaged. Likewise, the evaporation from the surface of lakes and wetlands will also be reduced.

Another activity associated with irrigation has an impact on the water resources. Drainage of wetlands and wet meadows to adjacent low lands or streams can cause flooding and thereby reduce the usefulness of some land.

Impact on Water Quality

Irrigation of the sandy soils will introduce contaminants into the groundwater by leaching. Some of the agricultural chemicals applied to corn, as nitrates in fertilizers and organic compounds in pesticides, can be dissolved by irrigation water or precipitation and infiltrate to the water table.

Drainage of wetlands and wet meadows to surface waters could have a short-term effect on surface-water quality. The construction activity generally increases the amount of material, including organic material, suspended in the draining water. In some cases, loss of the wetlands might also have a long-range impact, since they would no longer be available to act as a sink for nutrients and other contaminants.

ENVIRONMENTAL IMPACTS

The environmental impacts identified in this section are generally associated with the physical impacts listed in the previous section. There would be some additional impacts associated with irrigation operations, such as air pollution from diesel engines or the electric-power plants providing the power for electric motors, but they have not been considered in depth in this chapter.

Impacts Associated With Land Resources and Erosion

The greatest impact on the environment will probably be associated with the greatest change in the land resources--the shift from grassland and wetland habitat to cropland habitat. In addition to changes in the plant communities, there would be resultant changes in the wildlife dependent on a specific type of habitat. The conversion of Sandhills prairie to cropland would result in the loss of native climax vegetation which is best adapted to the climatic and edaphic characteristics of the Sandhills area. Native wildlife species, from insects to mammals, would be reduced in numbers and range. The greater vegetation and habitat diversity would be advantageous for some plant and animal species. Initially, there would be an increase in the numbers of plants and animals and greater diversity of species as those dependent on cropland moved into an area almost exclusively grassland and wetlands. This impact would be increasingly more beneficial as more land was converted, to a certain point, or threshold. After that, the impact would be reversed as the habitat diversity would actually decrease, especially if only one crop, corn, is grown.

There would also be a change in the aesthetics of the environment. The scenery would change from rangeland with cattle grazing on it to cropland being farmed with modern machinery.

Impacts Associated With the Water Supply

Environmental impacts associated with the reduction of the water supply are related to the declining water table and diminished streamflows. The amount of decline of the water table will determine the extent and degree of impact on lakes and wetland habitat. Lakes and wetlands that fluctuate with the water table will become progressively shallower and smaller. As the wetlands shrink, wildlife species and numbers will shift from wetland types, such as waterfowl, to grassland types. When the wetlands eventually dry out, the species dependent on such habitat will be lost. As the lakes become shallower and shrink in size, the fish and wildlife dependent on them will decrease proportionately in numbers. This will continue until a threshold depth is reached and some critical factor, such as winter kill, drastically reduces the number of more desirable species of game fish. As their depth continues to decline, the lakes will begin to replace the wetlands lost previously and the waterfowl and shorebirds displaced from lost wetlands will be able to utilize this small amount of new habitat. This change in habitat will affect the migratory species as well as the resident wildlife population.

The depletion of streamflows will have a similar impact on instream values, especially fish and other aquatic species. If the flow diminishes sufficiently, riparian habitat that supports upland species of wildlife could also be reduced.

Impacts Associated With Water Quality

The physical impacts of irrigation on water quality are considered to be environmental impacts. This direct impact also has some secondary impacts, mainly those associated with the nutrients from fertilizers like nitrates and phosphates. These nutrients enrich the waters of lakes, wetlands, and streams and change the ecosystem. In many instances, they support greater growth of plants, including algae, which further affects the quality of the surface waters. After a certain threshold is reached, plant growth becomes excessive, depleting dissolved oxygen when the plants die and decompose.

ECONOMIC IMPACTS

There is a fundamental difference between economic impacts and other kinds of impacts. The impacts mentioned in the preceding sections are by-products of irrigation. Economic impacts are the motivating force for most of the irrigation development. The primary impact on the irrigator usually is greater economic returns to land and management (a measure of farm income before land and management costs are taken into account). This produces substantial indirect impacts on the natural resources and the other people in the region.

The concept of "economic impact" is a very broad term that usually includes both the direct impacts on agriculture's gross income and the indirect effects on other industries of the state resulting from changes in this income. These incomes can lead to investment activity in agriculture and in related industries.

Impacts Associated With Land Resources and Erosion

The economic impacts of irrigation produced by the land resource are many and varied. The value of the product is substantially greater, which makes the value of the land much greater. This results in an increase in taxes on the land. By demonstrating that similar land is also suitable for such development, it also makes that type of rangeland more valuable and increases its sale price. These increases may not always remain constant, however. Over a period of years, the value of production may decline due to a reduction in yield.

If unsuitable land is developed, or the land is not managed correctly, the value of production can fall below costs, and failures can result, as has already occurred in isolated instances. The abandoned irrigated land has less value than the original grassland. The sod itself can be considered a resource. Some abandoned lands have not become fully productive rangelands after 60 or more years.

The economic impacts of the erosion of the land resource are both internal and external to the irrigation operation. Erosion increases costs when it results in seeds being blown away or it strips and kills young plants. This makes replanting necessary, which adds to the costs of operation. The externalities include costs to neighbors for the grass and beef production lost when sediment smothers adjacent rangeland. It also decreases the value of that rangeland on the market.

Impacts Associated With Water Resources

Economic impacts stemming from the effect of irrigation on the water resources are related to the declining water table, diminishing streamflow, and change in water quality. Declining water tables, both seasonally and annually, result in increased costs to the irrigator and adjacent ranchers or irrigators. As the water level falls, the cost of pumping increases, and in some cases additional costs are incurred for lowering pumps or drilling deeper wells. This is especially true for adjacent domestic and stock wells, most of which are very shallow in the Sandhills. Adjacent ranchers generally incur other costs also. The loss of hay from the wet meadows reduces the available winter feed. Its replacement is usually more expensive.

The increased value of production brought about by irrigating from groundwater is somewhat offset by the production forgone at downstream locations that could have used the lost streamflow in surface-water projects. The proposed Cedar Rapids Division is an example of an opportunity forgone. It has been eliminated because the streamflow is declining. However, the use of groundwater will support many more acres than the project would have, so the net impact is still an increase in economic returns. The net returns per acre will not be the same, though, because energy costs will be higher for groundwater irrigation. Pumping requires much more energy than gravity irrigation, and energy costs are becoming much more significant.

The economic impacts due to changes in water quality may be the costs of securing alternate supplies of drinking water, and possibly the loss of young livestock that drink water with high concentrations of nitrates. There could also be some impact on recreational costs and benefits if nutrient-enriched waters could no longer be used for fishing, but it appears this effect would be very small.

Impacts on the Regional Economy

The increase in production and the value of production resulting from irrigation increases economic activity in many sectors of the economy of the region and the state. Intensive agriculture of this type requires many more inputs to produce the higher valued crops. Purchase of goods and services such as irrigation equipment, machinery, fuel, fertilizer, and seed, plus the repair and maintenance services increase the economic activity in the area. Services for marketing the final product, whether it is grain or fed cattle, also increase the economic benefits to the region. Economists at the University of Nebraska point out that every dollar spent on irrigation produces several more dollars in the state's economy.

These economic impacts may not all accrue to the area impacted physically. In a number of instances, the necessary supporting infrastructure is not available in the Sandhills, and large developers have imported their machinery and supply from other regions, even other states.

Some other regional impacts have been, and will continue to be felt by local and state governments. Heavier traffic associated with irrigation increases the cost of maintenance on local roads. As population increases, costs for services such as schools, emergency medical services, and others, will also increase. In some cases, costs of municipal services could also be increased as public supply wells are replaced or deepened.

SOCIAL IMPACTS

Intensive irrigation development in the Sandhills will produce social impacts--that is, impacts on the style of living and the standard of living. The added economic activity produces changes in income, employment, and population, as well as the natural resources. The magnitude of possible changes is impossible to project without extensive detailed studies, but any of the usual changes brought about by irrigation would be much more apparent in this region than most places in the state. In comparison, there is very little farming in the region. This would make the switch from ranching to farming, and the supporting services required, very noticeable.

The basic change in life style would be from ranching to farming. Regardless of whether the farming was done by the owner or hired managers and laborers employed by absentee owners, more people would be required. More people would also be required to provide the services needed by the irrigators and feeders. The current residents and the newcomers would have to adjust their life styles to the new situation. The increase in economic activity would raise per capita income and the standard of living of some of the residents.

These changes would also result in an increase in the number of people coming into conflict. As the water table declines farther, interference with existing wells will increase, and the number of disputes and court cases could increase. There could also be additional conflicts over sedimentation from erosion and flooding from drainage projects that ruin adjacent grasslands.

Increases in the concentrations of contaminants in the water supply, especially groundwater, could have significant impacts on the region. Nitrates from fertilizers are a serious health hazard to infants and young animals. Drinking water supplies must be tested frequently and alternative supplies provided when the concentration becomes too great. This hazard has led to greater involvement of local and state agencies in some regions, and this influence could also be felt in the Sandhills.

In fact, increasing development and population will probably lead to greater involvement by local, state, and federal agencies in a number of areas, including education, law enforcement, and others.

POTENTIAL IMPROVEMENTS UNDER CURRENT POLICY

The adverse effects of irrigation development on the Sandhills could be minimized in a number of ways without any federal, state, or local government policy changes.

IMPROVEMENTS IN LAND RESOURCES AND EROSION CONTROL

Under existing regulations, improvements could be made in the use of the land resources and in erosion control. The use of presently available conservation and management practices could reduce erosion, but the extent of future application of protective measures under current conditions will depend on economics, education, and available technical assistance. If practices such as leaving crop residue, minimum tillage, and use of grasses or cover crops reduce losses or improve crop production, good managers should use them if they are aware of the benefits they can obtain.

IMPROVEMENTS IN WATER RESOURCES

The effects of irrigation development on the water resources of the Sandhills could also be reduced under current policies. The quantities of water pumped and the consequent decline in groundwater levels could be reduced by the conversion to more efficient sprinkler systems and better irrigation management. Reduction in the amount of water applied would also help reduce the amount of nitrates reaching the water table by reducing the amount of water available for leaching. Good fertilizer management would also help reduce the contamination of groundwater by nitrates. Using the right kind of fertilizer at the right time could significantly reduce the loss of nitrate to the groundwater.

IMPROVEMENTS IN ECOLOGICAL CONDITIONS

A few federal and state programs are working affirmatively to preserve and enhance ecological values under current irrigation development levels. A federal agency has proposed a program for acquiring rights and easements to preserve wetlands to complement its system of wildlife refuges. Another federal agency is attempting to diversify the ecological patterns and preserve existing ones in the National Forests. The state has a program for acquiring lands to preserve habitat that could also be used in the region. This program, which is directed at improving wildlife habitat through various land management practices, is administered on the local level by the NRD's. Some NRD's have established similar programs on their own.

Some additional reductions in the effects of irrigation development could be achieved by expansion of these programs and a few other methods. Careful location of irrigation developments could minimize the loss of valuable plant communities and wetlands. Leaving "corners", areas not reached by center pivots, in native vegetation would help preserve some values. Planting shelter belts between irrigated fields and cover crops would also help diversify the ecosystems.

IMPROVEMENTS IN EDUCATION AND TECHNOLOGY TRANSFER

Significant improvements could be made in all ways by improving one existing program--education and technology transfer. Irrigators could do a number of things that would reduce the impacts and that would also benefit them economically, as well as physically and environmentally. A good example of a program that would reduce an irrigator's cost and reduce the amount of contaminants introduced into the water supply is water and fertilizer management. Significant benefit could result from an education program that would convince all irrigators that they could improve their economic returns with an investment in the most efficient systems of applying water and fertilizer and with correct timing of applications. Many irrigators may not use these methods because they are not familiar with them. Expansion of information programs on the benefits and techniques for soil conservation, water and fertilizer management, and habitat programs, among others, could result in significant improvements in erosion control, water quality, and aesthetics.

CHAPTER 3. STRATEGIES FOR THE FUTURE

The impacts of development under current policies, even with potential improvements, could be so great that it would be necessary to take some action to reduce or prevent them. In most cases, there are methods of reducing or mitigating the adverse impacts of irrigation, but some changes in state and local policies will be required to ensure their implementation. If there should prove to be some intolerable impact that cannot be reduced sufficiently, policies would have to be changed to preclude further irrigation development. Some strategies for ensuring the reduction of impacts or restricting development are discussed in this chapter. The strategies outlined simply provide a range of alternatives and some examples of the types of systems that could be examined in the long-term study.

IRRIGATION DEVELOPMENT WITH POTENTIAL STRATEGIES

Irrigation development in the Sandhills can continue, and the impacts of it can be reduced. Management methods for reducing most impacts are available, though some may not have been proven as thoroughly as others. Strategies to implement these methods are needed.

DEFINITION OF METHODS AND STRATEGIES

Achieving the reduction of any possible adverse effects is a two-part process. First, it is necessary to determine which management methods will work in the field. Then it is necessary to identify the policy changes in administrative and legislative programs that will implement the management methods.

Management Methods

Management methods are physical means of producing a desired effect, such as reducing the amount of erosion by the wind. Some of the management methods that could be used in the Sandhills are well proven, but some are still relatively new and more experience with them is needed to prove their value.

Strategies for Implementation

Ensuring that the methods of management are used calls for implementation strategies. In some cases, implementation would require legislative or administrative policy changes.

Strategies for implementation are basically of two types: (1) financial incentives and/or disincentives, and (2) some form of regulation. There are several types of incentives and disincentives and hundreds of variations of these types. Incentives are generally either payments for performance, low-cost loans for construction, or tax breaks for using land in the least damaging ways. There are many examples of existing and potential payments for desired performance. A number of cost sharing programs for conservation practices already exist, and some even parallel the set-aside program. In addition, grants are made by the federal and state government for the construction of beneficial projects for such purposes as conserving water.

Disincentives are generally of two types: increased taxes or a system of fees, bonds, or escrow accounts to ensure performance. Property taxes, which are theoretically based on land value, are already higher on land developed for irrigation. A basic change would be required to increase these taxes on developments with severe adverse impacts. A system of fees for permits for some types of irrigation development already exist, but these fees are not high enough to affect a developer's decision on the type of system used or the land developed.

According to the public attitude survey of Sandhills residents, 68% felt that some regulation of usage of Sandhills water and land resources would be necessary. Therefore, an examination of representative regulations is needed.

Regulations listed in this chapter are generally of two types. Some are firm and applicable everywhere, and others are flexible and require a decision in each case by some administrative agency. A firm regulation, for example, might be a state law prohibiting development in a specific place such as sandy soils on slopes over 10%. The number of possiblities for regulations of this type seem limitless, as do the more flexible systems. To allow some flexibility the state law might set up a permit system to be administered by a state or local agency. For example, development could be prohibited without a permit, and a permit could be denied in areas where damage could not be limited to acceptable levels.

Any necessary policy changes could be implemented by a number of state and local agencies. In fact, many already have some responsibilities in one or more aspects of regulation of development. The Department of Water Resources and DEC already have responsibility for granting permits and enforcing regulations related to surface water. The NRD's can acquire some of these authorities under the Groundwater Management Act, and they theoretically have much broader authority over land use under their enabling legislation. Counties already have a considerable amount of authority under the zoning law. According to the public attitude survey, a majority of those residents favoring regulation felt that it should be administered at the local level.

LAND RESOURCES AND EROSION

The reduction of adverse effects on land resources can be achieved through the implementation of presently available management methods. Several basic procedures can be utilized including the use of acceptable soil management practices and production techniques. The intensity of management and the degree of practices required are dictated partly by the topography of the land and the texture of the soil. Therefore, some locations must be treated more carefully or not developed at all.

Management Methods

Management methods in the Sandhills are basically of two types: using conservation practices from the SCS technical guides and maintaining the area as grassland. Effective conservation practices for the Sandhills region include: cover crops, tree plantings, conservation planting, and residue management.

In the Sandhills, the potential for wind erosion is great. Therefore, controlling the problem areas involves decreasing the wind velocity at the soil surface to reduce the wind erosion. One technique that can be used is residue management. However, in order to employ efficient residue management, the residue requirement in pounds per acre for any particular soil type must be estimated. The SCS has developed the Wind Erosion Hazard Equation as a method to determine the erosion potential of soils under different crops, management techniques, and environmental conditions.

In the Wind Erosion Hazard Equation, $E = f(I\text{-}K\text{-}C\text{-}L\text{-}V)$:
E = the estimated soil loss
f = function of the fixed factors
I = soil erodibility depending on soil type
K = ridge roughness or topography
C = climate (e.g., precipitation, temperature, wind speed and evapotranspiration)
L = length of the field exposed to the wind
V = vegetative cover and resulting residue

The type of vegetative cover and resulting crop residue is one of the most important factors and one that the farmer can manage in order to keep the estimated erosion within the acceptable range for the soil type. For a typical Sandhills area, with I = 250 for Valentine fine sand and 134 for Dunday loam fine sand; K = 1.0; C = 30; and L = 3970 ft., the vegetative cover (V) must be a minimum of 1600 pounds of flat small grain residue; 3000 pounds of standing corn stubble 16 inches tall; or 5000 pounds of flat corn residue per acre, to keep the estimated erosion within the erosion tolerance range of 3 to 5 tons per acre per year.

Strategies for Implementation

Means of ensuring that these management methods are implemented include incentives and disincentives, with or without accompanying regulation. Incentives might include additional cost sharing in the installation of control measures, payments for cover crops, or new programs of the same kind. They might also include tax breaks for land maintained in cover crops or other effective conservation practices. Disincentives might include higher taxes on crop land not adequately treated. They might also include special taxes on irrigation equipment that could be granted exemptions for expenditures on erosion control measures.

There are a number of possible variations of firm regulations. A law could be enacted that would prohibit a certain type of development, such as row crops or irrigation, in special situations. This might include all sandy soils, all soils on slopes greater than 15%, or some combination (e.g., sandy soils on slopes greater than 10%). The areas from which development would be excluded would be those on which erosion could not be controlled. Another variation would be to provide an exemption to the prohibition if specified practices which would reduce the adverse effects to tolerable limits were used. For example, development might be prohibited on sandy soils with slopes over 10% unless cover crops were grown with row crops.

More flexible forms of administration could be used with the same types of regulations. Irrigation on sandy soils could be prohibited without a permit from some agency such as the county or NRD. Granting such permits could be based on a review of each individual case, and the permit could be conditioned on the use of adequate treatment measures to prevent damage. Another possibility would be to require the developer to file an approved conservation plan with the administrative agency before a permit is granted. For example, State School Lands are now managed according to a conservation plan and if developed for irrigation, done according to SCS technical guides. These guides have slope limits and place high emphasis on residue management.

Another management method would be to maintain or provide good grass cover on an area susceptible to erosion. Some areas may be unsuitable for irrigation or for row crops regardless of the type of practices employed. It appears the only alternative in such cases is to maintain the grass on the land. Strategies for making sure that management is implemented are the same. In this case, however, firm regulation would specify that certain areas could not be developed, and no exceptions would be made. Under the flexible systems of regulation, permits would have to be denied for development in critical areas. Zoning, if it were used, would have to be established so that it could provide no variances in these critical areas.

Management Methods for Abandonment and Restoration

In attempting to reduce the adverse effects on land resources, there is a special case that requires consideration. Discontinuing irrigation without restoration of cover on sandy soils is a critical problem. Two management methods could be used to reduce erosion on abandoned lands. In some cases it might be possible to irrigate crops other than row crops, such as grass or alfalfa. This would probably be limited to a small number of cases where circumstances would allow a neighboring ranch to keep a small development going. The only other alternative is to restore nonirrigated grass so the area can be used for rangeland.

Strategies for Implementation

In both cases, one of the most important actions is to keep the irrigation system on the land while the new crop is being established. Incentives for retaining the system might include the usual ones, such as reductions in taxes and cost-sharing in establishing the crops. In addition, a system could be established to provide grants or low-cost loans for continuing the payments on, or the purchase of, irrigation equipment in abandonment proceedings (e.g. bankruptcy). Disincentives for abandonment and removal of irrigation equipment from sandy soils would have to be an expansion of a regulatory system mentioned previously (i.e., a permit system). In order to get a permit, a developer would be required to post a bond to cover the restoration cost. In lieu of a bond, the developer could place restoration funds in an escrow account. Another method of ensuring the availability of restoration funds would be to make the fees for well permits large enough to develop a cash fund that would allow the administering agency to cover the cost of restoration.

The regulation options in this case would be much the same as those discussed previously, with certain additions. For instance, the removal of the irrigation equipment without a permit from the county, or the NRD, might be prohibited. In addition, the restoration of the area to grass prior to removal might be required. If more flexibility is desired, it would be possible to require permits for irrigation wells, have the administering agency inspect and approve the well and the irrigation system, and prohibit the removal of the approved system without a permit. This would also be a good way to ensure that wells are abandoned properly. Finally, some agency could be given the authority to enter the land in case of abandonment, restore the grass, and then recover its costs in administrative or court proceedings.

WATER SUPPLY

Several management methods are capable of reducing the effects of irrigation development on the water resources of the Sandhills. There is some question whether these strategies will work with unrestricted development. The level of management required to achieve given levels of reduction have not been precisely determined for all situations.

The quantity of surface water is affected by diversion and pumping directly from lakes and streams and by groundwater withdrawals that reduce the groundwater contribution to lakes and streams. Before groundwater pumpage can affect streams, however, it must reduce the amount of groundwater in storage such that the water table is lowered near the stream. Therefore, measures to reduce adverse effects on the quantities of groundwater would accomplish the same goal for surface water.

Management Methods

Management methods for reducing the effects of irrigation on the water supply include increasing the efficiency of irrigation systems and the crops that are grown, limiting the number of acres irrigated, and reducing related water losses such as the drainage of wetlands. Increasing the efficiency of irrigation would have the effect of reducing the net amount of water used per acre. This could be accomplished by such means as irrigation management, converting to low pressure sprinklers, and changing to other crops (such as sorghum) that require less water than corn.

Strategies for Implementation

Strategies for implementing these management methods are fairly standard, varying only slightly from those for reducing erosion. In addition to cost share payments, incentives could include establishing and subsidizing sprinkler conversion and pivot operation programs. Where it is desired to limit the number of acres irrigated, incentives might include payments for acres set aside from irrigation. A reduction in taxes on crops that use less water could be another incentive. Disincentives might include a higher tax on high water use crops or a user fee on water pumped.

Regulations would be nearly the same as those established by NRD's for groundwater control areas. To regulate the number of acres irrigated, firm regulations might specify the well spacing to be used in different types of soils. Flexible regulatory systems administered by state agencies or NRD's might require permits for wells and place a limit on the number of acres per development. They might also require the rotation (alternation) of the use of systems in alternating years. Another addition might be a limit on the number of acres that could be irrigated in any given area, such as a township. If this were accompanied by the right to transfer the ownership of development rights, theoretically only the best land would be developed.

WATER QUALITY

Reducing the effects of irrigation on the quality of the water resources is more difficult than reducing the effects on the supply. Management and implementation would both be more complex.

Management Methods

Maximizing the yield of irrigated crops requires the use of fertilizers and other chemicals. Reducing the amount of contaminants reaching the water supply must be accomplished by reducing the amount applied or preventing the chemicals from reaching the water table. The amount of fertilizer needed can be reduced by using the right type of fertilizer, by timing the applications correctly, and by using the appropriate rate of application for the different stages of crop growth. Proper well design and backflow prevention devices can prevent contamination through wells. Pumping groundwater that has been contaminated with nitrates onto cropland to give the crops a second chance to use the nitrogen may also help stabilize the level of nitrates in groundwater. This technique has limited application, however, where the nitrates are concentrated in the upper part of the aquifer and the wells are considerably deeper. The adverse effects of water from drainage projects on the water quality can only be reduced by controlling the discharge from drainage, or preventing drainage projects.

Strategies for Implementation

Strategies for implementing these methods of management include the standard incentives and disincentives as well as regulation. Only the purposes of the payments or the terms of the conditions of the permits would vary. One possible addition might be coordinating the permit programs with several federal programs. It appears that the Corps of Engineers wetlands permit program is applicable to the area, and the proposed easement program of the Fish and Wildlife Service would provide incentive payments for preservation of wetlands.

ECONOMICS OF SANDHILLS AGRICULTURE

The economic effects of irrigation in the Sandhills that are of concern to the general public include wide-spread private costs and the costs to local governments. Court cases have already established precedents concerning the reimbursement for damages when pumping from irrigation wells causes nearby domestic wells to pump air. However, it is not clear what remedies are available for cases where many ranchers' domestic and stock wells go dry because of the pumping from a large number of irrigation wells. The method of management in such cases is to prevent economic damages due to this interference with domestic and stock wells. This could be accomplished either by reimbursing owners for drilling new wells or by restricting irrigation pumping to prevent interference. To provide for reimbursement, a special fund could be created by making permit fees sufficiently large to create an adequate sinking fund, or by requiring that all irrigation well owners post a bond and share in the cost of deepening the wells in their region. Controlling the amount of interference would require the passage of a law giving some agency the authority to restrict the rate of pumping or shut down interfering wells until the water level recovers.

Management methods that would restrict development would also act to hold down land prices and taxes on rangeland. The effect of this strategy would be to relieve this economic pressure on ranching operations. The types of regulations that would implement this management method are similar to those mentioned previously, only the terms of the control would vary.

In cases where governmental costs, such as for road repairs and schools, are increased, management methods include increasing government revenue to pay the costs created by developments or preventing increases in government costs. The types of incentives, disincentives and regulations that would be needed are similar to those mentioned previously. In this case, however, it is more likely that restrictions on the total amount of development would be needed.

SANDHILLS ECOLOGY

The ecological management policies affecting the Sandhills under current development levels have been established mainly to preserve, to the extent possible, certain values defined by laws and regulations. Future policies would retain the same goals.

Management Methods

Means of reducing the effects of irrigation on the ecological systems include controlling the location of development and providing for replacement of areas that are changed. Careful location of irrigation developments could minimize the loss of valuable plant communities and wetlands. This would require a system of identifying those areas that are especially valuable.

Another approach to ensuring the reduction of the ecological effects would be to establish a program to put lands of equal or higher ecological value in public ownership. Since irrigation development results in increased economic benefits to the developer and the public, part of the public gain could be devoted to the purchase or preservation of other lands with the same types of ecosystems.

Methods of reducing the ecological effects on lakes might include dredging and pumping groundwater into them. In certain cases, these methods might maintain the additional depth needed.

Strategies for Implementation

Strategies for implementing management methods would again be variations on the incentives, disincentives, and regulations discussed previously. The Nongame and Endangered Species Conservation Act provides limited authorities for preserving threatened wildlife or plant species. Certain regulations governing the protection, conservation, and management of endangered and threatened wildlife species have been developed by the Game and Parks Commission. However, appropriate policy and regulations regarding review of existing programs, coordination between state departments and agencies and the Game and Parks Commission, and implementation of other state department and agencies' programs for the conservation of these species have not yet been established. Official designation of critical habitat for these species has not yet been made by the Game and Parks Commission.

Some valuable ecosystems may exist within the region that cannot be preserved by any means other than prevention of development. This would require legislation establishing standards and guidelines to be used in determining acceptable locations of development and locations where development cannot be allowed. A program would have to be established under state law to identify those areas that the public interest dictates must be preserved. Then some governmental unit would have to be given the authority to establish the rules and regulations by which decisions on development could be made by the landowner, the enforcing agency, and the courts. These could be established and enforced by a state agency, an NRD, or a county.

Controls could be based on one of several systems. For instance, the regulations could designate specific types of areas, based on soils or vegetation, that could not be irrigated, or could be irrigated only with a special permit or variance from the enforcing agency. Another system would be to require the filing of a development plan with every application for a well permit. Then the area could be checked for valuable ecosystems before the well permit was granted. A variation might be to require a permit or variance only when a certain amount of development will be reached, such as 50% of any section.

Instead of preventing development in a particular area containing a highly valuable ecosystem, or a valuable part of a system, it would be possible to establish a similar program of regulations and controls that would measure the potential loss to development and permit it if an acceptable substitute could be found and its survival insured. A system of this kind could be based on the same types of controls, except there would be no absolute prohibition of development. In this case, a system of incentives could be added to the controls. A developer who was required to donate replacement land to the public to insure the maintenance of its value could be given a substantial tax credit, or reduction, for that action. A similar tax reduction could be given for the establishment of a replacement area on the developer's land, if the threatened ecosystem could be duplicated and an easement were granted to ensure maintenance. In such cases, other incentives might also be provided, such as payment for fencing or providing and planting trees.

It would be possible to provide some replacement of lost values, without attempting to identify and assess specific values of a given area, by setting up a system that would encourage and require all developments to provide some type of replacement. This might include such things as wildlife plantings and easements on the corners not reached by center-pivot systems or the planting of shelter belts between developments. Such actions could be required and encouraged by the same types of controls and incentives mentioned in previous sections.

This concept could also provide for the replacement of values in wetlands and lakes that are impaired by irrigation development. The wetlands and lakes could be dredged, if necessary, and groundwater could be pumped into them to increase their respective capacity and depth.

POTENTIAL COMBINATIONS OF STRATEGIES

In the preceding sections, management methods and implementation strategies have been examined separately for each area of study. Some of the systems discussed could, with minor modifications and inclusions, be broadened to address several of these areas. This would be particularly true of the alternatives that act to restrict development. Conversely, some strategies would act to correct some problems to the detriment of others. Actions to reduce wind erosion that would require more water and fertilizer would be an example. To be most beneficial, the combination of strategies implemented would need to strike a balance between the benefits of irrigation development and all the problems associated with such development.

A combination of strategies including regulations to address the most serious problems may be necessary. Educational programs and cost share programs may also be needed to assure success of any regulatory programs. Programs to provide information to landowners and managers on potential problems, up-to-date technology and management techniques, and existing laws and requirements are needed. Cost-share or other types of financial assistance programs are also important to assure compliance without creating undue hardship.

Many of the strategies require only amendments to existing laws and expansion of existing systems. County zoning regulations, the land use sections of the NRD law, and the Groundwater Management Act could serve as the basis for many of the implementation strategies discussed previously.

Modification and Implementation of Zoning

Legislative action would not be required for a county to regulate development by zoning. The authority and procedural requirements are already contained in the statutes, but implementation could be delayed by court tests. By utilizing this authority, it might be possible to establish zones of land use based on soil type, slope, depth to the water table, or existing groundwater quality. Such areas might be zoned strictly for rangeland uses, and variances might be granted for cropland or irrigation only on the condition that specified management practices be used. This type of zoning might be used in conjunction with other programs such as well permit or conservation plan programs.

Modification and Use of the NRD Land Use Law

Natural Resources Districts have potential, limited powers to regulate land use. Legislative action would not be required, but 75% voter approval would be required for an NRD to establish any kind of land use regulatory system. It has been proposed that this requirement be reduced to 50% in order to implement a special regulatory program for restoration of abandoned irrigation areas. The district would then be able to establish rules and regulations, similar to those established for groundwater control areas, that would require permits for certain kinds of development on specific types of soils. Issuance of permits could be conditioned on the application of specified management practices, or on the submittal of an approved resource management plan. A developer could obtain aid from local, state, and federal agencies in working out an acceptable erosion control or water use plan. His permit from the NRD, or variance from the county, could then be conditioned on satisfactory implementation of his plan.

Modification and Use of the Groundwater Management Act

Under the Groundwater Management Act, groundwater control areas can be established where groundwater supplies are inadequate to meet present beneficial uses, or are projected to be inadequate to meet reasonably foreseeable needs. Those areas which have been declared control areas all have had previous declines in the water table and computer modeling studies that projected further declines. Modeling studies are time-consuming and expensive, and it is not known how extensive or detailed a study must be to prove that the supply will probably become inadequate. Another shortcoming of the Act is that it recognizes only water quality problems that arise from dewatering of the aquifer, not from the introduction of contaminants. Amendments have been proposed that would permit the establishment of interim control areas and the establishment of control areas to regulate development for maintaining water quality. Other amendments have been suggested that would allow the establishment of a control area by petition that would be restricted to the area where the petitioners reside.

After a control area has been established, the NRD's have the authority and responsibility to promulgate regulations that will alleviate or manage the situation that is causing inadequate supplies. Regulations they can impose include restrictions on irrigation such as well spacing requirements or allocations of the amount of water that can be pumped. The principles on which these types of regulations are based are the same principles on which most of the strategies for action listed in this chapter are based. They could be implemented by expanding the Groundwater Management Act, or by writing a similar act.

NO ADDITIONAL DEVELOPMENT

An alternative to allowing adverse impacts caused by the continuation of irrigation development is the prevention of additional irrigation in the Sandhills. This alternative could be applied if irrigation development is shown to result in severe and unpreventable damages to land and water resources and the economy and ecology of the Sandhills.

MANAGEMENT METHODS AND IMPLEMENTATION STRATEGIES

The methods to restrict the location of development that were discussed previously could be modified to prevent all development. County zoning or NRD land use authorities could be utilized to prevent all development. Legislation could be enacted to prohibit all development on Valentine and Dunday soils. Development also could be prevented by a permit system which would recognize the entire Sandhills area as a critical area.

CHAPTER 4. IMPACTS OF DEVELOPMENT WITH FUTURE STRATEGIES

Irrigation development will produce significant physical, environmental, economic, and social impacts. Any strategies used to control the effects of such development after it has started will change those impacts and possibly add some different ones. Management methods to reduce adverse effects of irrigation development in the Sandhills will change the physical, ecological, economic, and social impacts. The changes by implementation strategies would be primarily economic, social, legal, and institutional.

In this chapter, impacts are identified by type and direction. More definition of the alternatives would be required and much more study would be needed to judge the nature and magnitude of the impacts.

IMPACTS OF MANAGEMENT METHODS

The management methods discussed in chapter 3 can be classified as (1) limitations on the areas that can be developed, (2) use of proper management practices, (3) reductions in water use, (4) reductions in the use of chemicals, and (5) restoration and enhancement of habitat. Methods in each of these classifications have been proposed to reduce effects in one or more of the five areas: land resources, water supply, water quality, economics, and ecology. A particular method will have a characteristic impact that will not change except in degree depending, in part, on which problem area is addressed.

LIMITATIONS ON THE AREAS THAT CAN BE DEVELOPED

In chapter 3 there are proposals to limit development either by excluding development from critical areas or by placing a limit on the concentrations of development. Either proposal would tend to reduce development, erosion, water consumption, and pollution of ground and surface waters. Development may be more spread out through the entire Sandhills region as a result of this type of management. The proposal to exclude development in critical areas might have little effect on the total amount of development, depending on the extent of the critical areas. This approach could have a greater impact on the particular area of concern.

A reduction in total development would mean less conversion of native vegetation to cropland. The potential for wind erosion would be reduced by the reduction of development or the exclusion of development in critical eroding areas. A reduction in the amount of water consumed by irrigation would also result from reduced development. This would tend to reduce water-table declines and therefore reduce the loss of wet meadows and wetlands, lakes, and streamflow. Evapotranspiration losses from these sources would be increased. A reduction in the potential for fertilizers and other agricultural chemicals to enter the groundwater or surface waters follows a reduction in development or the exclusion of development in critical water quality areas.

A number of environmental impacts could be associated with limiting the areas that can be developed. There will be less of a shift from rangeland scenery to that of mixed agriculture. The change from grassland, wet meadow, and wetland habitat to cropland habitat would be reduced. Less habitat will be destroyed by wind deposited sand.

The loss of riparian habitat, fish and aquatic life, waterfowl, other wetland plants and animals, and other instream values will be diminished by the reduction in net water loss. The enrichment of lakes will be slowed by a reduction in available nitrates and phosphates. Air pollution would be reduced because the erosion potential will not be increased as much and the use of machinery would not be as great.

Limitations on the area that can be developed will have a number of economic impacts. It will reduce production in the region and result in some land not being developed to its full economic potential. Limitations will cause the land that can be developed to increase in value even more. The economic activity of the region will be decreased. Over the long term, limiting development will reduce increases in pumping costs and reduce the need to replace shallow wells. Reduced wind erosion will decrease damage to grasslands and reduce the need for replanting. The need for alternative water supplies will also be decreased. The financial burden on county, district, and state institutions will be eased, except for the implementation of this management method.

The social impacts of irrigation development, including additions to the population, changing from ranching to farming as a way of life, and the added income, will be reduced by limitations on irrigation development. Disputes over loss of wet meadows and shallow wells, and over sedimentation and flooding will be decreased. The additional governmental control will be unpopular with many people.

USE OF PROPER MANAGEMENT PRACTICES

The proper management practices include soil conservation practices, restoration techniques, and only acceptable methods (if there are any) of draining wetlands. A primary physical impact of proper management practices is the reduction of wind and water erosion. Water table declines and the loss of wetlands and lakes and the discharge of organics and nutrients to surface water may be reduced by limitations on wetland drainage. Development may be prevented in some areas if wetlands cannot be drained.

Environmental impacts of this method include a reduction in the loss of wetland and wet meadow habitat. The amount of habitat in abandoned areas and in cropped areas would also increase. The enrichment of lakes may be reduced by controlling wetland drainage. Damage to grassland and other habitat caused by blowing sand will be decreased. Air pollution will also be decreased.

The use of proper management practices may increase production and installation costs to the individual. Government expense to share costs with individuals who use these practices may be increased. The reduction of wind erosion may act to reduce production costs by reducing the need for replanting. The cost of restoration will place a burden on the individuals and government; benefits will include the returned productivity of the area and reduced damage to the surrounding area. Proper management practices could reduce disputes resulting from sedimentation and flooding.

REDUCTION IN WATER USE

The physical impacts of reducing the amount of water used include a reduction in water-table declines and corresponding reductions in losses of wetlands, lakes, and streamflow. Wind erosion may be increased to some extent. A crop which requires less water than corn may become the primary crop of the area. The careful application of water may result in less leaching of nitrates and other chemicals to the groundwater.

Habitat preservation, including wetlands, lakes, and riparian lands, and preservation of the associated animal and plant life, is an environmental impact of the reduction of water use. Other instream values will also be preserved. Increased wind erosion may cause some damage to habitat as well as to air quality. Substituting other crops for corn will increase habitat diversity. Groundwater pollution may be decreased by the reduction of contaminated water reaching the water table.

A potential loss of productivity and loss of profits by growing less profitable crops are two economic impacts that may affect an individual who reduces water usage. Costs of productivity may rise due to more intense management but pumping costs may be decreased. Government may be burdened with costs to inform and assist individuals. The productivity of wet meadows may be protected and the need to replace shallow wells may be reduced by reductions in water use. The need for information and assistance to minimize water usage while maximizing returns may create additional jobs. This management strategy could reduce disputes over loss of wet meadows, wetlands, and shallow wells.

REDUCTION IN THE USE OF CHEMICALS

A reduction in the use of fertilizers and pesticides may result in smaller quantities of these chemicals being leached to the groundwater. More weeds, lower yields, or changes in cropping patterns may also result from this strategy. Wind erosion may also be affected by a change in chemical use. It may also result in increased biological activity in the soils and the fields may become a more desirable environment for other animals and birds. The effects of irrigation on the quality of the groundwater may be reduced by proper chemical management.

Productivity may decline with reductions in chemical use, particularly if a change in crop is required. More efficient use of chemicals may result in savings but the types of chemicals that facilitate efficiency may be more expensive than those commonly used. The need for alternative water supplies due to nitrate contamination of the groundwater may be reduced by this strategy. The quality of drinking water supplies may be improved by this strategy.

RESTORATION AND ENHANCEMENT OF HABITAT

This method of management would result in some reduction in the area available for development. Wind erosion would be reduced by trees and a cover crop, but may result in more consumptive water use. This increase in water use could be offset by the reduction in water use due to the reduced concentration in development. The pollution load to the groundwater would be reduced by dilution only to the extent that development was spread out.

Ecological diversity would be maintained by leaving the unwatered areas around the center pivots in native vegetation and would be enhanced by planting trees and cover crops. The monetary return of a development could be decreased by the small reduction in cropped land. The individual must also bear at least a part of the costs of establishing the cover crop and windbreaks. Disputes resulting from sedimentation could be reduced as wind erosion is reduced.

IMPACTS OF IMPLEMENTATION STRATEGIES

The implementation strategies given in chapter 3 are of two types: (1) incentives and disincentives, and (2) regulations. Both types must be individually tailored for each of the five categories of management methods.

Incentives and disincentives can be classified in four categories: grants, such as cost-sharing programs; low-cost loans; taxes; and fees or bonds, especially those associated with permits. Firm regulations without exceptions, and flexible ones allowing individual judgments, are the two types of regulations that have been considered.

IMPACTS OF INCENTIVES AND DISINCENTIVES

Incentives in the form of payments for not developing some areas or for doing something to prevent erosion have been used in a number of programs for many years. Examples are set-aside programs and conservation practice cost-sharing programs. Such payments or grants could be used to implement all five types of management strategies: (1) limitations on areas that can be developed, (2) use of proper management practices, (3) reduction in water use, (4) reduction in the use of chemicals, and (5) restoration and enhancement of valuable ecological areas.

The economic impacts of grant programs are those impacts over and above the economic effect of the management methods. For instance, the economic impact of using proper management practices, including the cost of planting cover crops, among other things, is listed in the preceding sections. A grant program would reduce the cost of the practices to the irrigator and increase the cost to the general public through taxes. The same would be true for the other four types of management methods.

The social impacts of the grant program alone would be relatively small. The program itself would be unpopular with a small segment of the population. Any resulting increase in taxes would undoubtedly be unpopular with the large majority of those required to pay it.

The legal and institutional impacts of a grant program would be limited to the agency required to implement it. That agency would undoubtedly have to hire more staff and it would incur greater costs for overhead, operation, and management.

The impacts of a program providing low-cost loans would be essentially similar to the grant program. The economic impact would not be as great because it would not transfer as much of the cost from the irrigator to the general public. Ultimately, the only reduction in cost to the irrigator would be the reduction in the amount of interest.

Taxes could provide both incentives and disincentives. Reductions in property taxes and deductions from income taxes could provide incentives for implementation of the first, second, and fifth of the five types of management methods: (1) limitations on areas that can be developed, (2) use of proper management practices, and (5) restoration and enhancement of ecological areas. The economic impacts of these incentives would be to increase the profits or decrease the costs incurred by the irrigator. Also, they would either decrease government revenue or increase the taxes on other taxpayers to make up the loss.

Tax increases could be a disincentive to the use of certain classes of land or adverse practices. They could be used to implement all five types of management methods. They could be in the form of property tax, tax on personal property such as irrigation equipment, a tax on the amount of water pumped, or a state capital gains tax on speculative investments.

The economic impact of the disincentive alone is to reduce profits. If the reduction in profits reaches a certain threshold level, it begins to have physical, environmental and other economic impacts by limiting the amount of development or the amount of water use. These impacts are detailed in the section on the impacts of management methods. In addition to the economic impact on the irrigator, a tax increase would either produce more revenue for the government involved or it would reduce taxes for other taxpayers.

The social impact of the tax programs themselves are fairly predictable. The tax increases would be unpopular with those persons required to pay them and the tax reductions would be popular. The legal and institutional impacts would follow from the social impacts. Additional taxes would undoubtedly cause more problems for the agencies required to collect the tax and for the courts. The collection agency would probably require more people to collect the tax and incur greater costs in doing so. Some potential tax systems might also require extensive revision of the tax laws by the legislature.

The other type of disincentives includes fees or bonds for development. These fees would probably have to be linked with a system of permits. They will be discussed in the following section.

IMPACTS OF REGULATIONS

Firm regulations would be fairly simple, and the impacts of the program itself would not be extensive. They could be used to implement all five types of management methods. The main economic impact, of course, would be the impacts listed in the section on management methods. The economic impact of the regulation would be the cost of enforcing the law. The social impact would be its unpopularity. This could lead to legal and institutional impacts involving more violations of the law, which would require a larger staff in some enforcement agency.

Flexible regulations would be more complex, but they would allow the regulation to fit the local conditions better. In this case, state law would prohibit some activity without a permit that would be granted only if the conditions of the law were met. This type of implementation strategy would work for all five management methods.

The economic impact of the regulation alone would be slightly greater. There would be costs to the developer for the preparation of an application and possibly the preparation of a conservation plan. There would be additional cost to the implementing agency for investigating the property in the application and administering the program.

There could be additional economic impacts if this type of regulation were combined with a system of disincentives such as fees or bonds that were required to get the permit. If the fee was intended to defray the cost of administration or reimburse adjacent land owners for drilling new domestic or stock wells, the fee could be a significant disincentive. If the bond was required to provide assurance that the land would be restored to grass if irrigation was discontinued, the cost of the bond would reduce the irrigator's profits. The bond, or the sinking fund created by fees, would reduce the administrative costs if the permitting agency were required to take action, such as restoring abandoned land.

Regulations of this type would be unpopular, especially if combined with substantial fees or bonds. Administration of a permit system or extensive zoning laws would require an increase in the staff of the administering agency, and it would result in increased costs for overhead, operation, and enforcement. It would probably also result in an increased case load in the court system.

IMPACTS OF THE PROHIBITION OF ADDITIONAL DEVELOPMENT

A strategy for prohibiting additional irrigation development was described in chapter 3. Significant physical, environmental, economic, social, legal and institutional impacts would result if no additional development was allowed after a certain date. The impacts would be felt locally, regionally, and statewide.

The prohibition of additional development would mean that no additional grassland and wet meadows would be converted to cropland. Wind erosion would remain at roughly the same level as at the date of prohibition. With less development, the potential for reducing the organic matter in the topsoil will be decreased. As there would be no additional demand for groundwater, the concern for declining water tables would be lessened; some declines could occur in areas now intensely developed. Loss of wetlands, wet meadows, lakes, and streamflow could occur only near areas now intensely irrigated. Leaching of chemicals to the groundwater would also be limited to existing developments.

This strategy would prevent destruction of native vegetation. As potential groundwater declines would be limited to existing developments, the loss of wetlands and riparian lands and associated animal and plant life would not occur in other areas. The potential for enrichment of lakes and the contamination of groundwater would occur only near developed areas. Drinking water supplies would be protected from nitrate contamination in areas not developed.

The economic impact of this strategy would be the loss of the opportunity for production and profit. Trade, construction, and related activities would not increase as they would if development was allowed to continue. The land now developed would become more expensive and cases of abandonment might be reduced. This land may be farmed more intensely and productivity may be decreased. Land that cannot be developed will be relatively less valuable. Pumping costs would not increase as much as if development would continue, wet meadow production would be protected, and the loss of shallow wells would be reduced. Alternative drinking water supplies might be needed in the future only near areas now developed. The reduced economic activity resulting from this strategy will result in less impact on roads, schools, and other local institutions.

The social impact of prohibiting new development would be to reduce the change in the way of life in the area. The rate of increase in population might be reduced. There would be fewer disputes over the loss of wet meadows and shallow wells and over sedimentation and flooding. Another social impact may be the increase in resentment of government dictating what can and cannot be done by the individual on their own land.

Legislation would need to be enacted for this strategy to be applied. This action would obviously be controversial.

APPENDIX 1

SANDHILLS PUBLIC ATTITUDINAL RESEARCH PROJECT

The Nebraska Natural Resources Commission with the aid of the Nebraska Association of Resources Districts commissioned Selection Research, Inc. to conduct a public attitudinal research project in the Nebraska Sandhills. The purpose of this research project was to evaluate the attitudes and opinions of the resiidents within the Sandhills regarding development and regulation of the natural resources of the region. SRI conducted the interviews during the month of November 1980 by contacting seven hundred Sandhills residents via telephone interviews.

The results of the survey proved interesting and provide additional information for the decision-makers of this state in their attempt to formulate beneficial public policy related to this state's natural resources. In the following paragraphs, a brief summary of the more salient points will be discussed.

While 79% of those surveyed believe that large-scale irrigation in the Sandhills should be stopped or regulated, there was a significant level of undecided responses when asked to discuss the types of controls needed. Obviously, it is important that further information be gathered regarding the types of regulation. However, it is also important not to lose sight of the large majority voice which held the opinion that large-scale irrigation should be stopped or regulated.

A majority of the respondents (58%) were concerned about the potential of lowering the water table within the Sandhills region. Other concerns include the potential increase of soil erosion. Also of interest was the fact that 68% believe that some time in the future, it will become necessary to regulate the water and the accompanying land resources within the Sandhills. Of those who said that regulation would become necessary at some point in the future, 26% favored regulating the number of wells and 17% believed that limiting the amount used for irrigation would be important.

Approximately 45% of those polled believe that if regulation should occur, the authority to implement regulatory methods should be left in the hands of the local government. Counties were specified by 13% of those polled and 18% suggested that the local NRD's should have the power to regulate.

A large majority (73%) said that they felt large-scale irrigation development is threatening the Sandhills' natural resources. Of those who said large-scale irrigation was threatening, 32% believe that it will cause a potential situation in the Sandhills where the likelihood of running of water will occur. Another 23% see the effect of large-scale irrigation as an increase in blowout or erosion problems. On the other hand, 14% of those polled believe that large-scale irrigation was improving the Sandhills. Of those who believe it was improving the Sandhillls, 83% said that the improvement was in the production of the land.

A majority of those polled believe that the following areas have been severely or somewhat damaged as a result of development: surface water, surface water supply, groundwater quality, groundwater table, topsoil, grasslands, and trees. The groundwater table was the number one response when the respondents were asked which natural resource had suffered the most in the Sandhillls.

Finally, the demographic categories had little impact upon the responses of those interviewed. Basically, it did not matter whether you were young or old, a male or female, lived on a ranch or farm or in the town. There was a great deal of homogeneity within the opinions of the residents in the Sandhills. The demographic breakdowns had little effect upon the consensus opinion of those who lived in the Nebraska Sandhills.

It is important that information of the technical nature, which is provided by this Decision Document, be coupled with the public attitudes and opinions which are represented by a survey of this nature. By doing this, those who make the decisions regarding the natural resources of this state will have at their command pertinent information which will enable them to adequately implement significant public policy which is appropriate for the development, use and conservation of Nebraska's natural resources.

SANDHILLS PUBLIC ATTITUDINAL RESEARCH PROJECT

Sex: Male - 51% Female - 49%

Age: 18-24 -- 9% 25-34 -- 22% 35-44 -- 18% 45-54 -- 17% 55-64 -- 15% 65/Over --19%

Living in Town - 19% Living on a Ranch or Farm - 81%

Center Pivot owner? No - 77% Under 9 Center Pivots - 22% 10/Over Center Pivots - 1%

If not center pivot owner: Do you live within 25 miles of a large scale irrigation development? Yes - 80% No - 17% DK - 3%

Do you own or operate a ranch or farmland? Owner/Operator - 73% Nonowner/Operator - 27%

Length of residency: Less than 10 years - 20% 11-20 -- 17% 21-30 -- 17% 31-40 -- 17% 41-50 -- 11% 51-60 -- 8% 61/more -- 10%

Are you concerned about the natural resources of the Nebraska Sandhills? Yes - 89% No - 11%

If yes, what is your main concern? Low water table - 58% Soil erosion - 24% Keep land the way it is - 17%

Do you agree or disagree that it may become necessary to regulate the usage of the Sandhills water and land resources? Agree - 68% Disagree - 21% DK - 11%

What sort of regulation would you favor for water resources? Not sure - 35% Regulate # of wells - 26% Limit amount for irrigation - 17%

What sort of regulation would you favor for land resources? Not sure - 51% Regulate land usage - 20%

Who do you think should be responsible for enforcing any regulation of the land and water resources? Local Govt. (NRD) - 18% Local Govt. (County) - 17% State Govt. (NRC) - 4%

State Govt. (DWR) - 1% State Govt. (DEC) - 1% Fed. Govt. (EPA) - 0% Fed. Govt. (SCS) - 1% Fed. Govt. (ASCS) - 1%

Local Govt. (no specified agency) - 10% State Govt. (no specified agency) - 12% Fed. Govt. (no specified agency) - 1%

Other - 3% DK - 17% Local Landowner - 13%

What comes to mind when you think of large scale irrigation development in the Sandhills? Disapprove/Don't like - 15% Run out of water - 13% Too many pivots - 12% Outsiders/Big Companies - 12% Keep land in grass - 9% Blow Outs - 8% Other - 16%

Where have you gotten most of your information about the positive or negative effects of large scale irrigation development in the Sandhills? Word-of-mouth - 18% Implement/Center Pivot dealers - 0% Omaha World Herald - 5% Local Papers - 11% Radio - 0% T.V. - 1% Personal observation - 53% Farm Journals or Magazines - 6% DK - 2%

Do you think large scale irrigation development is threatening or is improving the future of the Sandhills natural resources? Threatening - 73% Improving - 14% DK - 13%

Threatening - In what way? Run out of water - 32% Blow outs/erosion - 23% Land not for irrigation - 17% Waste & Neglect - 11% Country life style - 7%

Improving - In what way? Productive use of land - 83% DK - 3% Other 14%

Should large scale irrigation development in the Sandhills be stopped - 21% Regulated - 58% Allowed to continue - 11% Encouraged - 2% DK - 8%

Will the general economy of the Sandhills area be improved, not improved, or not changed as the result of large scale irrigation development? Improved - 29% Not changed - 14% Not improved - 43% DK - 14%

If improved - Why? More money flow - 27% Raise more crops - 26% Temporary/ Increase - 18% More jobs - 15%

If not improved - Why not? For Hay & Pasture - 20% Not economically feasible - 18% Outside interest - 14% Land deterioration - 13% Run out of water - 11% Blow outs - 11%

If large scale irrigation development continues, what steps should be taken to lessen any negative impact on the natural resources of the Sandhills as they are today? Limit use of water - 21% Regulate/Control - 20% DK - 35%

Has your property been affected by the recent large scale irrigation development in your area? Yes - 25% No - 72% DK - 3%

If yes, how? Low water tables - 47% Land value increase - 14% Other - 13%

Do you believe the following resources or conditions are being severely damaged (SD), somewhat damaged (SoD), Not at all damaged (ND), DK, Could Be damaged in the future but isn't now (CB)?

Surface water supply -	SD - 23%	SoD - 45%	ND - 20%	DK - 8%	CB - 5%
Ground water quality -	SD - 16%	SoD - 37%	ND - 31%	DK - 11%	CB - 4%
Wildlife habitat -	SD - 14%	SoD - 31%	ND - 39%	DK - 10%	CB - 6%
Ground water table -	SD - 27%	SoD - 43%	ND - 16%	DK - 10%	CB - 4%
Top soil -	SD - 30%	SoD - 33%	ND - 24%	DK - 8%	CB - 5%
Surface water quality-	SD - 13%	SoD - 36%	ND - 32%	DK - 14%	CB - 5%
Grassland -	SD - 29%	SoD - 32%	ND - 25%	DK - 6%	CB - 9%
Trees -	SD - 30%	SoD - 25%	ND - 30%	DK - 6%	CB - 9%

Which of the above conditions have suffered the most? Surface Water Supply - 10% Ground Water Quality - 10% Wildlife Habitat - 3% Ground Water Table - 25% Top Soil - 14% Surface Water Quality - 2% Grassland - 16% Trees - 8% DK - 12% Other - 2%

Has the ground water on your property been affected by large scale irrigation development? Yes - 26% No - 70% DK - 4%

If yes, how? Low water table - 81% Ground water pollution - 7% Declining surface water - 5% DK - 3%

When considering large scale irrigation development, do you strongly agree (SA), somewhat agree (SoA), don't agree (DA) or DK that the following practices would be helpful to conserve the Sandhills natural resources as they are today?

Irrigation scheduling -	SA - 26%	SoA - 44%	DA - 19%	DK - 11%
Minimum tillage -	SA - 32%	SoA - 43%	DA - 12%	DK - 12%
Planting winter cover crops	SA - 47%	SoA - 31%	DA - 12%	DK - 10%
Tree planting	SA - 52%	SoA - 31%	DA - 9%	DK - 8%
Timely fertilizer applications	SA - 33%	SoA - 37%	DA - 14%	DK - 16%

Appendix II

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