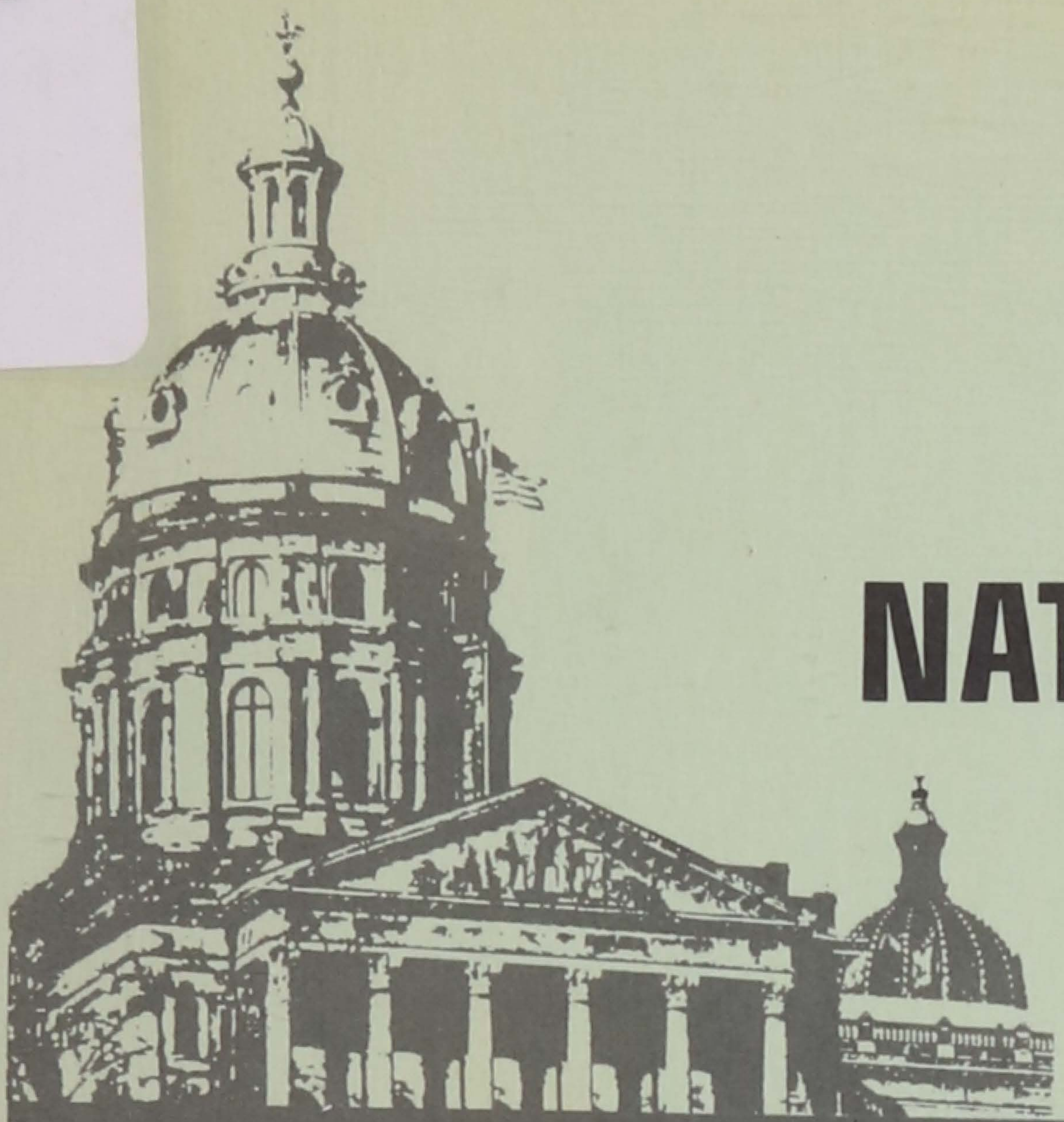

NATURAL RESOURCES In Iowa's Future

A Reference Paper

• • • Planning Committee for

Governor's Conference on Iowa in the Year 2000

October 1973

NATURAL RESOURCES

In Iowa's Future

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IOWA'S NATURAL RESOURCES

A discussion of the utilization of natural resources in Iowa was chosen as one of the four background papers to the Governor's Conference on Iowa in the Year 2000 because of its fundamental relationship to the other topics selected: energy, the economy, and life enhancement. This could be termed a "background paper to the background papers" because the natural resources of Iowa are so intimately related to the other topics--affecting energy in terms of the availability of mineral fuels and water for cooling, affecting the economy because of Iowa's great dependence on agriculture and therefore on the land-air-water system that supports it, and influencing progress towards the objectives that Iowans have for this and future generations in terms of life enhancement, for only in a healthy, productive and non-stressful environment can full attention be paid to these goals.

Policies concerning the human environment require judgments based on specialized scientific knowledge, but which must be made by all interested citizens in cooperation with their leaders. Such citizens must determine the options that their children will have and the social and civil order that they want to result from the interaction between the diversity of natural phenomena and the human will.

The importance of natural resources to Iowans in the year 2000 is evident, for the relationship between the elements of the environment are not static, but shifting through time. Even careful use has some impact on the resource base so that any projection for any aspect of life in Iowa in the year 2000 must take into account changes in the composition of the natural environment. Thus, resource management is susceptible to a futuristic interpretation, and benefits from long-term planning, investment and decision making.

Natural resources are generally considered to be those attributes of the environment that can be used by man to further his social and economic well-being, or which are considered essential to his existence. Such a resource has meaning only insofar as man uses it and recognizes its intrinsic value to him, even if its most effective use involves letting it alone. It should not be assumed that natural resources are endless and self-perpetuating. Like all "wealth" they must be managed carefully in order to realize a return to man and not deteriorate in value.

In Iowa four groups of resources can be recognized: land, water, air, and plant and animal life. Each can be considered in terms of its incidence of occurrence in Iowa, its present level of utilization, and the alternatives available for future use, but at all times it must be remembered that none is independent of the others.

LAND RESOURCES

> "The pressure of an increasing population on our fixed base of soil and water resources imposes added responsibility on every citizen to make the wisest and best use of these resources. The protection, use, maintenance and improvement of the land and water resources of Iowa is of the highest priority in the interest of providing adequate food, forest products, recreation and wildlife resources now and in the future."
>
> (Iowa Conservation Needs Committee, 1970)

Land is Iowa's most precious natural resource. The bulk of Iowa's 35.8 million acres is both accessible and extremely productive, but as the Iowa Conservation Needs Committee suggested in 1970, the use of such a resource will require careful planning if it is to be conserved for the future. Within the state certain land-use patterns have developed which compete for this vital resource. These include agricultural, urban, recreational and forestry as well as mining uses, each of which uses the land in different ways. The purpose of the following section is to examine the nature of land as a natural resource and its use by various public and private activities, and to examine the problems that have arisen from its use and the alternatives that exist in the future, specifically by the year 2000.

Agricultural Land

Since more than 85 percent of Iowa's land is farmed (table 1), agriculture is obviously important to the state's economy. Land is Iowa's most prominent natural resource. Iowa contains approximately one-fourth of the nation's prime agricultural land. Farming type and success can be related primarily to the basic quality of the land--soil type and parent materials, soil moisture content, inclination and aspect, climate, accessible terrain, etc. The richness and generally high productivity of Iowa's soils are a result of the interrelationships between these characteristics which produce a particular set of soil properties.

Table 1. Acreages and Percentage of Iowa's Total Land Area Devoted to Different Land Uses, 1967.

Land use	Acreage (000)	Percent total area
Cropland	26,458.3	73.82
Pasture land	3,996.9	11.17
Forest land	2,585.6	7.21
Urban land	1,564.0	4.36
Other	1,028.7	2.87
Federal land	159.4	0.44
Water	45.9	0.13
	35,838.9	100.00

Source: Iowa Conservation Needs Inventory, 1970

As a result of its midcontinental location, Iowa is characterized by a fairly uniform subhumid climate. Usually there is adequate soil moisture during the growing season, since the highest levels of precipitation normally fall during that time. Precipitation ranges from a low of 27 inches of rainfall in northwest Iowa to over 34 inches in the southeastern part of the state.

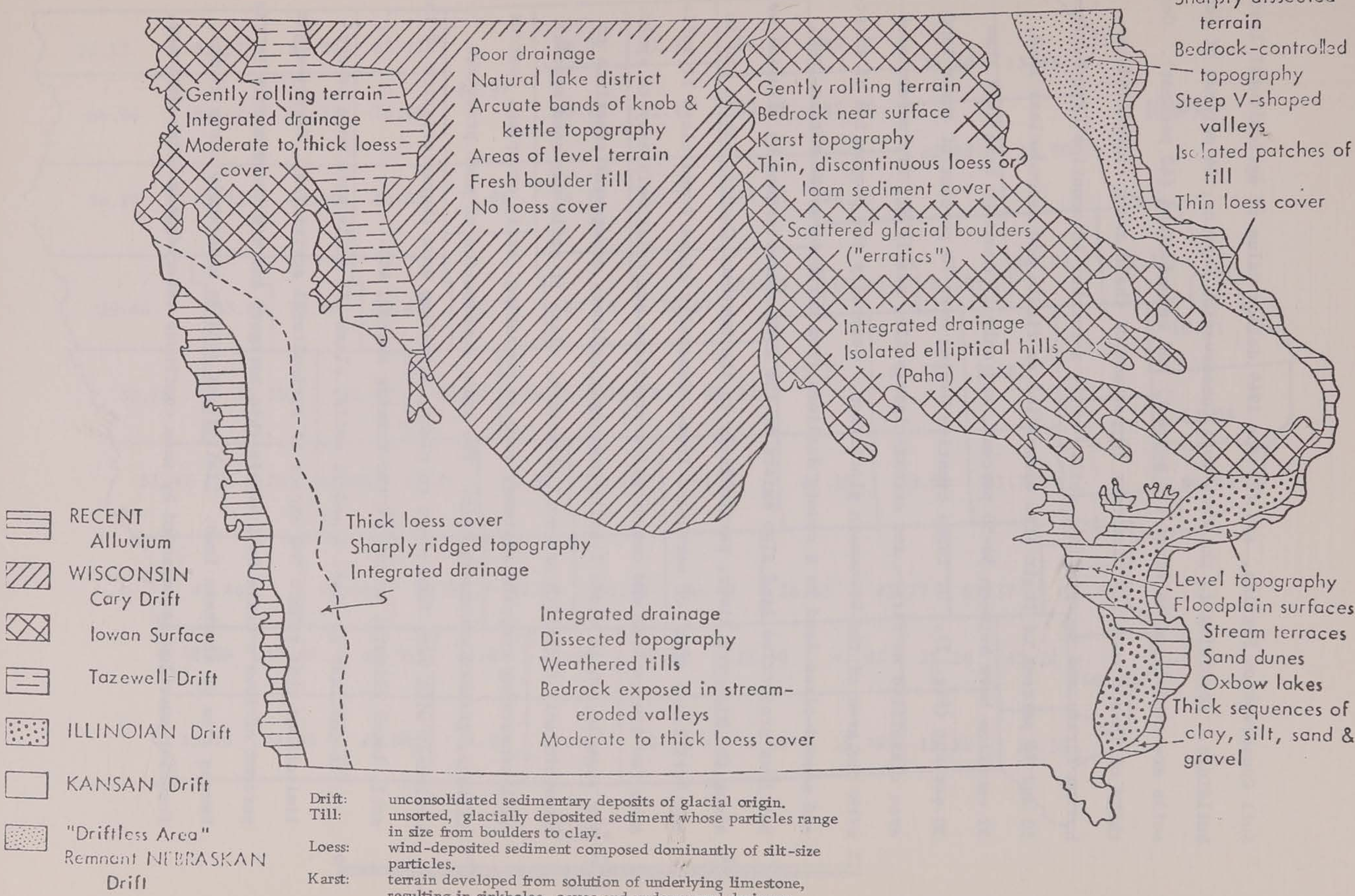
Much of Iowa's terrain has been directly influenced by past glaciations as have the state's rich soil resources, which in part owe their productivity to the glacial till, loess and alluvium deposited during the ice age eras. For example, much of the land is nearly level in the highly fertile Wisconsin till areas of north central Iowa, while the most rugged terrain occurs in northeastern Iowa where almost no glacial till is present. (Figure 1).

As a result of four main glacial advances during the Pleistocene (the earliest being the Nebraskan, followed by the Kansan, Illinoian, and Wisconsin-Iowan glacial eras), the parent materials of Iowa's soils are primarily glacial drift, loess and alluvium, the depositional products of glacial ice, wind and water. Approximately 95 percent of Iowa's soils were formed from one of these three materials, the remainder originating from parent materials deposited by gravity (colluvium), residues from the weathering of sedimentary rocks (residium) and organic deposits such as peat, occurring in wet, poorly drained areas. For example, loess, a silty wind-deposited material, covers much of Iowa and in the western part of the state often exceeds a thickness of 100 feet.

Although each of the principal soil groups in Iowa includes some of the most and least productive soils, generally the loam-till and clay loam-till soils that exist in the area of the Wisconsin glaciation are by far the most productive. This productivity can be illustrated by two measures: (1) the percentage of first- and second-class land in a county as defined by the Iowa

Figure 1. Iowa Geological Survey

QUATERNARY TERRAIN AND MATERIALS MAP



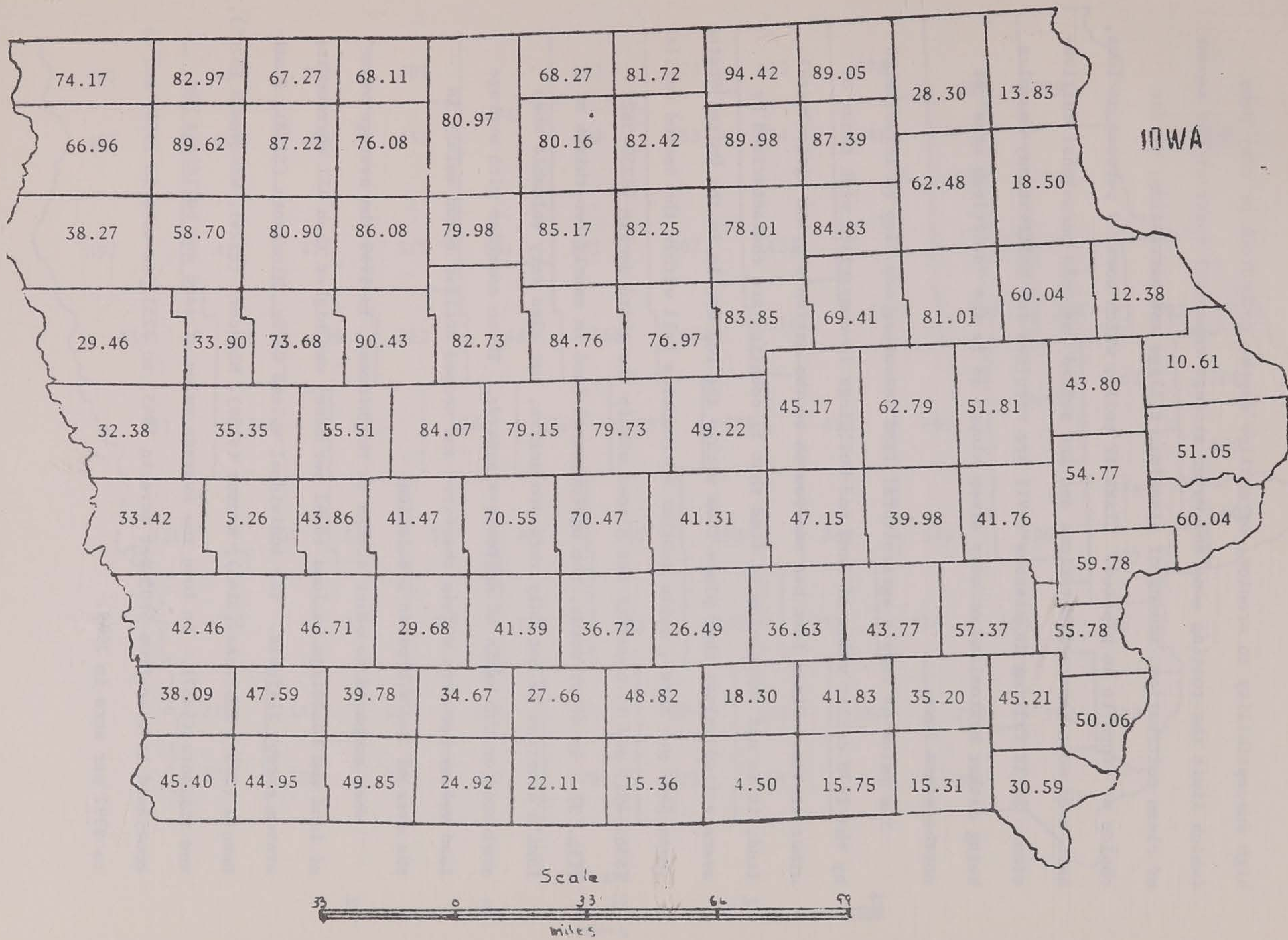
Drift: unconsolidated sedimentary deposits of glacial origin.
Till: unsorted, glacially deposited sediment whose particles range in size from boulders to clay.
Loess: wind-deposited sediment composed dominantly of silt-size particles.
Karst: terrain developed from solution of underlying limestone, resulting in sinkholes, caves and underground drainage.

Soil Conservation Service, and (2) the 1969 dollar value of agricultural land and buildings. According to the Iowa Soil Conservation Service, 54 percent of Iowa's soils are classified as first (12 percent) and second class (42 percent). One-third of Iowa's counties have over 70 percent of their areas classified as having first- and second-class soils, while a further 18 counties have between 50 and 70 percent of their area classified as first- and second-class land, 32 counties have between 30-50 percent, and only 17 counties have less than 30 percent (fig. 2). Of those counties having over 70 percent of their land area classified as first- and second-class soils, nearly all are coterminous with the area of the Wisconsin glaciation. Generally the proportion of first- and second-class land in a county declines from north to south across Iowa, but less productive land also exists in the area characterized by alluvial soils along the Missouri River, particularly to the north of Council Bluffs and in the "driftless area" of northeast Iowa. Generally class I and class II soils have few limitations and conservation practices are relatively easy to apply. For example, while class I soils need only ordinary management practices to maintain soil fertility and soil structure, class II soils may need special soil conserving cropping systems, such as terracing, strip cropping, contour tillage, grassed waterways, etc. The exact combination of such practices obviously will vary from place to place, depending upon characteristics of the soil, local climate, nature of the farming system, etc.

In contrast to class I and II soils, class III soils have more severe limitations that reduce the choice of agricultural activities. Twenty-eight percent of Iowa's soils fall within this category and are found mainly in the Kansan area of southern Iowa. Limitations such as moderately steep slopes, frequent overflow accompanied by some continued waterlogging after drainage,

Figure 2. Percentage of First- and Second-Class Land, By County, 1970

Figure 2. Percentage of First- and Second-Class Land, By County, 1970

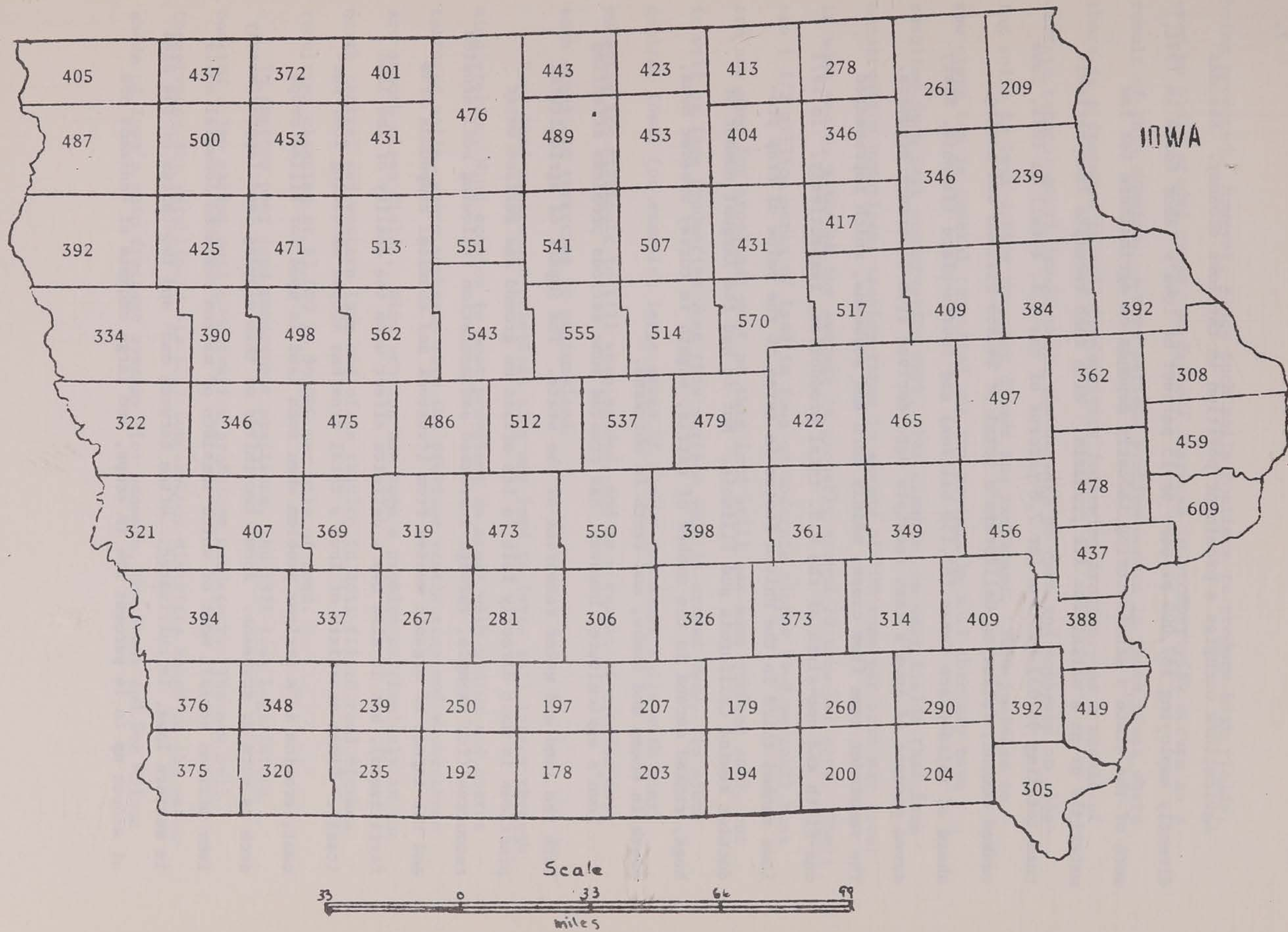


high susceptibility to erosion, or shallow depths to bedrock or clay pans (which limit the rooting zone and water storage capacity) restrict the amount of clean cultivation, timing of planting, tillage and harvesting, or the choice of crops to be planted. Class IV soils, which cover 7 percent of Iowa, have even more severe limitations and are suited for only occasional cultivation. Soils falling in classes V-VII are unsuited for cultivation, examples being either bottomland or very steep slopes as in the "driftless area" of northeastern Iowa.

The value of Iowa's agricultural land resources can also be illustrated by the 1970 dollar value of land and buildings in comparison with those of other states. Since Iowa has one-fourth of the nation's prime agricultural land, it is not surprising to find that 17 counties are characterized by average land values that place them within the top decile in the United States (over $491 per acre), while another 45 counties fall within the second decile ($362-491) and 17 counties are placed within the third decile ($259-362) (fig. 3). In other words, the agricultural land in nearly two-thirds of Iowa's counties is not only very productive, but also very valuable when evaluated on the basis of national standards. Those counties with average land values per acre within the first and second deciles occur mainly in the area of the Wisconsin glaciation.

When compared to other states in the Midwest, in 1969 the average value of land and buildings in Iowa ($392 per acre) was higher than all surrounding states except Illinois. The individual values were: Minnesota ($218), South Dakota ($78), Nebraska ($145), Kansas ($159), Missouri ($224), Wisconsin ($209), and Illinois ($487). In Iowa the average value of land and buildings has continued to rise from $105 per acre in 1945, to $253 per acre in 1959, and up to $392 per acre in 1969.

Figure 3. Average Dollar Value of Agricultural Land and Buildings, All Farms, By County, 1969



Agriculture occupies a prominent position in the Iowa economy. Besides directly employing 187,000 persons or 15 percent of Iowa's labor force in 1971, much of the state's manufacturing industry depends on agriculture for raw materials or as a market for its products. With cash receipts from agriculture totaling $4.037 billion (or 7.8 percent of the U.S. total) in 1971, Iowa ranked second, following California's total of $4.853 billion and coming ahead of third-place Texas ($3.153 billion) and fourth-place Illinois. Sixty-seven percent of Iowa's cash receipts were derived from livestock products. The remainder came from crops, mainly corn and soybeans, which represented one-fifth and one-sixth of the U.S. total production, respectively. In 1971 Iowa ranked third in the United States in terms of the value of crop production behind California and Illinois. But it had the largest number of hogs, ranked second in the number of cattle, eighth in turkey breeder hens, ninth in sheep and lambs, and tenth in chickens.

Iowa's agriculture, however, has created some serious problems affecting both the land and water resources of the state. The impact of agricultural practices is most directly felt in its effect on ground and surface water resources (for example, through increased sedimentation following soil erosion and the impact of organic wastes from livestock and chemical compounds from fertilizers), but it also has a definite effect upon the quality of the land itself. Since one-sixth of Iowa's total area has slopes exceeding four percent, erosion is a serious problem when such land is used for tilled crops such as corn or soybeans. About two-thirds of this sloping land (approximately four million acres), most of which consists of medium textured loessial soils in western Iowa, is cultivated. Often between one- and two-thirds of the area of slopes up to 14 percent are in crops, and large amounts of sediment are being produced. However, since such soils continue to produce high yields, even on badly eroded areas, no serious decrease in productivity occurs as a result of this erosion. A more serious problem occurs in those areas where there is a decrease in soil productivity following erosion. As a result of certain technological developments the acreage of corn and soybeans on sloping soils in Iowa during the past decade has increased. This increase in row crops has in general cancelled out the savings in soil that may have resulted from past conservation work. For example, on many fields that lack conservation practices, erosion rates in excess of 100 tons per acre may occur in some years, although the average is probably around 20 tons per acre. There are 1 1/2 million acres of land in Iowa on moderate slopes (4-8 percent) that are now used for cropland; most of this land still has some surface soil, but it will be less productive when this surface soil is eroded away. In south central Iowa, for example, large areas of Shelby and Adair soils with clay subsoils are difficult to till when eroded, and as a result of erosion many such areas are reverting to pastureland.

Poor land management practices also may lead to large soil losses through wind erosion. Wind erosion is most prevalent in areas with medium and coarse textured soils, where soybeans were the previous year's crop and where there are smooth clean fields. Wind erosion has been a problem particularly in the north central and western Iowa and often results in soil-filled road ditches requiring cleaning at $3,000 to $6,000 per mile of road.

To improve poor land management practices, the 1971 Iowa Legislature enacted a law making soil conservation practices mandatory. The new Soil Conservancy Act established six soil conservancy districts based on the watersheds of Iowa's main drainage systems (for example, the Skunk and Des Moines

Conservancy Districts). Implementation of this act is the responsibility of the Iowa Department of Soil Conservation and the local soil conservation districts. The latter have the power to enforce the employment of soil conservation practices when damages occur because of excessive erosion in either urban or rural areas. These agencies are presently establishing maximum soil loss limits for all soils in the state, the "permissible" erosion limits being determined by local conditions.

Despite the changes brought about by the passage of the Soil Conservancy Act, three main problems relating to land management practices still face Iowans. First, mandatory wind erosion controls were deleted from the act, in part a response to the difficulty of controlling this form of erosion, even though such erosion causes problems beyond a farm's boundaries. Secondly, damage must occur before a complaint can be filed with a local soil conservation officer, and thirdly, the bill does not provide for control of erosion based on its effects on the land actually being eroded. In other words, control can come only after the demonstration of adverse effects external to a farmer's property.

To aid in the conservation of Iowa's agricultural land, an inventory was compiled in 1970 by the Iowa Conservation Needs Inventory Committee for the Soil Conservation Service. According to the survey, however, it was determined that on only 34 percent of Iowa's cropland were conservation practices adequate compared to 32 percent of the pasture land and 36 percent of the state's forest area. Since Iowa needs to make efficient use as well as to care wisely for its land to assure its continuing productivity, the inventory will serve as a useful tool in further developing land use policy.

Urban Land

Serving the agricultural regions of Iowa and processing their products are a large number of urban areas, smaller cities and townships, the largest of which is the Standard Metropolitan Statistical Area (SMSA) of Des Moines with a 1970 census population of 286,101. Iowa contains 111 cities and towns with population exceeding 2,500 persons and 16 urban areas with populations exceeding 20,000. Land devoted to urban uses comprised 4.36 percent of the state's total land area in 1967 or approximately 1 1/2 million acres out of Iowa's total area of 35.8 million acres. The 16 urban areas with populations exceeding 20,000 are responsible for over 90 percent of the state's industrial production, which amounted to $3.25 billion dollars in 1967.

In contrast to land used for farming, the proportion devoted to urban functions has expanded fairly rapidly in certain parts of Iowa recently. Between 1958 and 1967 average annual growth rates in the proportion of built-up land ranged from a high of 18.07 percent in Johnson County to an actual decline in the proportion of such land in Benton County. The statewide average growth for this period was 9.54 percent or 0.95 percent per year. Since two-thirds of Iowa's counties do not have zoning ordinances, much urban growth remains uncontrolled. Even in the major urban areas where zoning practices have been developed, they have failed to curb urban sprawl, since much of this growth is now occurring outside the political limits of central cities or suburban municipalities in unincorporated areas in the counties. During the 64th General Assembly (1972) when the Iowa Legislature Land Use Policies Study Committee held hearings around the state, few recommendations related to the regulation of urban sprawl. Iowa's population has continually become more urbanized over the past few decades, from 25.6 percent urban in 1920 to 57.2 percent urban in 1970.

Most of the rapid growth in urban and other built-up land (expressways or flood control projects) has not necessarily taken place around the largest urban areas, but in many counties has occurred in medium-sized cities short distances from the major metropolitan areas or along major highways. Of the top 14 counties displaying annual rates of growth of built-up land exceeding 2 percent between 1958 and 1967, only six (Scott (5.44), Johnson (18.07), Muscatine (3.54), Clinton (3.53), Dubuque (3.88), and Polk (2.74)) contained cities of substantial size. Of the other eight counties with high rates of land conversion to nonagricultural purposes, five were contiguous to Polk County and/or major throughways such as Interstate 80 (Dallas, Boone, Jasper, Iowa, and Cass counties). Of the 16 counties having moderate annual increases in their proportion of built-up land (1-2 percent) most of the growth occurred in counties containing medium-sized cities or larger urban areas and/or along routes connecting medium or large cities.

In Iowa the total amount of agricultural land transferred to nonagricultural (mainly urban and transportation) uses between 1958 and 1967 was 136,299 acres or approximately 13,630 acres annually (rising from 1,427,553 acres in 1958 to 1,563,852 acres in 1967). This acreage may not seem large when compared to the amount of land removed from agriculture annually (1.6-2 million acres) in the United States as a whole, but it becomes more significant in terms of the quality of the land consumed. Of the 30 counties in which average annual increases in land conversion from agriculture to urban and other uses exceeded the state mean (0.954 percent), 22 counties had over 40 percent of their area comprised of first- and second-class land and of these, 14 counties had acreages of first- and second-class soils comprising over 50 percent of their area. For example, over two-thirds (or 70.47 percent) of

Polk County in which 13,458 acres were removed from agricultural production between 1958 and 1967 (representing approximately 1,345 acres or 0.35 percent of the area of Polk County annually) is characterized by first- and second-class soils. If this constant rate of growth should continue to the year 2000, a further 10 percent, or over one-fourth of the total area of Polk County (26.5 percent) will be urbanized.

The actual dollar value of Iowa agricultural land and buildings may also be compared with the over-all distribution of high valued agricultural land in the United States. Of the 30 Iowa counties displaying the highest rates of land conversion from rural to urban and other uses, 10 in 1970 had agricultural land values which placed them in the first decile in terms of value in the United States (for example, Scott, Linn and Polk counties), while another 14 counties were in the second ($362-$491 per acre) and third ($259-$362 per acre) deciles.

Forest and Recreational Land Resources

Parks and other recreational resources administered by public agencies (federal, state and county) in Iowa comprised 393,811 acres in 1970 or 1.09 percent of the total area of the state. In addition more than 2.5 million acres of Iowa is forested (7.21 percent of the state's area), but of this total only 2 percent is administered by public agencies compared to a national average of 30 percent. Of the remainder, 88 percent of the state total is privately owned and 10 percent is utilized by nonfarm and industrial interests.

Recreational and Forest Resources Administered by Public Agencies

Five basic functions are served by land administered by public agencies. These are: (1) the provision of recreational areas, considered by many to be the prime function of public agencies administering nonagricultural and nonurban land; (2) the protection of natural resources, for example, the preservation of wildlife habitats or watershed erosion control through afforestation projects; (3) the preservation of distinctive landscape features of historic, botanic or geologic nature; (4) promoting economic development such as tourism; and (5) the enhancement of the aesthetic quality of the environment.

Although little opportunity exists in Iowa for the development of a national park because of the lack of suitable features, the federal government still administers 13 areas in the state totaling 221,673 acres or 0.61 percent of Iowa's total land area. Iowa has the smallest amount of federal as well as state-owned land in the United States. In Iowa the National Park Service has jurisdiction over Effigy Mounds National Monument in Allamakee County and the Herbert Hoover National Historic Site in Cedar County. In addition, the Bureau of Sport Fisheries and Wildlife maintains two federal fish hatcheries with limited recreational facilities in Clayton and Delaware counties and also four wildlife refuges, the De Soto Bend (in Harrison and Pottawattamie counties), Mark Twain (Louisa County), Upper Mississippi (Allamakee, Clayton, Dubuque, Jackson, Clinton and Scott counties) and the Union Slough refuge in Kossuth County. Finally, the federal government, through the Corps of Engineers, manages four multi-purpose reservoirs (Coralville, Rathbun, Red Rock and Saylorville) with extensive recreational facilities, while a further project is planned on the Skunk River near Ames.

Managing a much smaller area than the federal government, the State Conservation Commission maintains 318 areas in the state totaling 152,902 acres, together with 1,640 miles of meandered streams including 153 miles of spring-fed trout streams in northeast Iowa. Of this total acreage, 67 state parks make up 19.4 percent of the area administered by the Commission. Initially such parks were acquired to preserve areas of natural and scenic beauty (for example, Backbone, Maquoketa Caves and Palisades-Kepler state parks). Beginning in the 1930's most were developed around artificial lakes, particularly in the southern one-third of the state, to provide general recreational and water control areas. The State Conservation Commission also administers 15 state preserves totaling 478 acres. These are protected areas containing features of high historical, archeological (for example, Fish Farm Mounds in Allamakee County), botanical and geological interest. Many areas of geological interest remain and these could be included in the system of preserves--notably the loess bluffs of Monona County, areas of glacial moraines in northern Iowa, or fossiliferous formations such as the Pennsylvanian age plant remains in the coal beds near Pella. If such areas are to be protected a program of land acquisition is needed. In addition to Iowa's state parks and preserves, the Conservation Commission also administers seven forests with a combined area of 20,332 acres, the largest of which is Yellow River Forest in Allamakee County. Although acquired primarily not for recreation but for demonstrating good woodland management practices and the production of forest products, such forests provide considerable areas for camping, hunting and fishing. Finally, 210 state fish and game areas (totaling over 77,000 acres) are also managed by the Conservation Commission. Their main functions are to provide access to lakes and streams in the state as well as to serve as wildlife habitats.

The continuing urbanization of Iowa's population together with rising per capita incomes and increased amounts of leisure time have resulted in a rapidly rising demand for outdoor recreational facilities. For example, between 1946 and 1966 state park attendance rose from about 2.3 million persons to over 9.9 million, an annual average increase of 381,289 persons per year or a rate of 16.52 percent. On the basis of this 20-year trend, state park attendance could double by 1985. Out-of-state visitors have increasingly contributed to this large increase. In 1970 such visitors contributed $304 million to Iowa's economy or 57.5 percent of the total traveler expenditures of $529 million. The 14 million out-of-state visitors also created 22,000 jobs for Iowans or one-fourth of the total employment generated by tourist activities.

Given this rapid rise in the demand upon Iowa's public land resources, a number of special problems can be outlined regarding their future utilization. Perhaps the most important problem facing the state is the shortage of publicly owned land. To help overcome this shortage, the state through a program of land acquisition has established County Conservation Boards in 1955 (now present in 93 of Iowa's 99 counties and assisted in small land acquisition programs by the State Conservation Commission's special department of County Conservation Activities). Also, the Conservation Commission developed a comprehensive statewide outdoor recreation plan (initiated in 1966 and revised in 1968) to provide a framework for solving Iowa's lack of recreational land. Included in the revised edition of the plan were suggestions to establish "environmental corridors" which would protect wild river areas (for example, the Upper Iowa River in Howard, Winneshiek and Allamakee counties) or to help develop "green belts," multiple-use strips that would follow some relatively continuous recreation resource such as a river valley. The Lewis and Clark Trail Commission, for example, hopes to preserve historical sites along the Missouri River from private commercial development, while similar but more tourist-oriented projects are also planned for the Hiawatha Pioneer Trail and the Great River Road in eastern and northern Iowa.

It appears that additional large multi-use recreation areas are needed in Iowa to provide extra facilities, with this need being most evident around the larger metropolitan areas, particularly Des Moines and other cities of central Iowa. One estimate of the minimum amount of land needed for recreation by 1985 is based on county recreation space standards of 20 acres/1000 population, state standards of 80 acres/1000 population, and federal standards of 100 acres/1000 population and a projected Iowa population of approximately 3.2 million. With those assumptions, minimum recreational land needs will be an additional 36,099 acres of county and metropolitan recreational land, 88,493 acres of state-owned land and 83,988 acres of federal land. This totals 208,580 acres, a 50 percent increase in the existing supply of the state's recreational resources. By the year 2000, when Iowa's population is expected to reach 4 million, the need for recreational facilities will triple. Much imagination and intelligent planning will be needed if the state can meet this demand.

Forest Resources Utilized by Private Agencies

In addition to public forest resources, much larger private areas are present in the state. But since most of these are under private ownership they are not always readily available for recreation and therefore are more of an economic than a recreational resource. As previously noted, 7.21 percent of Iowa's land area is forested, a small percentage when compared to the national average of 34 percent. Only Allamakee County approaches the national average with 32 percent of its area in forest, while six other counties have more than one-fifth of their area in forest and 29 are more than 10 percent tree-covered. The only fairly extensive forested areas in Iowa are in the eastern part of the state.

While forest production ranks behind agriculture as a source of cash income, Iowa's forests are also valuable in stabilizing soils and runoff and hence erosion. There are 88 fulltime commercial sawmills in Iowa, and forest products from both public and private sources contribute $90 million annually to the state's economy.

Extractive Resources

Reflecting its history of glaciation, a large proportion of the bedrock of Iowa is covered by a layer composed of clay, sand, and unsorted gravels. Generally this surface covering is less than 200 feet thick, although in some areas, particularly in western and northwestern Iowa, it may reach a thickness of 500-600 feet. The covering of glacial drift may be nearly absent as in the "driftless area" of northeast Iowa, or has been removed by stream erosion. Immediately underlying this glacial drift are sedimentary rock formations of limestones, sandstones and shales, which are commonly referred to as "bedrock" and represent the most common types of rock found in Iowa. These rocks in turn were superimposed upon a series of igneous or volcanic formations which today are only found at great depths in Iowa, except for an area in Pocahontas County where they have been encountered in shallow drilling for wells.

Given this geological background it is not surprising that the range of mineral resources found in Iowa is relatively small compared to many other states, for example, those of the Rocky Mountains, where more complex geological processes have led to a greater assemblage of mineral deposits. Thus, nonmetallic minerals such as coal, limestone, dolomite, gypsum and various clays, sands and gravels are those most frequently encountered in Iowa. Some lead and zinc deposits are found in the sedimentary limestone and dolomite formations near Dubuque, and it is also possible that further base metal deposits may be found in or near the deeply buried igneous formations.

A number of mining companies have been slowly expanding production over the years, although the annual value of mineral production in Iowa, compared to the United States as a whole, or to the state's agricultural output, is rather small. In 1970 the value of Iowa's mineral products amounted to $127.8 million, or 0.42 percent of the U. S. total. Iowa was ranked 31st in the United States according to the value of its mineral production, compared to 34th place in 1950 and 30th place in 1960. However, the value of Iowa's mineral production amounted to only $26 million in 1945, rose rapidly to $41.7 million in 1950 and even more rapidly by another $60 million to nearly $100 million in 1960, and then slackened off with an increase of only one-third as much in the 1960's.

Ranking first in terms of mineral output and value are aggregates produced primarily from two source materials: unconsolidated granular deposits such as fine sands and gravels and consolidated rock such as limestone and dolomite. Of these two types, the latter are the most important, with the output of limestone and dolomite increasing appreciably over the past decade. Of the 49 states producing these minerals in 1970, Iowa ranked 16th and accounted for 2.8 percent of the national output. Eighty companies quarried 25 million tons in 66 counties, over three-fourths of which was used for road construction and the rest for cement manufacture and agricultural purposes. This was one and one-half times the production of sand and gravel and many times, in tonnage and value, the production of gypsum or clay. Most of the limestone and dolomite has been produced in eastern Iowa; three out of the four counties (Scott, Cerro Gordo and Linn) produce over a million tons annually. Huge reserves of high-quality limestone and dolomite are available for exploitation in eastern Iowa, for example, in parts of the Cedar and Wapsipinicon Valleys and in the Gilmore City area of Pocahontas and Humboldt counties, although practically no economic development has occurred in this area. In contrast, only a few quarries are located in southwest Iowa because of the lack of workable limestone ledges.

Fine sands and gravels occur mostly in the eastern and northeastern part of the state, while abundant gravel deposits occur both as river alluvium and in northern Iowa as glacial deposits, particularly in areas of the Wisconsin glaciation. Southern Iowa has only a few scattered deposits of low-quality aggregates except for the area along the Des Moines River. Most of the sands and gravels come from quarries in counties located northeast and particularly northwest of Des Moines, their distribution reflecting the area of the Wisconsin glaciation as well as the east-southeast trend of the major river valleys. In 1970 Iowa ranked 21st among the 50 states with a production of over 21 million tons and contributed 1.78 percent to the national total in terms of dollar value. Most of the output is used in the road construction and in the building industry.

The third major mineral produced in Iowa and one particularly important in the building, glass and cement industries, is gypsum. While the production of gypsum is greatest from the Jurassic age rocks of the Fort Dodge area, the greatest potential reserves probably exist in the Mississippian rocks of south central Iowa (for example, in Marion and Monroe counties), and particularly in the much larger area of Devonian evaporites farther to the east, for example, in Grundy, Iowa, Benton and Tama counties (Dorheim, 1966). In 1970, following Texas and Michigan, Iowa ranked third in the United States in the quantity of crude gypsum produced, and the state's output of over 1,136,000 tons represented 11.41 percent of the national total. Four open pit mines in the Jurassic rocks in Webster County and the U.S. Gypsum Company's underground mine at Sperry in the Devonian rocks of Des Moines County accounted for the state's total production. Since the Fort Dodge reserves will be depleted within the next 70 years, a potential source is also under development in Marion County.

In addition to the above mineral resources, a large number of clay and shale deposits exist in the state, and in 1970, nearly 1.2 million tons of clay were produced from 23 mines in 16 counties, with Cerro Gordo, Appanoose and Scott counties being the largest producers. Clay products were used mainly in the brick, tile, pipe and cement industries. No separate estimate of the reserves of clay minerals in Iowa is presently available, but it would appear to be large (McCormick, 1973).

Although coal production makes up only a small proportion of the total value of Iowa's mineral output, considerable reserves of this fossil fuel occur in central Iowa south of Fort Dodge, this basin forming the northern section of the Western Interior Coalfield of the United States. An estimated 7.2 billion tons of bituminous coal remain in the state (of which 3.5 billion are classified as measured and 3.7 billion classed as inferred). Assuming a 50 percent recovery rate, 3.6 billion tons remain for possible economic exploitation. However, this figure is equivalent to only one percent of the total U.S. bituminous coal reserves and 0.22 percent of all coal reserves. In contrast, neighboring Illinois' bituminous coal reserves amount to 140 billion tons or 19.3 percent of the U.S. total, equivalent to 8.61 percent of all U.S. coal reserves, nearly 70 billion tons of which is recoverable. Most of Iowa's coal is of a high volatile C bituminous variety with a low to medium ash content. But such high BTU bituminous coals also have a fairly high sulfur content of over 6-7 pounds of sulfur dioxide per million BTU compared to less than 5 pounds of sulfur dioxide per million BTU for low sulfur coals. The caloric or heat value of Iowa coals lies between 11,500 and 13,000 BTU per pound compared to 2,500-9,000 BTU per pound for low BTU coal, the latter caloric value being typical of 55 percent of all U.S. reserves.

Fifty percent of Iowa's 1970 coal production of 987,000 tons was produced by 10 strip mines operated by eight companies in four counties (Mahaska, Marion, Monroe, and Van Buren), while the other 43 percent was produced by three underground mines in three counties (Monroe, Lucas and Appanoose) farther to the south. The 1970 Minerals Yearbook states that of the 6.16 million tons of coal consumed in Iowa in 1970, the local coal industry produced only 14.32 percent at a dollar value of $4.06 million. In addition, a small amount of peat was mined in Winnebago and Worth counties, but that was mainly used for soil improvement rather than for fuel. Of the total Iowa coal reserves 60 percent occurs in seven contiguous counties (Monroe, Polk, Appanoose, Marion, Mahaska, Lucas and Warren), while another 14 counties (Adams, Boone, Dallas, Davis, Decatur, Jasper, Jefferson, Keokuk, Page, Story, Van Buren, Wapello, Wayne and Webster) all contain measured and indicated reserves exceeding 100 million tons, representing 34.82 percent of Iowa's total. However, Iowa's coal resources are possibly much greater than known reserves when the area underlain by potentially coal-bearing rocks of Pennsylvanian age (which comprise 36 percent of the total area of the state) is taken into account. This favorable area is almost equivalent to the area of estimated reserves and thus Iowa's total coal reserves are probably in the neighborhood of 21 billion tons (Landis, 1965, 13-14). This is also equivalent to an energy reserve of 483 quadrillion BTU or 7.1 times the total U.S. consumption of energy in 1970 (Van Eck, 1973). Unfortunately, the areal extent of individual coal seams is usually limited, and their thickness is not uniform. Thirty-one percent of the seams are estimated to be of intermediate thickness (28-42 inches), and 39 percent are in the thick category (over 42 inches). This leaves 30 percent in the thin category (14-28 inches), and only 9 percent of the total U.S. coal production in 1960 came from seams this thick.

No oil or natural gas is currently being produced in Iowa, although a little oil was produced during 1963 near Keota. Since that time a number of exploration wells (all dry) have been drilled in Keokuk and Appanoose counties. Geologic conditions suitable for the underground storage of either natural or liquid petroleum gas also exist in certain parts of Iowa, for example, east and west of Des Moines, near Fort Dodge and east of Iowa City. Such storage makes it possible to provide these products more economically to a much larger market in Iowa and adjacent states than would otherwise be possible.

Some Alternatives for the Future Utilization of Iowa Land

The relationship between agricultural and other uses of Iowa's land will require special attention and planning by public agencies by the year 2000 if this important natural resource is to be preserved and utilized in the most efficient manner. Although the acreage of agricultural land consumed annually by urban and other land uses is small by national standards, the number of alternatives open to the state with respect to the conservation of its valuable agricultural resources are few.

Existing land use planning tools, zoning in particular, allow for little coordinated planning between state and local public agencies. Therefore, at the state level an areawide comprehensive plan for land use in which long-range goals are clearly specified could be developed and implemented by a proposed State Land Use Policy Commission. For example, areas containing highly fertile agricultural land could be conserved for agricultural purposes only, despite the impact that such a decision would have upon other economic activity also requiring the use of such land. Within urban areas, for instance, the Des Moines SMSA, residential sprawl could be contained within the proposed interstate beltway planned to eventually encircle the metropolitan area. This would result in much higher residential densities, but would save large acreages of first- and second-class land, which has been shown to be some of the nation's most valuable agricultural land resources. To some extent similar proposals have been advocated but not acted upon by the Central Iowa Regional Association of Local Governments. At the county level, land use planning laws could be implemented in all counties and existing laws could be strengthened. Legislation could be passed requiring stricter enforcement of "aesthetic controls" within areas occupied by different land uses, in particular ugly and space wasting commercial strip development. In Iowa's rural areas, "second-home sprawl" could be stopped in all public recreational areas such as Storm Lake or Lake MacBride. This could be done by following Vermont's 1970 Shoreline Zoning Act which prohibited construction within 500 feet of lakes exceeding 20 acres. Approval of all site development in accordance with an over-all statewide plan for land use could be required for all residential development outside incorporated areas, as well as for all large industrial or commercial developments, the impacts of which may be felt beyond the confines of an individual county.

Instead of containing urban growth within the present boundaries of SMSA's, a further alternative would be to redirect such growth either by building new towns or stimulating growth in other centers that are located in areas of poorer agricultural land. For example, regional planning promoting urban and industrial growth in areas of south central Iowa might serve not only to revitalize a depressed coal industry (given the technology to achieve environmental air pollution control standards), but also provide jobs in an economically depressed part of Iowa where cash returns from farming are generally lower than elsewhere in the state.

Although Iowa's largest cities and the state are not lacking in open spaces, Iowa's recreational land resources are often both poorly developed and, at the same time, heavily overused. Despite the fact that land potentially available for recreational purposes is generally of small acreage and has many individual private owners, the State Conservation Commission could continue to acquire and preserve the remaining significant forests, river valleys, wetlands and unique areas. As part of its "Open Space Acquisition Program," the Conservation Commission is using a standing appropriation established by legislation early in 1973 to purchase such areas for public use whenever they become available. Since Iowa's recreational areas are already highly overused, it is unlikely that purchases at present levels will be adequate to meet future demand. It is possible that such demands for land for recreational purposes could be met, but only by acquiring large tracts of land. Because of the high agricultural land values that exist in Iowa, such a policy might prove to be viable only in the purchase of lower cost agricultural land, for example, in southern Iowa. However, such land at present is in general distant from major population centers and main transport routes.

The proportion of land devoted to mining will no doubt continue to increase (in terms of the percent of land disturbed by surface mining, Iowa ranked 24th out of 50 states in 1965). But because of new federal sulfur dioxide and particulate air pollution standards and problems of reclaiming highly acidic strip mined land typical of Iowa surface operations, the coal mining industry's future is in serious jeopardy. The Governor's Advisory Committee on Fuel Supply has estimated that the proportion of coal used in Iowa from Iowa mines will drop from 13.63 percent in 1973 to 2.71 percent by 1982. Imports from Illinois will also decline. The slack will be taken up by low sulfur but unfortunately low caloric value Wyoming coal which will supply nearly 60 percent of Iowa's needs after 1980. Instead of using Wyoming coal three other alternatives are:

(1) Appropriate additional funds for more extensive study of strip mined land--for example, problems involved in present utilization if any (Van Eck, 1973), new methods of reclamation, etc. Since much of south central Iowa's farmland is of medium to low quality, studies should be done comparing productivity for certain types of crops before and after reclamation. The Center for Industrial Research has carried out experiments on test plots of strip mined land in Mahaska County, but results have been incomplete and in some cases, inconclusive;

(2) request the Iowa Air Quality Commission of the State Department of Environmental Quality to withhold the implementation of federal air pollution standards for sulfur dioxide until a later date;

(3) or utilize Wyoming coal in the short term only until effective pollution control technologies have been developed.

It is important to explore alternatives to the use of Wyoming coal because its use may only be a short-term solution to demand for energy needs. State Geologist Samuel J. Tuthill notes that not only may Wyoming coal rapidly increase in cost, but Iowa's contracting position may also rapidly deteriorate as national demand increases. In addition, the correction of environmental problems such as reclaiming presently stripped regions will also be more difficult if no active coal industry exists in Iowa. Although the demise of Iowa's coal industry would mean a loss of only 123 jobs and a $6 million annual input into the state's economy, it would occur in one of the more depressed areas of the state.

Given the demands of various economic activities for the use of Iowa's land, there is need to develop land use priorities within the framework of a future state land use policy. However, the extent to which the state itself will engage in the planning process beyond the provision of general guidelines, inventories of land use changes, etc., is not yet clear; nor is the extent to which such planning will balance individual property rights against those of the public good. The 1972 Iowa Land Use Policy Conference stressed the need to develop a new land ethic in which the land owner is responsible for the use of his land as a resource to be protected and not just as a commodity. Given the heavy dependence of Iowa's economy upon agriculture, it is possible that future legislation may assist in promoting such an ethic. For example, the Soil Conservancy Act of 1971 could be amended to include controls or Soil Conservancy District guidelines relating to specified uses or misuses of different classes of land irrespective of the effects of such use upon other landowners.

WATER RESOURCES

The significance of water as one of our primary natural resources has been summarized well by State Geologist Samuel J. Tuthill:

> "All of society's attempts to live in a rational state of balance with nature depend upon an understanding of the limits imposed upon its existence by the quantity and quality of water available to it."

Precipitation (rain, snow, hail) is a principal source of water in Iowa in addition to that imported by flowing streams and by underground waterbearing formations recharged from outside the state. Precipitation amounts vary across the state, ranging from about 34 inches in the south and southeast to 26 inches per annum in the northwest corner. The water that reaches the ground from this source may be dispersed through the hydrologic cycle in several ways. In Iowa where the land is intensively farmed, perhaps two-thirds will be returned to the atmosphere through evapotranspiration of growing plants and trees. The remaining one-third contributes to available resources either by running off into the 15,000 miles of creeks and rivers or by infiltrating into the ground (about one-tenth) to become part of the groundwater reserves.

Surface Water Resources

The rivers and lakes that constitute the surface water resources are replenished at the rate of 2,125,000 gallons per annum. However, the problem with these waters is that the discharge of a stream can be highly variable, as many Iowans know from their experience of floods and droughts. Over the long term, variation on a significant scale is possible, both seasonally and over long periods. For instance, from the stream flow records of the Cedar River at Cedar Rapids (the longest period of record in the state), since the turn of the century there have been periods of six consecutive years (1915-20, 1942-47) when streamflow was consistently above average, and one seven-year period (1953-59) when it was below average.

The quality of Iowa's surface water is generally good. Its natural water chemistry, expressed in terms of total dissolved solids, is generally more favorable than the "hard" water associated with bedrock sources. Quality varies from time to time and from place to place. During periods of high discharge any pollutants in the water are at a much lower concentration because of dilution, although at the same time high runoff results in material from the land being washed into the streams. To the inevitably higher volume of sediment in the water is added both the increased concentrations of chemicals from fertilizers and pesticides (notably nitrates and phosphates) and the organic compounds from feedlot waste. The highest concentrations of pollutants naturally occur during the winter when water is low and there is a potential ice cover. However, there is no one time of the year when water quality can be considered at its best. Factors which encourage lower levels in some chemicals and particulate materials are also those conditions which contribute to higher concentrations of others.

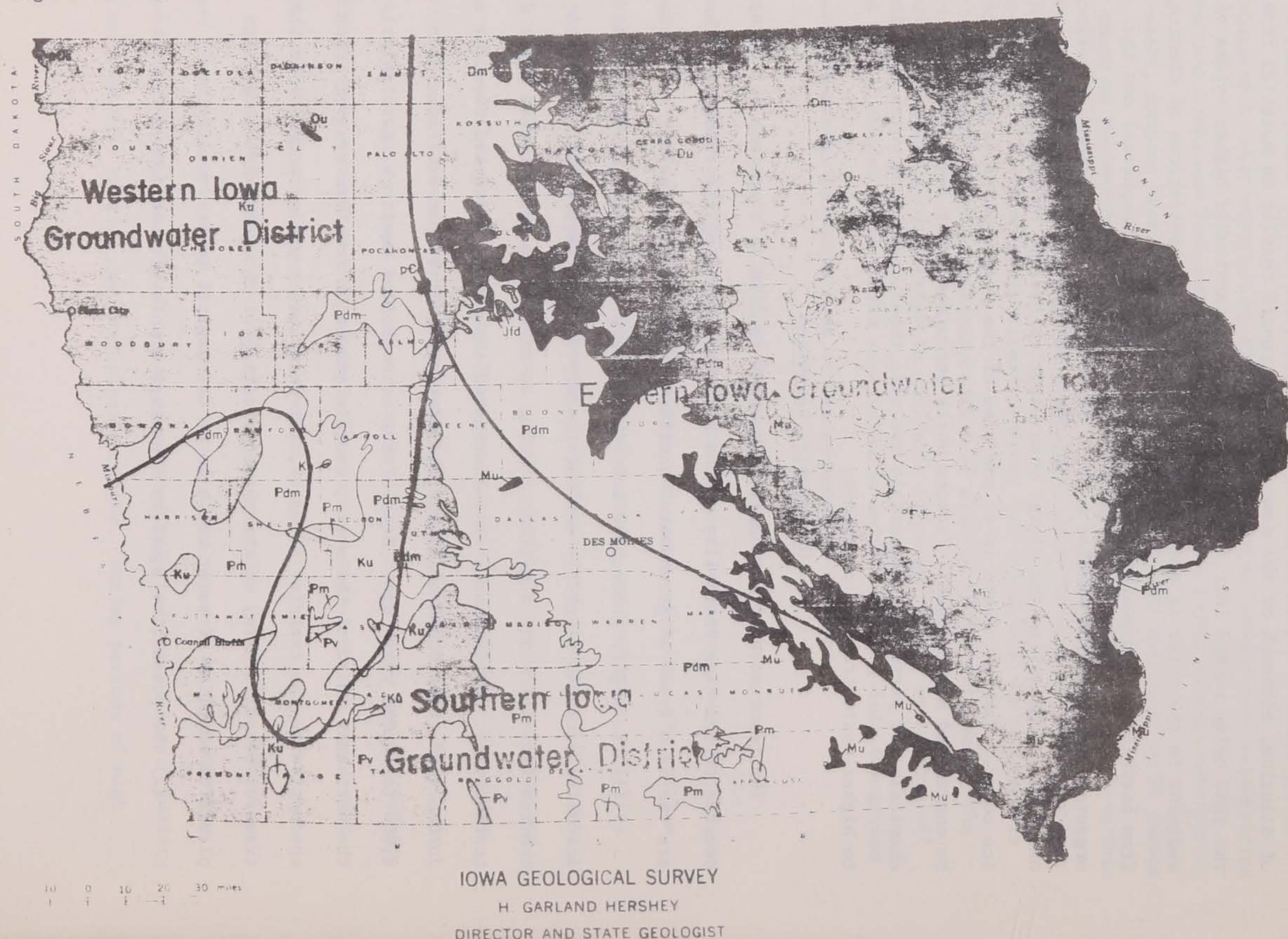
Groundwater Resources

The importance of groundwater reserves in Iowa is sometimes not recognized because of the high visibility of the surface portion of the resource. There are two main types of groundwater aquifers (water-bearing rocks):

(1) The highly productive bedrock aquifers of sandstones, limestones and dolomites arranged in gently southwestwardly dipping layers, often several hundred feet thick and sometimes drawing on water from infiltration great distances away. For instance, it is estimated that water extracted from the deep Jordan sandstone formation in central Iowa entered it near St. Paul, Minn. 8,000 to 10,000 years ago. Some of the more shallow aquifers, particularly in the northeast third of the state, contain extensive fracture systems which are conductive to the transfer of water, but which are equally conducive to the transfer of pollutants, so the characteristics of the rock which encourage plentiful supplies of water can also be detrimental to its quality.

(2) The productive aquifers contained within unconsolidated deposits of

Figure 4. Map of the Groundwater Districts of Iowa



glacial origin or alluvial sediments connected to the principal streams. These last are found underlying the flood plains and terraces of the large rivers, and it has been estimated that 6 trillion gallons of water are available in the Missouri alluvium on the Iowa side. Smaller streams naturally have related aquifers of smaller size, and these are locally important. The glacial drift deposits over much of the state, except in the northeast, also form variable but substantial sources of water at shallow depths for farms and homesteads.

The innate quality of groundwater supplies depends on the types of material in which they are held and through which they have moved. Generally the alluvial and unconsolidated aquifers offer sources of good quality water, but this depends highly upon local factors such as the depth of wells, and the source from which the water was derived. The only area having consistently high levels of dissolved solids (greater than 1000 mg/liter) are in the northwest part of the state along the Little Sioux and Little Rock rivers. The major bedrock reservoirs vary individually but generally produce good quality water, although it is not surprising that water that has been passing through rock for thousands of years should dissolve substantial quantities of the material through which it has traveled. Thus bedrock aquifers usually have more total dissolved solids, and are "hard" as compared to their alluvial or unconsolidated counterparts. Variation, however, is great between and within aquifers. For instance, the Dakota sandstone which is the major bedrock aquifer underlying west and northwest Iowa covers more than 20 percent of the state, but the quality of water is adequate at the 500 milligram per liter level over only 5 percent of its area, and at or below 1000 milligram/liter over only 12 percent. In contrast, the Jordan aquifer has levels of dissolved solids at or below the 100 milligram/liter level over 35 percent of the state.

Water Use in Iowa

By 1973 water use in Iowa has reached a highly sophisticated level in all areas of social and economic life. It is important to identify those areas of use, and relate the level of utilization to the status of resources both in the present and in the future.

Agricultural Use

Agriculture uses the largest amounts of water of any sector of the economy although the real volume of this use is hidden in the evapotranspiration process by which all plants grow. This use has been estimated to be about 48 billion gallons per day in Iowa, about two-thirds of the total precipitation that falls on the state.

Table 2

Estimated Rural Water Use in Iowa: 1970
(Millions of gallons per day)

	Groundwater	Surface water	Total	Percent
Domestic	47.3	0.13	47.43	22.8
Livestock	108.5	25.1	133.6	64.3
Irrigation	23.1	3.6	26.7	12.9
Totals	178.9	28.83	207.73	
Percent of Total	86.1	13.9		

(Source: Tuthill, 1972)

Of the man-controlled uses of water, irrigation involves a relatively small amount of water, approximately 27 million gallons per day, two-thirds of this drawn from groundwater reserves. Irrigation is widespread across the state but practiced intensively only along the Missouri flood plain where 40 percent of all irrigation permits are issued in only six counties, 14 percent in Monona County alone. Often only half the irrigation rights are exercised in any year in the state as a whole, and only speciality or nursery crops are intensively irrigated.

Irrigation is one of the most natural uses of water. Water is applied to the land, where it is used by plants and then returned to the air via evapotranspiration or allowed to filter down to lower levels to become part of groundwater reserves. While there is loss to the atmosphere and the ground, there is little real waste, and contamination is not inherent in the procedure. Since irrigation forms only 13 percent of all extraction for agricultural use from both ground and surface water sources, this causes no real problem in the general depletion of water reserves. However in those counties where irrigation is practiced most intensively, future planning should take irrigation needs into account.

Nearly 23 percent of rural water use is for domestic consumption. Water used for livestock averages 133.6 million gallons per day, 80 percent of which is drawn from both bedrock and unconsolidated groundwater sources.

The great volume of water drawn from both ground and surface water must be carefully considered for its effect on reserves. In terms of depletion it is fortunate that livestock production is well distributed throughout the state. This allows more widespread use of wells than would intensive extraction at a few locations. The continuing development of Rural Water Districts, which are designed to provide and distribute water on a regional basis, should help increase the supply of water to farmers who do not have adequate supplies on their own land. The total amount of water to be supplied can be expected to increase, but large-volume extraction is an important question because intensive pumping can have deleterious effects on the amount and availability of underground water.

The preservation of the quality as well as the quantity of both ground and surface water poses a problem with both long- and short-term implications for Iowans. Agricultural pollutants fall into three main groups: increased sediment from soil erosion, organic wastes from livestock production, and chemical compounds from pesticides and fertilizers. These are interrelated and often transported in the same manner or in association with with each other. However, on the principle that prevention of entry into either ground or surface water systems is the optimal solution to any pollution problem, they are discussed individually.

The effect of increased runoff and soil erosion on streams has an impact on the aquatic environment, often inhibiting the survival of fish, and on human use of water. Eroded soil deposited in stream channels also impedes water infiltration, thereby reducing recharge to groundwater sources and facilitating the export of water out of the state. Surface storage capacity of reservoirs is reduced by siltation and their amenity value also suffers. The Soil Conservancy District Act (1971) set an important precedent in this area. The Act recognized the responsibility of upstream parties to keep soil and attendant chemicals "on the fields where they belong--NOT IN THE STREAM." The provisions of the Act require cooperation between the Iowa Department of Soil Conservation, which establishes standards, the six soil conservation districts which enforce them, and the state and federal agencies that assist in financing and planning individual projects. Not only does the Act have immediate and practical application, but also it establishes the principle of individual responsibility for good management on the part of users at any point on the stream.

The problem of organic wastes originating from livestock production in the state is sizable; nearly 8 million cattle and 15 million hogs and pigs on Iowa farms produce organic waste equivalent to 185 million humans. While filtration through the ground has a certain purifying effect, the problem of contamination, particularly at shallow levels, is important in terms of the safety of supply for other uses, especially domestic. The Iowa Pollution Control Law, now administered by the Department of Environmental Quality, requires the registration of livestock and poultry operations where potential pollution is expected. Feedlots are inspected, and if a problem is found the operator is required to construct the necessary control facilities and obtain a permit for waste water disposal. The Department of Health works with the Soil Conservation Service to provide planning assistance, and limited financial assistance is available from federal sources. In July 1972 a total of 395 feedlots were registered with the Commission; 246 had already constructed control facilities and had been issued permits. Since livestock production is distributed in relatively small production units throughout the state, there are few areas where intense production and thus feedlot waste becomes a problem on a massive scale. However, recent developments indicate that to achieve maximum output and efficiency such decentralization might be reversed. In fact one major new cooperative venture near Sioux City will feed 10,000 cattle. Construction is proceeding with close cooperation from environmental agencies. Under the auspices of the Water Quality Commission, the Limnology Division of the State Hygienic Laboratory has implemented a monitoring system specifically oriented toward feedlot contamination. Such research and regulatory activities, coupled with the growing awareness on the part of farmers and all citizens, contribute to an increasingly effective effort to arrest pollution from agricultural organic wastes.

The use of chemical forms of fertilizers, herbicides and pesticides has raised the productivity for Iowa farmers. However, in recent years it has become clear that portions of the chemicals applied to the fields find their way into the streams and groundwater resources of the state. On the basis of some extensive but nonsystematic groundwater data and more comprehensive surfacewater sampling, it seems clear that nitrate and phosphate concentrations are widespread, particularly in the surface waters of the state. The Iowa State Conservation Commission has provided funds to determine the levels of chemicals that affect the aquatic environment, and the State Hygienic Laboratory has also done much work in this area, particularly with regard to mode of entry into streams and wells.

Some interesting conclusions emerge, primarily that many cases of local groundwater contamination are the result of improper application, overuse, careless handling or disposal, or locally inadequate well casings and are not inherently related to actual use on the land. However, once such compounds are in our waters they are extremely difficult to remove and can be toxic to humans. The control of agricultural chemical wastes can be partially achieved by improved practices as prescribed under the Soil Conservancy District Act, and by other preventive measures that are a matter of common sense and public education. The Iowa Chemical Technology Commission studies problems caused by agricultural chemicals and has already taken action by restricting the use of specific groups of compounds, and initiating programs of investigation.

Domestic and Industrial Water Use

The urban population of Iowa is presently over 2 million and is increasing at a rate that indicates a 3 million level for the year 2000. The increase in industrial development associated with this trend toward urbanization has led to an increase in water use that is more than proportional to the increase in population. This is illustrated by the case of Des Moines from 1920 to 1968. As population doubled, per capita consumption also doubled, resulting in a fourfold increase in total consumption. This relationship has been found to be true on a nationwide basis and can be expected to hold true to some extent in Iowa cities and towns, depending on their size.

There are difficulties in gathering estimates of total extractions for nonagricultural purposes in Iowa. Not all municipal or industrial users are required to apply for permits as long as their water use does not exceed pre-1957 daily levels by more than 3 percent or is less than 5,000 gallons per day. However, the Department of Environmental Quality is presently working on a comprehensive updating of extraction information on a statewide basis, and any realistic future planning must be based on such an inventory. From the Census of Public Water Supplies for Iowa Communities: 1972 it can be ascertained that 794 communities with populations totaling approximately 2,034,000 have a regulated source of public supply, and the great majority of these (95 percent) derive all or part of their water from groundwater sources. Such emphasis on groundwater resources will have important implications at the local and regional level; since the consumption of water in the year 2000 in central Iowa is estimated to increase 130 percent over 1960 levels, while the population is expected to increase by only 55 percent.

In individual areas localized problems are evident, especially in connection with large groundwater withdrawals for domestic and industrial use. The problem of diminishing accessible water resources is significant because of the nature of extraction at any one location. Clearly, as a well is pumped, the level of water and pressure of water decline, and a cone of depression is formed, which radiates from the point of pumping; the diameter and depth of the cone increase with time. Specific areas have encountered this problem. In Cerro Gordo County the Jordan aquifer, which supplies Mason City, has been pumped to the point where effective drawdown at the cone center is dropping 4 feet per annum, and the cone radius is continually widening. Such examples are evidence that alternative sources must be considered and priorities of water use established.

Presently surface water is used as a partial or total source for only 36 communities, and so mere extraction does not threaten the future of the resource. Also, stream levels are protected by low flow regulations which have been established for the principal streams, in part to prevent damage to the aquatic environment which might result from depletion of levels and concentration of pollutants. Even heavy withdrawals permitted for cooling for power generation are temporary and are rapidly returned to the river with only a slight effect on temperature levels in the stream. The Duane Arnold nuclear power generation plant at Palo on the Cedar River is expected to use 4,000 gallons per minute for cooling, 40 percent more water than would be used in power generation by conventional methods.

Surface waters are not fully utilized as a resource, particularly in contrast to the precarious position of groundwater resources in some areas. However, in terms of municipal and industrial use of surface water, the most significant use of rivers and streams is as conduits for waste disposal. The discharge of both domestic and industrial effluent has been the subject of public concern, scientific investigation, and now strict federal and local standards. Domestic and industrial pollutants are similar to those derived from agricultural waste (i.e., both organic and inorganic), but also include changes in water temperature (thermal pollution). However, their sources tend to be concentrated just as industrial and urban activity is concentrated rather than diffused as agriculture. This has allowed for research to be more easily focused by the State Hygienic Laboratory, and for regulations to be better enforced by the Iowa Water Quality Commission.

Almost 100 percent of the municipal population of Iowa is served by sewer systems, and state and matching federal funds are available to local authorities to construct treatment plants (in 1971-72 the state alone contributed $6 million to 49 municipalities to construct sewer facilities), to train and certify operators, and for various kinds of technical assistance. The Environmental Protection Agency requires annual inspection of all disposal installations (including nonmunicipal facilities such as trailer parks, recreational facilities, etc.) and the State Hygienic Laboratory also maintains a statewide water quality record program under which municipalities mail in samples for analysis. The Laboratory also undertakes specific investigations in response to public or agency requests, and in 1971-72 was instrumental in identifying problem areas and violations of water quality standards. For instance, complaints from residents near the Dubuque treatment plant of severe odor problems precipitated a study of the operation. The study indicated that the plant was not achieving optimal levels of efficiency in the removal of nitrogenous material, and an engineering study was begun to correct the situation.

Pollutants of a specifically industrial nature are sometimes difficult to monitor because they are often discharged through municipal sewer systems. Nevertheless it is clear that more pretreatment is needed in the case of industrial wastes. The Iowa Water Quality Commission does not presently have a total inventory of all industrial effluent discharged, and although such an inventory would partially duplicate a Corps of Engineers program, it is essential for future planning. Specific problems have been identified in wastes from agriculturally related industries (packing plants, creameries, etc.) as well as from mining operations and manufacturing. Problems are anticipated from the generation of nuclear power. In spite of extensive preliminary studies and a favorable final report, there are legitimate concerns about waste discharge into the Cedar River from the Duane Arnold Energy Center. Of particular concern is the proposed discharge of 5 pounds of chlorine per day, and plans are being made to monitor this on a regular basis.

While the effects of municipal and industrial waste on surface water are evident, their impact on groundwater should be carefully considered, particularly since groundwater quality is more difficult to monitor, regulate and remedy. Contamination of groundwater is a particular threat in the northeast third of the state, where extensive fracture systems in the carbonate rocks allow rapid transfer of pollutants with very little potential for dilution. This was dramatically illustrated in 1963 in Fayette County, when discharge from a creamery traveled through a portion of fractured limestone and emerged, essentially undiluted, 15 miles away at the Big Springs Trout Hatchery at Strawberry Point, resulting in an almost total fish kill. Unfortunately there is currently no way of predicting in which direction flow will occur. Treatment is impossible once the contaminent is in the subsurface system, and so prevention at the surface is essential.

Threats to the general quality of groundwater supplies are also inherent in any type of solid waste disposal that involves either water-soluble or water-transportable material in contact with the ground. This has been a problem in areas of uncontrolled dumping, particularly since such dumps have been located on otherwise unusable land, often floodplain land where contact with the water table and surface streams is inevitable. The lower economic value of floodplain land has led to the frequent selection of such areas as dumping grounds. Even more critical is the use, in northeast Iowa, of unproductive sinkholes as dumps. These sinkholes are directly connected to the underground fractures and channels which contain valuable groundwater supplies and which also permit pollutants to be rapidly conveyed to local wells.

Clearly this is an area where strong regulation is necessary, for the technology does not exist to allow the construction of safe and sanitary landfill sites, and recent specific regulations in Iowa are designed to accomplish this objective. By July 1975 every city, town and county must provide for the operation of a site for the sanitary disposal of solid waste, and each local authority is required to submit plans to this effect. By March 1, 1973, two-thirds of all the counties and almost all the cities had submitted plans, indicating important progress that will increase the protection of groundwater supplies from pollution.

Recreational Use

The conclusions drawn in connection with land allocation for recreational purposes also apply to the allocation of water resources: They are insufficient but are all we have and must be carefully managed to maximize their value to Iowans.

Water recreational facilities might take two basic forms: those devoted entirely to that objective and those designed for multipurpose use. The first group is limited to certain stretches of rivers designated as "wild" and not subject to commercial exploitation. In fact, this has significant side benefits because by preserving shoreline vegetation, runoff and erosion are reduced.

The scarcity of surface water in Iowa, the few lakes of the north and reservoirs of the south, make it mandatory that most recreational facilities fulfill other objectives (flood control, municipal supply, farm ponds, etc.). In connection with recreation, actual use sometimes downgrades resources so that the attributes that make it attractive (plenty of fish, waterfowl, clear waters) are those that deteriorate with frequent use. Without the efforts of the Conservation Commission in restocking and redevelopment of habitats, many streams and game areas would be of poor quality.

Development of lake shorelines, increased density of camping facilities, power boat emissions and subsequent water turbidity inevitably degrade water recreational facilities. Because of the huge pressure on limited resources, there is a real need to restrict the type of development so that the future of such areas is protected for the enjoyment of all citizens.

Some Alternatives for the Future of Water Resources

Effective utilization of land depends on careful management of associated water supplies, and all land use planning should take into account the status of water resources. Ground and surface water resources are intimately linked. There is much interaction between the upper levels of groundwater and surface streams, either by being capable of recharging the other under certain circumstances, and all future planning should consider the unity of supply. Several municipalities use both ground and surface water reserves, and some use two different types of groundwater sources (shallow and deep wells), and so the possibilities of enlarged resources are realistic if a flexible approach is maintained.

There are problems in the different legal status of ground and surface water resources. Surface waters are publicly owned, belonging to us all, and therefore have been subject to systematic and beneficial controls for some time in the regulation of extractions, and more recently in relation to quality standard enforcement. Groundwater resources are, however, the property of the landowner and not subject to the same level of control. The recent history of groundwater development has reflected this lack of control in terms of conflicting use, overextraction and deterioration of quality. Rural Water Districts may fulfill some of these regulatory functions, but only at a regional level, and there are serious limitations in terms of the coordination between Rural Water Districts which often depend on the same source of supply.

The heavy dependence of both the agricultural and municipal-industrial sectors of the economy on groundwater suggests the initiation of a statewide program for goundwater management. This might be considered a fundamental departure from the principle of rights of ownership. However, all pollution controls and the Soil Conservancy District Act in particular recognize the necessity for holding individuals and organizations responsible for the impact their actions might have beyond the boundaries of their property. Thus, in looking ahead to Iowa's water requirements in the year 2000, a statewide program of groundwater management may not be unrealistic.

Water supply problems in the year 2000 should not necessarily be weighed in terms of today's technology. Possibly by then large-scale transfer of water on a regional basis might be feasible or necessary for Iowa as it is elsewhere in the United States. Or local recycling might remove the necessity for increasing total volume withdrawn, even though the actual amounts of water used may increase. This is already practiced in some industries and holds much promise.

Technology may also be the means by which quality control problems are managed. Iowa has rigorous water quality standards that are even now being revised to conform with stringent federal guidelines. Better forms of treatment so that discharge is less polluting is an ideal goal, and each year sees the addition of more tertiary treatment facilities in Iowa. However, the issue of agricultural chemical pollutants remains the most intractable problem of the moment. Few alternatives currently exist at the state agency level other than education in the proper use of these products and in good conservation practices. These are interim measures before better chemical compounds (i.e., those that break down into nontoxic components) become the alternative to reduction in field applications. Some chemicals have already been removed from use in Iowa (heptachlor, DDT) and efforts are continually being made by state and national research institutions to find less harmful substitutes, either of a biological nature or of more suitable inorganic constituents. A citizen can contribute to such developments by helping make research funds available from public sources, and by keeping well-informed of developments in that area. The information by which such decisions can be anticipated is available from extensive research that has been directed nationally and locally to these alternatives. Especially important is a study by Mayer and Hargrove (1971) at Iowa State University. Their study indicated that reduced application of chemical fertilizers would result in a sizable rise in costs of food.

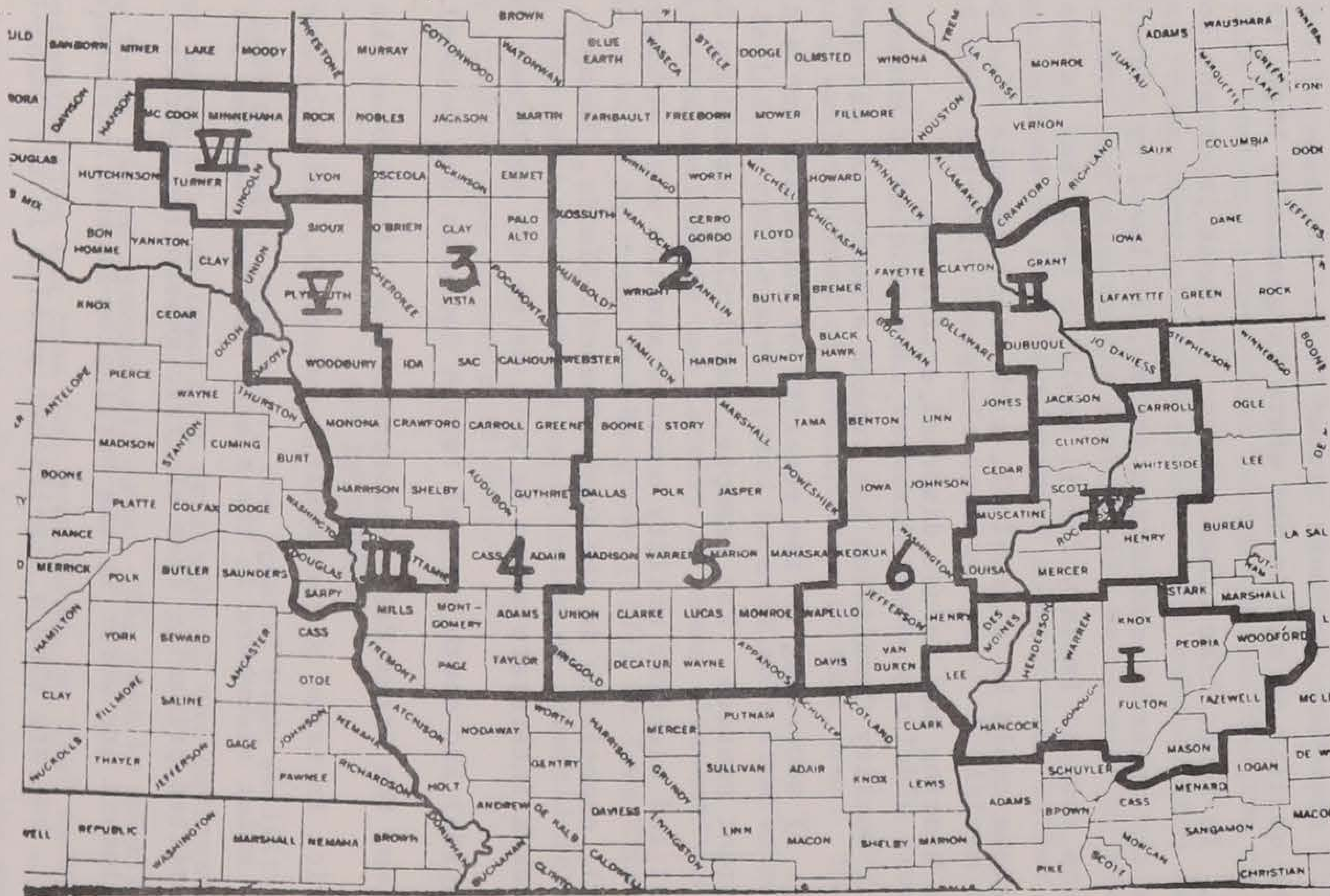
AIR RESOURCES

Like land and water resources, the general high quality of air resources in Iowa also makes this an important attribute of the environment. Iowa is part of the Great Plains atmospheric area. The area is generally characterized by high wind velocities and thus few inversions, by flat terrain and the lack of stationary high pressure centers--all factors promoting the natural cleansing of the air and diminishing the possibility of pollution concentration. Although Iowa is not a heavily industrialized state, certain concentrations of air pollution exist in parts of the Mississippi Valley and particularly over the major metropolitan areas. The costs of such pollution are difficult to measure, but it has important effects upon the health of urban populations, vegetation and wildlife in urban and surrounding rural areas, as well as having a general impact upon the quality of life.

Although the quality of air in the state is generally high, it varies from region to region. In Iowa, like other states, the most important source of pollution remains the internal combustion engine, followed by industrial and electric generation sources (mainly fossil fuels in Iowa, but in the future radioactive emissions could be a problem), with minor amounts also being produced by space heating and refuse disposal activities.

The Iowa Air Quality Commission has ranked a number of air quality regions in the state (fig. 5) according to the severity of pollution (on a class I-III scale) from different sources. For example, particulate emissions from automobile, industrial and electric utility sources are the most widespread problem (class I priority), especially in the Omaha-Council Bluffs, Dubuque, Quad Cities and Burlington-Keokuk interstate areas as well as in the northeast (which includes Cedar Rapids) and south central (which includes Des Moines) intrastate areas. In addition, the Sioux Falls interstate area is rated as the only class II priority district in terms of particulate emissions, and only low concentrations of such emissions exist elsewhere in the state. Sulfur dioxides are also a problem and are emitted primarily from electric generation sources. Concentrations of this pollutant are worst in the Burlington-Keokuk interstate region (class I priority), but are also a significant problem in the Omaha-Council Bluffs

Figure 5. Air Quality Control Regions



INTERSTATE REGIONS

I. Burlington-Keokuk
II. Dubuque
III. Omaha-Council Bluffs
IV. Quad Cities
V. Sioux City
VI. Sioux Falls

INTRASTATE REGIONS

1. Northeast
2. North Central
3. Northwest
4. Southwest
5. South Central
6. Southeast

interstate area (class II priority). Hydrocarbons from automobile emissions reached significant concentrations only in the south central intrastate (Des Moines) area (class I priority), and nitrogen oxide, also mainly from automobile emissions, was rated as a class I problem in both the Dubuque and Council Bluffs interstate areas.

In 1971 major steps were taken to improve and protect the quality of Iowa's air resources. A state plan for the implementation of federal air quality standards was submitted to the Environmental Protection Agency by the Iowa Air Pollution Control Commission. Included were primary standards required to protect the public health, and secondary standards (requiring further reductions in particulates and sulfur oxides) to prevent other undesirable effects of pollution. In addition, in accordance with the Federal Clean Air Acts of 1967 and 1970 and the Iowa Air Pollution Law of 1968, the state was subdivided into a number of air quality control regions. Now Iowa, like other states, must carry out approved implementation plans for limiting emissions of the six principal and most widespread Environmental Protection Agency classes of pollutants so as to achieve the primary standards by mid-1975 and the secondary standards soon after. These regions include six interstate and six intrastate areas. The former includes counties containing the Standard Metropolitan Statistical Areas of Omaha-Council Bluffs, Sioux Falls, Sioux City, the Quad Cities, Dubuque and Burlington-Keokuk. The latter areas include other major urban concentrations (some of which are SMSA's) and their contiguous county areas.

Under the implementation plan special control strategies have been developed by choosing example regions in the state, in which pollutant levels are determined, and then projecting future rates of pollution after the application of controls cropland to only 5 percent (1948-67). Intense efforts by the Conservation Commission to develop other suitable habitats have encouraged increases in the pheasant population. Similarly other game birds--quail, partridge, grouse, etc.--are increasing in number. Two formerly extinct birds--the wild turkey and the giant Canada goose--have been re-established in the state. A growing population of the eastern wild turkey is dispersing satisfactorily, but its range is limited by the lack of extensive stands of hardwoods. Through the provision of protected nesting areas, the giant Canada goose population has increased from very few pairs (1964) to about 1,000 birds (1970), and distinct migratory patterns have been established that will allow flocks to be built up to about 7,000 birds, using three northeast Iowa marsh areas as refuges. To preserve such habitats, some lake, marsh and fen areas have been included in state parks and preserves. Few of these areas are unmodified by man, and almost all have been affected by recreational development and agriculture.

Populations of Iowa game animals are relatively stable under careful management and licensing requirements, with minor year-to-year fluctuations depending on local food and weather conditions. Deer is the only large game species in Iowa and has adapted to the open farming conditions of the state. During the 1969 hunting season a total of 11,582 deer were harvested by Iowa hunters. This was a decline from 1968, and the trend was reflected in a 6 percent decrease in the deer population according to the winter 1970 census. Similar year-by-year fluctuations have been noted for the squirrel, rabbit and beaver populations.

In recent years there has been a particular effort to develop the fisheries of the state, especially maintenance of habitats and restocking of popular species. In 1969-70 over 200,000 rainbow trout and brown trout were stocked in 44 cold water streams in nine northeast Iowa counties. Neither trout would be able to survive unassisted under the prevailing temperature and habitat conditions of Iowa streams. The artificial populating of these streams, plus the work of the five warm-water hatcheries which stock walleye, pike, catfish and bass, contributes significantly to the resource base of the state and the ecological well-being of its waterways.

Commercial as well as sport catches are also being monitored. In the Mississippi River there are indications that periodic overharvesting in relation to the capacity of the species to reproduce has resulted from pollution-associated changes in habitat. Similar monitoring of the Coralville Reservoir led to a cessation of commercial fishing in 1972 because of unacceptably high concentrations of chemical pollutants, including mercury, in the catch.

Some Alternatives for Future Management

The plant and animal resources of Iowa are intensively used either because of their scarce distribution, as in the case of certain vegetation forms, or because of their desirability as game. In spite of such intensive use, there appears to be no short- or long-term problem of depletion because of careful management practices on the part of licensing and administrative agencies. The system of state preserves and agreements with private landowners should protect that land now essentially devoted to management of floral and fauna. However, futher expansion of areas primarily devoted to plant and animal conservation will be prevented by the almost total utilization of productive land for agriculture.

The suitability of prairie vegetation to the Iowa climate and terrain suggests that perhaps efforts should be made to <u>extend</u> rather than merely preserve prairie cover. Successful experimental attempts have been made to transplant both seedling and sod specimens, and this could be done on a larger scale in connection with wildlife or beautification programs. One such project is already in effect on Interstate 35, south of Des Moines.

There is a real problem of depletion of wildlife reserves through the presence of external pollutants and those (such as lead shot) generated by intensive use of the resource. This may result in the degradation of the habitat and therefore reduce the ability of the species to survive. Such factors are often beyond the control of the Conservation Commission, except as its officers participate in the policy development and decision-making of the Department of Environmental Quality. This department was only created in January 1973 and its effectiveness in this area has yet to be determined. However, a total ecological approach is appropriate to the preservation of plant and animal life, and only through a commitment to this approach can desirable alternatives for the future of the plant and animal populations of Iowa be realized.

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