

WRC RESEARCH REPORT NO. 9

S O C I A L I M P A C T O F M E T E O R O L O G I C A L D R O U G H T
I N I L L I N O I S

Alfred W. Booth
Professor of Geography

Don Voeller
Research Assistant
University of Illinois, Urbana

F I N A L R E P O R T

Project No. A-007-ILL
June 1, 1965 - June 30, 1966

The work upon which this publication is based was supported by funds provided by the U.S. Department of the Interior as authorized under the Water Resources Research Act of 1964, P.L. 88-379 Agreement No. 14-01-0001-783

UNIVERSITY OF ILLINOIS
WATER RESOURCES CENTER
307 Engineering Hall
Urbana, Illinois 61801

March 13, 1967

SOCIAL IMPACT OF METEOROLOGICAL DROUGHT IN ILLINOIS

ABSTRACT

Drought invariably infers a shortage of moisture in one context or another, wherein a situation of stress evolves; and attempts have been made to develop a procedure whereby the relative and absolute impact of this phenomenon can be measured. It was proposed to test the validity of meteorological drought, as defined by the recently derived Palmer Index, by comparing the variability of drought in Illinois, as indicated by the index, with the effects of this phenomenon on various sectors of the State's society. The research was based on the hypothesis that the impact of drought on the social realm varies as drought severity varies.

Due primarily to the lack of long-term, readily available data and of developed methodology for isolating the effects of natural phenomenon on man and his activities, little conclusive objective evidence was obtained; however, it appears that drought has variable impact: (1) from one sector of society to another at a given time, (2) within the same sector of society in given areas at a given time, (3) in given sectors of society through space, and (4) through time on society as a whole, all because of the dynamic nature of man's culture which enables him to better cope with the vagaries of nature on the one hand and results in his becoming more susceptible to them on the other.

Booth, Alfred W. and Voeller, Don

SOCIAL IMPACT OF METEOROLOGICAL DROUGHT IN ILLINOIS

Completion Report to Office of Water Resources Research, U.S. Department of the Interior, March 1967, Washington, D.C., 31 pp.

KEYWORDS--*drought/*social impact of drought/*Illinois

ACKNOWLEDGMENT

The work upon which this publication is based was supported in part by funds provided by the United States Department of the Interior as authorized under the Water Resources Research Act of 1964, Public Law 88-379.

Special thanks are due to Don Voeller, now of Whitewater State University, who, as Research Assistant on the project carried on all of the basic research and also carried much of the burden of compiling the report.

Preface

The general problem in testing the validity of meteorological drought in a social context as proposed is the difficulty in isolating the impact of drought. This problem is very difficult even when attempting to isolate the impact on a given place at a given time. A number of problems under this general heading follow:

- 1) Methodology for measuring the degree of variation in most relevant variables (physical and social) as related to precipitation variability is very "weak".
- 2) Many factors alter the impact of drought of a given severity through time; e.g., there is an increasing sophistication and effectiveness in moderating or decreasing the impact of drought through government and privately sponsored program, contouring, new seed varieties, fertilizers, and new methods of obtaining and retaining water. However, not all geographic areas or sectors of society have the same capacity to take advantages of these moderating factors.
- 3) In comparing different areas or one area through time the proportion of society dependent upon agriculture, industry, services and other means of livelihood changes.
- 4) The coverage in news media relating specifically to agriculture as affected by drought, may well diminish after the growing season even though according to the Palmer index moisture conditions may be worsening.
- 5) The type, degree, and number of simultaneously occurring stress producing or impact ameliorating factors vary greatly through time. There may also be an interaction when two or more stress producing factors occur simultaneously wherein the impact is greater than had these factors occurred singly.

6) Effects frequently appear to be attributed to droughts that were caused by other factors, and vice versa. For example, drought has been used as a scapegoat in the past, as a coverup for faulty administration or water supply systems.

7) Often there is a considerable lag in the initial impact of a given drought and all of society's reaction to it. Furthermore, some effects of extreme droughts as those occurring during the 1930's and 1950's may be very durable.

8) Dry spells, which are not considered in the Palmer system, particularly in areas with soils of low moisture holding capacities may be more significant than an entire drought period occurring at another time.

9) An evolving water problem may be met by actions based upon decisions made or not made with drought being considered.

10) A municipality with a poor water situation may be desirous of industry or recreational facilities (reservoir), and as a consequence it may expend its energy toward obtaining a reservoir, which also solves the original water problem. Drought may or may not have been a significant factor in the decision to act.

11) Drought may be an important factor in decisions to act, but one action is taken even severe or extreme droughts may have only a minor impact at a future date.

12) Decisions to act in response to drought may take place only after the effects of several drought periods have accumulated. In such a case a greater impact may be attributed to the drought occurring at the time of the decision to act than should be.

13) The nature of the data and other sources of information:

- a) Accuracy of data and completeness and consistency of records relating to given variables through time are very inadequate.
- b) Collection and compilation of data of several variables that could be used in testing drought in a social context were impossible with the time and personnel available for this investigation.

Of more significance in the matter of planning remedial measures for alleviating the impact of drought but nevertheless factors which must be considered because of their relationship to drought are the following variables:

1) The varying nature of the physical environment, specifically with regard to its capacity to supply constant and adequate quantities of water for human activity.

2) The rate of increase in demands for water, especially concentrated increases in areas of rapidly expanding industry or per capita use of water.

3) The variable frequency, severity, and areal extent of drought. Closely spaced droughts have a greater accumulative impact than the same number in the same time which are more evenly spaced.

4) Changing economic conditions at the national, state, or community levels.

- a) Financial position of individuals, and groups, including municipalities.
- b) Aid available or ease with which credit is extended or loans are granted.
- c) Political and social attitudes and activities of government and private concerns directed toward water research, more efficient use of water, or moderating the impact of drought.

5) Occupation or economic activity engaged in.

- 6) Attitudes and psychological makeup of individuals (decision makers).
- 7) Past experience of members of society.
- 8) Level of knowledge and technology available.
- 9) Degree of independence and interdependence of members of society; degree to which activity is individual or group.
- 10) Adequacy and appropriateness of adjustment to the water regime of an area; attitudes of people toward water.
- 11) Leisure time activities.
- 12) Value system of societal members.

Introduction

Every area or region of the world has a given capacity to supply water to the biotic communities found within it, and the continuing availability of water within the environment of plants and animals is one of the limiting factors to their proliferation. Both plants and animals are adapted to the prevailing environmental conditions, but plants are very limited in their ability to obtain moisture if that moisture is not found in the immediately adjacent soil or atmosphere. Most animals are somewhat less dependent upon water in their immediate location since they are generally relatively mobile within their ecumene and can obtain water from surface-water sources, plants, or faunal prey. Nevertheless the range of movement of animals is also relatively restricted.

When natural variations in moisture occur, members of the biotic community respond within their range of adaption; but should the moisture deviation be too extreme, those unable to make necessary changes perish.

Human societies present a different case with respect to adjustment or adaption to moisture variation. Because of the reasoning power and the accumulation of knowledge of and technology available to its members, human societies can "exploit" their environments more fully than other biotic forms, specifically, in terms of the search for, location of, storage of, and/or transport of water found near the earth's surface. But today as in the past, man must also rely, almost entirely, upon moisture that originates in the atmosphere in various forms of precipitation; precipitation that varies both in time and place. Even the

most advanced cultures are unable to do anything significant in terms of altering precipitation amounts or reducing the variation in its distribution.*

In light of its water requirements, its given ability to manipulate water at or near the earth's surface, and its inability to alter the amount and distribution of precipitation one would assume that a society would establish its activities in accordance with the amount of water that it perceives can be obtained under existing physical, political, technological, economic, and other cultural conditions and restraints. Furthermore one would logically assume that a society would not continue to inhabit an area in which it is extremely difficult to obtain a constant supply of water for at least basic activities.

For the most part these assumptions appear to hold even though there are thousands of cases on record in which various types of activities have been disrupted in some degree as a result of water shortages. And without a doubt at least some parts of our society will be confronted with recurring water shortages, a possibility that some experts look upon as being one of the major problems of the future.

THE DROUGHT CONCEPT

Drought as a concept

Water shortages have been and continue to be common topics of discussion. Furthermore the frequency with which they occur as topics of discussion increases as these shortages become more acute, particularly within the sectors of society that are actually being affected, at a given time, or that may be affected if the situation persists or becomes more critical.

* Weather-modification and desalinization of ocean and brackish water may alter this situation significantly at some time in the future.

In news accounts, literature, and personal interviews and conversations relating to meteorological and climatological conditions, the term drought is used rather consistently to convey the idea of water shortages that are attributed to negative deviations from expected amounts of precipitation. Whether or not the precipitation deviation was primarily responsible for the water shortage is not, however, necessarily considered.

Drought--a perceived precipitation deficiency from an expected or calculated normal--as a term or concept is elaborated upon, in general, in all sectors of society in terms of its duration and intensity, i.e., its severity, and frequently in the areal extent of the precipitation deficiency or drought. However, the accuracy of the scale being used in these characterizations varies considerably from person to person and aside from the basic idea that drought is a time period during which a reduction in normal precipitation has resulted in a water shortage for someone, the use and definition of the term becomes rather ambiguous.

Many attempts have been made to define drought, but no single, concise definition or methodology for its characterization has been widely accepted. It appears that one of the primary problems stems from the relativity of the concept, carried through time, both in space and from sector to sector within society.

Regardless of how it is perceived or defined, drought is a cumulative phenomenon--one that takes some time to develop--for within the hydrological system there exist a number of natural reservoirs which serve as buffers against variations in precipitation. As droughts develop, greater amounts of moisture are being taken from these reservoirs than are being replaced. The soil

reservoir is in general the shortest-term reservoir in the system, for seldom does total precipitation meet evapotranspiration demands for an extended period.

Drought has been studied in a variety of contexts; e.g., as hydrological drought, biological drought, agricultural drought, and so forth. Thornthwaite, however, states that the "various aspects of drought are interrelated and there is no need to distinguish climatic, biological, or hydrological drought" (1).

In a recent work (2) by Wayne C. Palmer, the author states that drought can be considered "as a strictly meteorological phenomenon" and he evaluates drought "as a meteorological anomaly characterized by a prolonged and abnormal* moisture deficiency." His study "is based on periods no shorter than one month. This is objectionable in that no account is taken of the distribution of precipitation within the month. Although this produces errors in timing of computed moisture deficiencies, it is not likely seriously to bias the magnitude of the total moisture deficiency during abnormally dry periods, the item with which this study is primarily concerned. Shorter periods have been studied by machine methods and results seem to justify the preceding statement." (2:5) A drought period is defined then by Palmer "as an interval of time, generally of the order of months or years in duration, during which the actual moisture supply at a given place rather consistently falls short of the climatically expected or climatically appropriate moisture supply. The severity of drought may be considered as being a function of both the duration and magnitude of the moisture deficiency."

* A thing is abnormal that deviates markedly from what has been established as some measure of the middle point between extremes.

The objective of the work was to "develop a general methodology for evaluating the meteorological anomaly in terms of an index which permits time and space comparisons of drought severity." Palmer's system of characterizing drought is in essence a weighted moisture-accounting system, which can be used to follow the local or areal moisture situation throughout the year. His methodology takes into account the most significant facets of the hydrological system, including evapotranspiration, runoff, recharge available water holding capacity, and precipitation. A climatic weighting factor for each monthly moisture departure at a given point is employed in order that a comparison of drought severity from place to place and through time can be made. The result of the application of the methodology is a moisture anomaly index, from now on referred to as the Palmer index, which hypothetically indicates the relative severity of a given drought in an area. Although Palmer did not deal with points in his study, moisture anomaly indexes can be calculated for points as well.

The Palmer index is based upon what has been calculated the normal or the climatically expected amount of precipitation for a particular place or area. If an index, for a given month, of zero is calculated, according to the Palmer reasoning, moisture conditions have been near normal or is climatically appropriate for that time or place. Droughts are expressed by four classes based upon the effects of given drought severities on natural vegetation (i.e. ecological criteria) (2:44) : (a) mild drought if the calculated index ranges between -1.0 and -2.0; (b) moderate drought, index between -2.0 and -3.0; (c) severe drought, index between -3.0 and -4.0; (d) extreme drought, index less than -4.0.

Palmer states however that "...probably the severity is mostly closely related to some localized economic measure of the disruption of the established economy", but none presently exists (2:3). Furthermore "...the underlying concept of the paper is that the amount of precipitation required for the near-normal operation of the established economy of an area during some stated period is dependent on the average climate of the area and on the prevailing meteorological conditions both during and preceding the months or period in question."

The system, whereby the moisture anomaly index was derived, was developed basically in the context of an established economy which "is significantly dependent on the vagaries of weather for its moisture supply," and he postulates "that a drought index of -4.0 spells economic disaster in any region" characterized by such an economy. He concludes finally that the drought index values are reasonably comparable in their local significance both in time and space" (2:45) after testing to some degree the assumption that time and space comparisons should be possible if the economic consequences of the driest year in one area were approximately as serious for the inhabitants of that area as were the consequences of the driest year for the residents of another area.

Man-made drought, "a demand, created by economic development for more water than is normally available in an area" was not considered in Palmer's study. However, it was deemed desirable to investigate this concept in conjunction with the investigation of meteorological drought since even Palmer bases his ultimate criterion on the needs of "an established economy." Established economies evolve largely through a process of trial and error, i.e., overusing water supplies at some times and places and/or underusing them at others. Thus in a highly dynamic economy such as Illinois, a constant appraisal of present conditions is necessary. Therefore it seems difficult to conceive of a separation between "natural"

drought and man-made or culturally induced drought. In a sense any drought is man-made if man relies upon anything but naturally occurring sources of food and water.

Palmer's methodology is carefully derived and does appear to be capable of indicating the relative moisture status. It is the objective of this investigation to test the validity of meteorological drought as indicated by the Palmer index system by examining the social impact, through time in Illinois, in an attempt to determine whether covariations in drought severity and impact on society do exist. This impact can include both that which resulted in a diminution or an improvement in societal welfare. For example, drought may be partially or largely responsible for decisions to act, on the part of the individual or group, in order to moderate the effects of a drought occurring at a given time or in the future; i.e., to change the manner in which present activities are carried on. This impact includes political, economic, and other cultural effects.

Method of Investigation

There have been a number of recent studies conducted relating to drought and water supply in the context of hydrology, meteorology, and crop yields in Illinois (5, 6, 7) but none have treated the impact of drought mainly in the context of its effects on the human activity in the State, which, it is maintained, is the most appropriate test of drought severity. The proposal for this investigation stemmed essentially from the following premises:

- (1) that under a situation of prolonged drought, society, as a group or on an individual basis, reacts in some discernible manner;

(2) that society through time attempts to create or discover a secure position in relation to available water supplies, which are ultimately derived from precipitation;

(3) that water deficits of sufficient magnitude, as to be reflected in the records of societal activities or impressed upon the human mind, have occurred within the State of Illinois, and,

(4) that as the severity of drought, as defined, varies or as drought of various severities occur through time, the impact, as reflected in the records of societal activities or as impressed upon human minds, also varies. At the outset it was assumed that the Palmer index can be used to compare the relative impact of drought on societal activities through time and space.

Palmer indexes for each month from 1930 to 1960 for each of the nine meteorological divisions of Illinois were obtained with the objective being to correlate index variation with variation in societal activities within the State as reflected in records of various organizations, in newspapers, and in personal interviews.

During the early portion of the investigation an attempt was made to select a number of relevant dependent variables that might conceivably vary in response to variations in the supply of water, thereby giving some indication of the relative or absolute impact of drought on society in general or on some sector of society.

The selection of these variables was made after consulting with a number of individuals who were known to be students of drought and its effects and man-physical environment relationships. Included among those variables that were selected and for which data were sought in particular are the:

- 1) attitudes and opinions of members of Illinois society,
- 2) implementation of measures for defense against the vagaries of nature,
- 3) degree of participation in programs designed to ameliorate the impact of the vagaries of nature,
- 4) political activity relating to water resources,
- 5) variation in income (economic), sales, and employment, and
- 6) variation in capital investment and personal spending.

It became obvious in the early stages of work that readily processable data, i.e., data that could be correlated with the Palmer indexes through any period of time, were not available; and, to compile the data that was available would be unfeasible in the time and with the personnel available. In addition many conceivable difficulties would arise in attempts to process the data, some of which are listed under the section entitled "Problems".

Following this preliminary work a decision was made to continue the investigation by (1) systematically perusing a number of Illinois newspapers, (2) interviewing a wide variety of individuals, and (3) studying records that might reflect the impact of drought in selected areas within the State. Attention was concentrated primarily to an area in eastern Illinois, approximately 75 miles north and south of the Shelbyville terminal moraine. This area was selected primarily because (1) of the very distinct soil differences to the north and to the south of the moraine and (2) it contains an area noted for the effects of drought and another in which the effects attributed to drought are appreciably less. Between 10 and 15 newspapers were perused for various time periods and approximately 200 interviews, consultations, and conversations were engaged in.

Conclusions, hypotheses, problems, and unanswered questions advanced below are based upon apparently consistent information obtained during the course of this study. A formal interview schedule is also being devised for future use.

General Impact in Illinois

The vital nature of water has been known for thousands of years, and one can logically assume that as Illinois was being settled and activities of all types are being established, water availability, at least for basic domestic purposes, was given prime consideration. The same assumption would in all likelihood hold as the State's population increased and water using activities expanded or became more intensive. But many decisions relating to settlement and expansion in the past were necessarily made with little knowledge of total precipitation and its variability and distribution throughout the year and from year to year. Understandably many adjustments were made as men attempted to determine which and to what extent various activities were suited to existing cultural and natural conditions, including water availability.

This process of human reaction and adjustment to water supplies still continues today in Illinois in spite of the facts that (1) the State, in general, has a very favorable precipitation and water supply situation when compared to other earth areas and (2) the level of understanding and knowledge relating to the water regime is as sophisticated as anywhere on earth. As a consequence of this investigation it is hypothesized that certain conditions exist or types of situations evolve that in part give some indication why water shortages still occur rather frequently:

1) An over estimation of the water or moisture that is actually available, or will be available, is made in a given area either because of optimism or ignorance. In some cases one might conclude that the availability of water is taken for granted.

2) A relatively rapid overexpansion of activity occurs thereby taxing either the natural and/or cultural system that supply water especially during periods of subnormal precipitation; again either ignorance or "taking water availability for granted" may be the ultimate cause;

3) Precipitation is variable in time and through space and established activities, based upon the awareness that some water deficiencies will occur, but will result in only temporary and partial disturbances, are carried on. In other words man is unable to and/or unwilling to store adequate amounts of water for conducting all of his activities at their normal level thru periods of drought. Farming is undoubtedly the most notable and significant example because of its virtual dependence on precipitation and the nature of its source of water, the soil reservoir;

4) An inertia factor exists and often water use activity increases more rapidly than the implementation of political or technological machinery makes it possible to obtain this increased demand for water from local or distant areas or reservoirs; and

5) Advice from professional water experts on the local water situation or meteorological and hydrological records that would give an indication of the probability of given amounts of water at various times are not given appropriate consideration.

Drought, as defined, is integrally related to all of these situations; and, when droughts do occur a rather distinct sequence of events appear to occur. First, members of society recognize the symptoms of drought. They may or may not know what to attribute these symptoms to but they are cognizant of a water shortage.

Upon recognition of symptoms, the next impact involves a psychological reaction--anxiety. The degree of anxiety depends largely upon the perceived "damage" that may result, e.g., reduction (loss) in income due to reduced crop yields, damage to lawns, etc.

Next people begin to speak of the effects and possible effects, which may be followed shortly by news media coverage.

Finally, people begin to react in some manner to reduce effects or rid themselves of the drought. This takes many forms, the most severe reaction perhaps being the packing-up and leaving of an area.

Not all persons recognize the symptoms of drought at the same time in a given area. Persons in certain professions and occupations, such as farmers, farm advisors, foresters, soil conservation field workers, water superintendents, hydrologists, meteorologists, climatologists and bankers follow the moisture conditions more closely than most persons. Some persons with lawns or gardens as hobbies and income supplements in city, town, or country also recognize symptoms early.

Cognizance of a drought anxiety (or psychological impact), conversations, concerning it, and overt reaction to drought do not occur throughout society simultaneously. A farmer, for example, may be adversely affected even before a resident in an urban-industrialized area becomes cognizant of the drought. In some cases extreme drought occur with some persons in "large" cities not

even being aware of its occurrence. On the other hand all four stages, cognizance, anxiety, conversation and overt reaction may also occur nearly simultaneously in some cases in virtually any sector.

Drought does not necessarily produce only what can be termed disruptive effects. Excellent cases of cooperation and aid among members of society have occurred in response to drought and have thereby reduced the potential impact of drought. Social pressure and/or conscience can and have resulted in the establishment and implementation of programs to alleviate the impact of drought in progress and/or expected drought. Included among the most notable measures or programs implemented to moderate drought impact are wind erosion measures, help in refinancing farm debts by direct loans, research on ground and surface water, extra feed allotments, insurance payments, and partial financing of water supply and storage systems. Some measures instituted especially for sub-humid areas have been incorporated in more humid areas.

The impact sequence from cognizance to the most severe effects varies from individual to individual, occupation to occupation, and area to area. This variation, it is hypothesized is dependent upon a large number of factors. But from the idea of awareness and discernible effect, one might expect that the impact of drought is roughly inversely proportional to the ratio of urbanization-industrialization orientation to agricultural orientation. In other words, the impact as measured by variations in a given variable is greater the nearer one is related to a dependence upon the physical environment. Precipitation is an input over which there is little or no control in farming, except in its effectiveness, and where relatively large modifications cannot be made in relation to the relative importance of water to the entire operation.

It, therefore, appears that possibly occupation, place of residency, adequacy of natural sources, among others can "shelter" an individual or organization from the potential impact of drought. It is possible for an extreme drought to occur and find many citizens literally unaware and virtually unaffected by it within the State. At most they may sense higher than normal temperatures and perhaps water their lawn more frequently if they have one.

In summary some of the effects attributable to various periods of drought in Illinois are:

- 1) Increased use of water.
- 2) Increase in number of requests for information relating to water, e.g., to the Illinois Water Survey.
- 3) Increase in number of wells drilled.
- 4) Increase in number of reservoirs constructed and/or pipelines extended to new sources.
- 5) Increase in number of crop insurance payments.
- 6) Increase in number of irrigation systems installed.
- 7) Increase in amount of water being hauled.
- 8) Deterioration of esthetic value of stream courses, lakes, and other outdoor recreational areas.
- 9) Increase in number of persons laid off of jobs and number of businesses being closed down.
- 10) Decrease in sales by car dealers and farm implement dealers, particularly in agriculturally oriented areas; decrease in bank accounts and savings in the same type of area; decrease in rate of outstanding payments.
- 11) Increase in number of cracks in water lines.
- 12) Decrease in number of livestock maintained.
- 13) Increase in forest and range fires.
- 14) Increase in heat strain.

15) Increase in number of legal battles among individuals and groups relating to water.

16) Increase in number of water use restrictions.

Drought and Agriculture

Basic to the livelihood of the agricultural sector is the growth and development of grains and forages. One of the most critical factors in this growth and development is the amount and distribution of precipitation, and deficiencies resulting from drought conditions have tended to reduce yields throughout the State from time to time.

Because of this extremely close relationship between the farmers' welfare, precipitation, and crop yield it is hypothesized that the agricultural sector is most often affected earliest, most consistently, and ultimately most severely by drought conditions. The absolute impact on any individual farmer, however, appears to depend in part upon many factors such as age, experience, economic situation and education.

The farmer, aside from individuals keeping precipitation records, perhaps recognizes the development of drought before nearly all other members of society since the crops, upon which he depends, react very early to moisture deficiencies compared to most other indicators. But unless he has installed an irrigation system, the farmer can do little to alleviate the situation.

As the prospect of declining crop yields increases understandably some anxiety develops, and the prospects of a decline become reflected in both the farmers' conversations and attitudes. Within the State, however, there is both considerable regional as well as local variation with respect to attitudes and anxiety as related to farming operations and day to day living. For example, south of the Shelbyville Terminal Moraine where soils have low effective water holding capacities and "effectual" droughts are more frequent and severe than

the area north of the Moraine having high water-holding capacity soils, farmers seem to be more conditioned to the prospect of drought. At the same time the southern farmer appears to be more conservative in his capital-investment and loaning practices because of the greater prospects of a rapidly-developing short term, but serious, drought.

Actually the greater prospects of damaging drought, when comparing areas north and south of the Shelbyville Moraine, exist not so much because of great differences in the precipitation or potential evapotranspiration regime, but because of the manner in which moisture is retained by the soil. This may result in the most significant difference in impact that can be attributed to drought within Illinois, and yet the magnitude of this difference would not be reflected in a corresponding difference in the Palmer index.

Individuals dealing with and working with farmers, in particular farm advisors, attest to the idea that attitudes toward farming and other facets of daily living literally change with the weather. Basically, in Illinois agriculture three significant effects can seemingly be attributed to recurring drought: (1) temporary changes in the distribution of income allotment by the farm family, (2) temporary changes in facets of farm operations, and (3) through time a relatively slow change in investment and spending habits and overall pattern of farming. The most dramatic changes understandably occur during the relatively infrequent extreme droughts.

During all but these extreme droughts, as defined, the most obvious and perhaps the most significant general impact is the tendency for the income of farmers to be reduced as a result of decreased yields. If their income is reduced significantly the tendency is to reduce spending, and according to an unpublished study (9) of income disposal among Illinois farmers there are indications that reductions would occur in the various sectors in the following order.

(1) actual disinvestment or cutbacks on the addition to savings and investments,

(2) delay in the replacement of capital goods such as buildings, tractors, and other machinery, and

(3) cutbacks or restrictions on personal consumption such as vacations, recreation and other personal satisfactions. Farmers do not generally cut back on production inputs such as fertilizer and seed, but will if necessary seek financing in order to carry on near normal operations. They will, if income is not reduced too drastically, make interest payments on outstanding loans, but not on the principal portion.

Farmers are also affected by drought in terms of their acceptability to ideas. During drought, for example, farm advisors suggest that farmers are less willing to listen to and implement measures which might possibly prove beneficial in the future. On the other hand they are more willing to participate in programs in which, no matter how severe a drought may be, will contribute something to annual income or reduce losses, and at the same time serve as a good management practice. A case in point occurred in 1964-65 in Marion County. In 1964, 550 farmers participated in the Government feed grain program and diverted 9502 acres. In 1965, after a very dry year, 831 farmers participated and diverted 12,476 acres. A significant number of plans made in the spring of 1964 to apply limestone in the fall of 1964 also did not materialize after the poor 1964 crop year (19).

Irrigation systems in Illinois are scattered throughout the State, but total acreage under irrigation was less than 20,000 acres in 1957 (8). A large proportion of these systems are used primarily for supplemental purposes during periods of drought.

Normally one would expect decisions to install irrigation systems to increase during or shortly after severe or extreme drought, but a significant rise in the number of installations occurred between 1959 and 1960 after a drought classed as only mild to moderate by the Palmer index.

In the past 30 to 35 years every part of Illinois has experienced one or more extreme droughts as indicated by the Palmer index. But not even in conjunction with serious economic conditions has drought in Illinois resulted in the wholesale disruptive effects as have occurred in subhumid to semi-arid areas to the West. A study relating to factors causing farmers to leave Illinois farms revealed that drought was not one of the major factors (12).

Drought has, however, had some effect on farmers who have decided to sell, and it is hypothesized that occasionally drought occurring at a critical economic or psychological period does provide the incentive to the farmer to leave the farm.

Extreme droughts, like the one of the 1950's did also give rise to significant anti-drought activity. A prime example involved the rapid increase in the number of farm ponds in areas of limited ground water potential. Water hauling and well digging activities also increase very markedly during and sometime after the drought.

Drought and Impact in Municipal, Industrial, and Commercial Sectors

Municipalities, industry, and individuals within the State obtain water for day-to-day activities from surface sources, groundwater sources, or a combination of both. There is great variation in the adequacy of the sources that are being tapped ranging from those that are virtually inexhaustable even under concentrated pumping to those that are highly inadequate under virtually any

kind of precipitation drought. But a water source is no better than the system through which the water is obtained and distributed, and these water supply systems have essentially the same variation in terms of adequacy as the sources themselves.

In this investigation it was discovered that numerous cities have encountered water shortages on one or more occasions. In some instances one could state with relative accuracy that given cities have had chronic water shortages for many years almost irrespective of the drought severity. In other words there is a concern for water nearly as frequently as a drought is indicated by the Palmer index.

Unfortunately for those cities with chronic water shortages, and for other cities as well, demands for water generally increase significantly during a drought. This is also the period when the hydrological system is in the poorest condition for supplying water with or without adequate pumping facilities.

Since drought severity and the adequacy of water supplies vary, not all cities encounter a discernible pressure relating to their domestic needs at the same time. In fact some experience an increased use that is well within the adequacy of the water source and supply system.

But as droughts increase in severity, more and more cities are confronted with various degrees of water shortage. Usually the water superintendent or observant citizens recognize either increased usage or drops in reservoir levels. This situation may then be related by word of mouth or news media to the remaining citizens.

Drought may or may not result in more significant overt action than the increased watering of lawns or washing of cars in municipalities, and it appears that this is the extent of the reaction during most mild and moderate drought

in Illinois cities. There have, however, been many instances wherein more drastic, restrictive or corrective measures or both were resorted to, and as often as not, drought is simply a contributory factor occurring at a strategic period in an already marginal water supply situation.

Restrictions on the use of water for certain activities such as lawn watering and car washing are the most frequently used first-line defenses against peak water shortages. Should this type of measure be inadequate, restricting water use to certain hours of the day is another frequently used measure in conjunction with the other restrictions.

In cases where either one or both of these measures are inadequate, supplies are sometimes supplemented by hauling water for drinking purposes or extending temporary pipelines to new sources. Water hauling increases significantly in areas south of the Shelbyville Moraine and has become a profitable business particularly during periods of drought.

Unless such measures are required only during droughts of extreme severity of the type occurring for example about once in 15-20 years, cities doing so considerably more frequently have marginal to chronic water supply situations. A number of Illinois cities fit this categorization, and of these some might well discover one or two facts upon investigation:

(1) the total cost of temporary measures over several years has amounted to considerably more than it would have cost to take other measures which would have solved their problem for many years. The nature of these more appropriate measures moreover may have been readily obtainable from consultation with water resource experts in the State.

(2) leaks in the water supply system, if repaired, would enable the municipality to withstand far more severe droughts. Instances of leakage amounting to greater than 30 percent of total pumpage have been discovered. This is not to say that all marginal cities have a relatively favorable location or site with respect to a water source, for a permanent solution may involve a prohibitive cost under existing conditions.

The cost involved is, aside from a seemingly all too often indifference on the part of too many citizens, the major deterrent to nearly all water shortage problems. People seem to receive and accept the idea of partial abstinence from water more readily than they do the idea of increased costs of water or taxes in order to make their water situation more secure. But in either case there often seems to be a basic difficulty in convincing a very substantial part of the citizenry that a water shortage is at hand or is inevitable. The antics sometimes involved when citizens do realize the situation especially near election time are rather interesting and at times pathetic.

One type of reaction is found in cases in which the citizenry either justly or unjustly places the responsibility for the water shortage upon city water officials and ousts them from office on that premise. Another involves the official who uses the drought as a scapegoat, and the pending water shortage, as part of a propaganda and political move by demonstrating in some manner that he is making an effort to solve the water problem. However, upon being elected he may or may not continue his efforts.

Many water shortage situations have developed upon the rapid expansion of water use by unwary groups of cities, individuals, and industry. An occasional result is the development of friction pertaining to the use of the water available, particularly when droughts occur and the possibility of a shortage becomes

evident, when earlier users recognize a possible correlation between the water shortage and the new water users. In some of these cases drought in effect may just have brought a potentially critical situation to the forefront, viz. an overdevelopment of local water-production capacity.

A substantial number of municipalities have functioned, with a marginal water situation for many years. Some have had plans to expand their supply system for some time, but for one reason or other never implement them. One common occurrence involves a break in the drought time and again at a near critical point. Once reservoir levels begin to rise, thoughts are directed elsewhere. In effect these cities live from wet spell to wet spell.

When extreme droughts do occur such as those of the 1930's and 1950's, marginal cities increasingly are virtually pressured into doing something more permanent than during less severe periods. During the late thirties there was a very distinct rise in the number of reservoirs that were constructed largely because of the prolonged drought in conjunction with governmental programs (6).

Not only extreme drought motivates readily discernible measures, for the occurrence of less severe droughts in combination with other factors such as forceful civic leaders, technological improvements, the presence of a large water using industry, new government programs, or elections may combine to make expansion appear worthwhile and attractive, especially with respect to cost and resulting opportunities, such as recreation in and around newly constructed reservoirs. The most important impact of drought in many of these cases would seem to be that citizens become aware of their water situation.

Lesser Effects of Drought Impact

Although the apparent impact of drought relating to other facets of social activity may be relatively minor, it can be rather significant particularly within the realms of recreation and personal health. During periods of drought as stream flow decreases and demands for stream water increase, concentrations of pollutants often increase significantly, thereby resulting in injury or death to plants and animals, and deterioration in recreational value of stream courses. Increased pollution and the development of stagnant pools along river courses also increases dangers to human health, as well, in at least two respects. First, the probability of unsafe drinking water being consumed is increased. Second, favorable habitats are provided for disease carrying insects, particularly the mosquito, which upon proliferating, increases the probability of spreading diseases of which it is a vector.

Restrictions on the use of campgrounds may be deemed necessary as protection against the increasing probability of fires which increase as drought severity increases. The imposition may be felt in all sectors of society since people of all ages and occupations use these recreational facilities. Restrictions on their use naturally makes them less attractive.

Resort owners on lakes as well are susceptible to the impact of drought, especially on lakes having gently sloping bottoms. Drops in the water level of a foot or two can expose a large portion of unsightly lake bottom.

Drought and Management Decisions

There is considerable evidence to the effect that individuals and groups have and do consider drought in Illinois when making management decisions, when the activities to be carried on will require significant quantities of water.

Either these decision makers acquire the notion of precipitation variation within the State or elsewhere, or droughts of the past impressed them sufficiently to make it a factor in the decision-making process. To what degree drought is considered in this process, however, appears to vary considerably not only from area to area, but also within sectors of societies or occupations.

However, not infrequently ignorance seems to prevail and water-use activities are established as though all the necessary water will be obtainable within the area. There appears, even today, to be a basic misconception of the availability of water, for even otherwise highly responsible individuals do not study the local water conditions even when large quantities of water will be required. As a result these individuals are occasionally affected very substantially, and the situation serves as a good illustration of what one could appropriately term a culturally-induced drought. Even a moderate drought can produce an impact all out of proportion to those of similar severities in the past. In such a case the index would hardly indicate accurately the relative impact at a given point through time.

CONCLUSIONS

According to the Palmer system approximately 30 percent of the period from 1930 to 1960 has been classified as being part of a drought period ranging in severity from mild to extreme. Distinct effects on societal activity--economic, political, social, psychological, leisure--are relatively apparent in accounts, both verbal and written, of the periods classed as extreme. The impact attributable to mild or moderate drought is much more subtle and more difficult to detect and measure.

However in light of this investigation, how does the Palmer scheme of classifying drought severity in a meteorological sense, measure up to giving some indication of the impact that drought actually has upon Illinois society as reflected in certain variables? Palmer in essence delimited a drought hierarchy based in an ecological context, but ideally it would be possible to also use this scheme to characterize a drought hierarchy in a social context. To a degree it appears that the Palmer index can be used for this purpose.

As in plant and animal communities not all members of human societies are affected simultaneously with the same degree of impact. In societies, in particular those that are relatively static and/or primitive and heavily dependent upon unchanging biotic communities through time, the index would seemingly give a fairly accurate indication of the relative social impact of one drought compared to another.

However in more advanced and dynamic societies, where the relative constraints imposed upon the types of and successes of various activities by the natural environment are less, the application of the index becomes more questionable. Advanced cultures have made great strides toward creating an artificiality about the physical environment for humans and domesticated plants and animals, from which food and industrial commodities are obtained. Furthermore, there is essentially a constant quest in these societies to further reduce the effects of the natural variations in the elements of their environments.

Throughout time and particularly within the past 30 years or so, society in Illinois as well as throughout most of the United States has been highly dynamic in terms of technology and attitudes toward social welfare. Illinois society has had the advantages of the most advanced knowledge and technology for both the use of and modification of the environment for its benefit.

Because of a wide variety of public and private programs and advances being made to smooth out the effects of both physical and cultural occurrences, it is hypothesized that the total impact of a drought of given severity has been reduced significantly. More sophisticated methods have been implemented throughout society, viz. methods for actually obtaining, transporting, and/or retaining moisture brought through the precipitation process. Specifically soil and water conservation techniques, improved crop strains, water supply systems, and advanced techniques for determining the location and amount of water available enable water users to withstand the effect of drought in a more desirable manner today as compared with the past.

The roles of the Federal Government and some lower levels of government and private organizations present an increasing number of opportunities to groups and individuals to buffer themselves against the impact of drought. What seems to be suggested by this evolution is that the burden of the impact of drought is being shifted and spread over a greater segment of society or is being paid for in a different manner than in the past. The costs of the discovery, implementation, and financing of remedial measures and techniques ranging from "permanent" land terracing and reservoir construction to the more temporary water-use restrictions and aid, financial or otherwise, are, for example, paid for in a variety of ways by different sectors of society. Yet the earlier premise that the total potential impact of a drought of given severity has also been decreased through time may hold as well.

In effect, then, the underlying concept upon which the Palmer index is formulated, viz., "the near-normal operation of the established economy of an area during some stated period is dependent on the average climate of the area and

on the prevailing meteorological conditions both during and preceding the month or period in question," has been changing relatively rapidly through time, but differentially from place to place and within society, while the nature of the hydrological system remains essentially unchanged through long periods.

There is considerable variability from individual to individual and from group to group with respect to the effects of this evolution of the moderation of the impact of drought. This variability, it is suggested, depends in part upon the amount of water needed for established operations, the criticalness of the given quantities of water required, or the manner in which water is supplied. For example, it is suggested that the implementation of programs and measures have reduced the potential impact to a greater relative degree in the sectors whose welfare depends directly upon normal crop yields, i.e., the agriculturist, than in the industrial-service oriented communities.

Through time the State's population has become increasingly urban oriented, and the number of persons dependent directly upon normal crop yields is decreasing. This fact in conjunction with man's increasing ability to use the precipitation that is received more efficiently and effectively seems to substantiate further the premise that the total impact has decreased through time.

Within the industrial-service urban sector as well as techniques for locating, obtaining, and storing water have been refined. However, the use of water is becoming more highly concentrated and the probability of overdeveloping an area's water resources is increasing. This situation is intensifying through time, but unlike the agricultural sector, the industrial-service urban sector can either extend its water supplying area or reuse much of the water previously allowed to return to the stream systems.

This is not to say that these advances and the ability to implement them is an assurance that drought of the future will not also have a very significant impact on Illinois society, for another important aspect relating to the dynamic nature of society concerns its increasing ability to "overdevelop" the water resources of an area thereby creating critical situations not occurring in the past or in less advanced societies at present.

Palmer states that he did not consider this aspect of drought; but in considering the impact of drought through time and space in a state such as Illinois where the population is becoming rapidly urbanized, it seems highly desirable to subject the concept of meteorological drought, as defined, to the test in the realm of manmade or culturally-induced drought. In a sense all drought is manmade if severity is based upon the impact on an established economy, and economy that is not dependent almost wholly upon non-domesticated plants and animals such as the few primitive societies of the world. Both the positive and negative implications of man's actions are important in any final evaluation of the validity of meteorological drought.

Within the social realm measurement of impact objectively in the economic sphere seems to have the most promise because of the nature of the data. However, the impact at any one time in the political, social, and recreational spheres may be as significant as in the economic sphere. On the other hand, political, economic, social, psychological, and recreational effects are nearly always very closely interrelated.

Thus in summary it would appear that:

- 1) The more severe a drought becomes, as measured by the Palmer index, the greater the proportion of societal members who feel its impact.

2) The impact of drought increases at a greater rate than the rate of increase of severity as indicated by the Palmer index.

3) Drought can have (produce) both positive and negative effects.

4) The impact of a given drought in Illinois has been reduced through time.

5) The impact of drought has been spread more evenly through society through time.

6) Because of rapid overdevelopment of water resources, potentially critical water situations have been created.

7) There is both regional and within-sector of society variation in response to drought, and not all regions or sectors of society have the same ability to reduce the potential effects of drought through time.

8) The impact of comparable extreme droughts, as indicated by the Palmer index, is greater in the more arid western U. S. than in Illinois. The same degree of societal disruption as has occurred in the Great Plains, e.g., never occurs in Illinois.

Aside from the questions that remain unanswered as suggested by the tentativeness of the aforestated conclusions, the following questions for further study may also be listed:

1) How can effects of drought be isolated from the many other factors that influence the distribution and utilization of water?

2) What techniques should be used in the attempt to isolate the impact of drought?

3) What effects merit study? In which areas should study be concentrated? Should studies of this nature be conducted at this time?

4) Why do some individuals or groups work out their water problems long before other groups in seemingly similar situations?

5) Why do many persons seemingly take water supplies "for granted"?

6) Why do people react differently to the impact of drought?

- (1) Thornthwaite, C. W., "Climate and Moisture Conservation," Annals, Association of American Geographers, Vol. 37, (1947): 87-100.
- (2) Palmer, Wayne C., Meteorological Drought, U. S. Dept. of Commerce, Weather Bureau, Research Paper No. 45, G.P.O.: Wash., Feb. 1965.
- (3) Edwards, A. D., "Effect of Drought and Depression on a Rural Community: A Case Study of Haskell County, Kansas," Ph.D. Thesis, Duke University, 1936.
- (4) Drouth: A Report, (Prepared Under the Direction of the Special Assistant to the President for Public Works Planning), Wash.: G.P.O., 1958 (Oct.)
- (5) Huff, F. A. and Changnon, Jr., S. A., Drought Climatology of Illinois, Illinois State Water Survey Bulletin 50, Urbana, 1963.
- (6) Hudson, H. E., and Roberts, W. J., 1952-1955 Illinois Drought With Special Reference to Impounding Reservoir Design, Illinois State Water Survey Bull. 43, Urbana, 1955.
- (7) Gallagher, James W., "Drought in Southern Illinois" Ph.D. Thesis, University of Illinois, 1959.
- (8) Atlas of Illinois Resources, Section 1, Water Resources and Climate, Ill. Div. Ind. Plan. and Devel., Springfield, Ill., 1958.
- (9) Mueller, A. G., Dept. of Agricultural Economics, Univ. of Illinois.
- (10) Mr. Leslie Rogers, Farm Advisor, Marion Co., Salem, Ill.
- (11) Walker, Wm. H., et.al., "Preliminary Report on the Ground-Water Resources of the Havana Region in West-Central Illinois," Ill. State Water Survey and State Geological Survey, Cooperative Ground-Water Report 3, Urbana, 1965.
- (12) Guither, Harold D., "Characteristics, Motivations, and Adjustment Problems of Farmers Who Leave Farming," Ph.D. Thesis, University of Illinois, 1962.