NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA AND INFORMATION SERVICE
NATIONAL CLIMATIC CENTER

THE STATE CLIMATOLOGIST

IN COOPERATION WITH THE
AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS

VOLUME 6 NUMBER 4 OCTOBER 1982
PUBLISHED QUARTERLY AT THE NATIONAL CLIMATIC CENTER, ASHEVILLE, N.C.

1951-80 Normals. The 1951-80 monthly normals of temperature, precipitation, and heating and cooling degree days have been published. Maximum, minimum, and mean temperature normals and heating and cooling degree day normals have been prepared for 3,017 cooperative and 332 first-order stations. Precipitation normals have been prepared for 5,179 cooperative and 332 first-order stations. Sequential data listings have not been printed, but they will be available on microfiche. The normals and sequential listings are also available on tape. (N. Guttman, FTS 672-0319)

****

Publications. The following publications by M. J. Changery of the National Climatic Center have been published by the U.S. Nuclear Regulatory Commission:

1. National Thunderstorm Frequencies for the Contiguous United States, NUREG/CR-2252, published November 1981.

2. Historical Extreme Winds for the United States - Atlantic and Gulf of Mexico Coastlines, NUREG/CR-2639, published May 1982.

3. Historical Extreme Winds for the United States - Great Lakes and Adjacent Regions, NUREG/CR-2890, published August 1982.

A limited supply of each publication is available from the National Climatic Center. (R. G. Quayle, FTS 672-0765)

****

Data Inventory. The National Climatic Center (NCC) has printed an 80-page draft Inventory of Sources of Long Term Climatic Data in Microfilm and Publication Form by H. Diaz, E. Funderburk, III, and M. Burgin. The project was funded partly by DOE under the auspices of their CO_2-climate program, which requires historical climatological data. The sources documented in the publication have been collected by NCC and the Climatic Research Unit, University of East Anglia, Norwich, England. A limited supply is available from the NCC. (Robert G. Quayle, FTS 672-0765)

AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS

ANNUAL BUSINESS MEETING
Charlottesville, Virginia

The business meeting was called to order at 10:45 a.m., August 13, 1982 by President Dethier.

Chairman Plummer (Georgia) of the State Programs Committee reported that a lack of activities precluded a formal report. He identified the climatic divisions in Georgia as a problem and suggested that the climatic divisions might be an area for study by the AASC.

Chairman Schaal (Indiana) of the Relations with EDIS and NWS Committee reported no actions during the past year. He recommended that liaison between the State Climatologists and the Network Specialists be established within each State.

Chairman Molnau (Idaho) of the Computer Committee submitted a written report. That report is attached to these minutes.

Chairman Michaels (Virginia) of the Constitution and Bylaws Committee distributed the revised constitution to members present. A copy of the revised constitution is attached to these minutes.

Chairman McKee (Colorado) of the Nominating Committee submitted the nominations of Dr. Robert A. Muller (Louisiana) for President Elect and Dr. Kenneth G. Hubbard (Nebraska) for Secretary-Treasurer. These individuals were elected by acclamation.

Minutes of the 1981 meeting as published in The State Climatologist were approved without opposition.

Secretary-Treasurer Conner (Kentucky) presented the financial report which is appended to these minutes.

President Dethier reported on several meetings which he attended during the past year. He reported four problem areas which require attention. First, no one should speak for the AASC except the President and the Executive Board. Second, we should encourage non-member State Climatologists to join our Association. Third, the question of dues should be addressed next meeting because, as the sole source of

funds, the current dues are insufficient to support the required travel of the President. Finally, the question of members versus associate members remains and a committee should be appointed to investigate and recommend action.

President Dethier opened the meeting for nominations for Associate Membership in the AASC. Griffiths (Texas) nominated George Bomar, Wise (Alaska) nominated Ken Hadeen, Waite (Iowa) nominated Larry Schaal, Goodridge (California) nominated John James, McKee (Colorado) nominated Lowell Krawitz and James Rahn, Mather (Delaware) nominated Daniel Mitchell, Michaels (Virginia) nominated Mark Perry, Havens (New Jersey) nominated Stan Changnon, and Conner (Kentucky) nominated Charles Bach. Nominations approved without opposition.

President Dethier moved that President Elect Nurnberger send a letter of appreciation from the AASC to Val Mitchell and Larry Schaal for their support and contributions to the Association. Seconded by Waite (Iowa) and approved without opposition.

President Dethier moved that he draft a letter to Joe Friday and Margaret Courain expressing appreciation for the presentations made by the Federal representatives at this meeting. Seconded by Nurnberger (Michigan) and approved without opposition.

McKee (Colorado) complimented Peter Robinson's performance in the National Climate Program Office. He also expressed best wishes to Bernie Dethier who is replacing Robinson in that office.

President Dethier extended thanks to Pat Michaels (Virgina) and his staff for the superb support of our meeting and the hospitality of the University of Virginia. All members present joined in that acclaim.

President Dethier gave the gavel to the new President Nurnberger who thanked President Dethier for his leadership during the past year. The members voiced their approval of President Dethier's efforts in our behalf.

President Nurnberger expressed the Association's gratitude to Secretary-Treasurer Conner for his work in that office during the past two years.

President Nurnberger opened with a discussion of the committees. There was general agreement that the current committees could be continued except for the Storm Data Committee. That Committee's work is effectively completed

with the improvement now evidenced in the Storm Data publication. The President will consider appointing a Publications Committee to address other publications. Murphy (Oregon) suggested that a committee on the value and utility of climatic information be established. Support for such a committee was voiced by the members. Discussion of the quality of data included suggestions of a committee to investigate quality. President Nurnberger took the suggestions for committees under advisement and will announce committee appointments at a later date.

McKee (Colorado) stated his support for retention of the current membership and voting procedures. His views were supported by the membership and re-opening these issues was opposed.

Several invitations were proffered for a meeting location for the 1983 meeting. The membership voted to accept the invitation to hold the 1983 meeting at Asheville, North Carolina with the National Climatic Center as the host.

Wise (Alaska) extended an invitation to meet in Alaska in 1984. No action taken on this most gracious offer.

A list of attendees at the meeting is attached to these minutes.

The business meeting was adjourned at 12:00, August 13, 1982.

FINANCIAL STATEMENT

Balance as of 13 August 1981	$2,533.67
Dues collected	280.00
Total	$2,813.67
Expenses 13 August 1981 - 11 August 1982	
Colorado State University (1981 meeting)	$1,203.82
President's Expenses	350.00
Secretary's Expenses	5.00
Total	$1,254.85
Registration, Fees, Dues Collected 12-13 August 1982	$3,168.00
Expenses relative to 1982 meeting	
University of Virginia	$1,750.00
Other	209.00
Total	$1,959.04
Balance as of 15 September 1982	$2,463.81

University of Idaho
Department of
Agricultural Engineering
Moscow, Idaho/83843
(208) 885-6182

DATE: August 4, 1982

TO: AASC Membership

FROM: Myron Molnau, Computer Committee Chairman

SUBJECT: 1981-82 Computer Committee Report

This last year was not a very active one for the Computer Committee. This was not the fault of the Committee members but a result of procrastination and drastic reallocation of time on my part.

The primary activity was the operation of the program exchange. A total of 59 programs were submitted to the program exchange. A list of these was mailed to the membership in June. I have received requests for several of the Idaho programs but have no idea as to the usefulness of this exchange. I feel that this could be a useful continuing service to the membership.

Two items have been brought to my attention that need some thought by AASC. The first is that the $500 allotment from NCC has been very useful, especially to those who obtain data or tapes. In view of the dramatic increase in costs for a tape, this $500 does not buy enough to keep the state files updated. AASC should thank NCC for help in the past, encourage NCC to continue it in the future, and ask for an increase if possible to $700 to $1,000. The second item is the development of the new cooperative data processing system as reported in the April 1982 issue of the State Climatologists. The use of this system results in two tapes, an original tape, and one with "corrected" or "predicted" values in it. This poses a real dilemma for those who rely on these tapes for data base updating. To be complete, two tapes now need to be ordered, at least until the SC and user community establish confidence in the new system.

Items which next years Committee ought to consider are:

1. Should more application type programs be solicited for the program exchange? Most of the present programs are merely to read the NCC format tapes and output fairly simple tables.

2. Should programs from non-AASC members be solicited?

3. A detailed study of the new data processing system could be instituted, sponsored by AASC, NCPO, and NCC. This could determine (from the SC point of view, not as NCC sees it) the usefulness of this system over widely varying climatic conditions and the effects of the change on "typical" station statistics.

mjm

CONSTITUTION

AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS

I. Name

This non-profit organization shall be called the American Association of State Climatologists.

II. Objectives

The objectives of the Association are to:

1. Promote cooperation between State Climatologists and and those federal, state, and private agencies whose functions include the collection, analysis and dissemination of climatic information;

2. Facilitate exchange of information among State Climatologists, and

3. Provide mutual assistance in the development of effective State Climatologist programs.

twithstanding any other provision of these articles, this sociation shall not carry on any other activities not per- cted to be carried on by (a) an Organization exempt from deral Income Tax under Section 501(c) (3) of the Internal venue Code of 1954 or the corresponding provision of any ture United States Internal Revenue Law or (b) an Organ- ation contributions to which are deductible der Section 170(c) (2) of the Internal Revenue Code of 1954 or the corresponding provision of any future United ates Internal Revenue Law.

ssolution

on the dissolution of the Association, the Executive Board all, after paying or making provision for the payment of l liabilities of the Association, dispose of all the assets the Association exclusively for the purpose of the Associ- ion in such manner, or to such organization or organizations ganized and operated exclusively for charitable, educational, scientific purposes as shall at the time qualify as an ex- pt organization or organizations under Section 501(c) (3) the Internal Revenue Code of 1954 (or the corresponding ovision of any future United States Internal Revenue Law), the Executive Board shall determine. Any of such assets t so disposed of shall be disposed by the Superior Court the county in which the principal office of the Association then located, exclusively for such purpose or to such or- nization or organizations, as said Court shall determine, ich are organized and operated exclusively for such purposes.

IV. Membership

1. The Membership of the Association shall consist of:

Voting Members Voting Members

Associate Members.

2. Any person who is currently recognized by the Director of the National Climatic Center and a state agency as an official State Climatologist shall become a Voting Member upon voluntary registration of his or her name and address with the Secretary of the Association, and payment of dues.

3. Any person who subscribes to the Constitution and By-laws of the Association shall be eligible for Associate Membership upon nomination by one or more Voting Members and election by a majority of Voting Members, and payment of dues. Associate Members shall be entitled to all rights and privileges of Association Membership except the right to vote and the right to hold office.

Officers V.

Elected A.

1. In order to direct the activities of the Association toward its objectives an Executive Board, elected by majority vote of Voting Members, shall consist of a President, who shall be the immediate past President-Elect; a President-Elect; the immediate Past President, and a Secretary-Treasurer. Each must be a Voting Member of the Association. Their duties shall be those normally assigned to comparable offices in national scientific organizations.

2. Regular terms of office shall be for one year, or until the next Association meeting following the regular one-year term.

3. The Secretary-Treasurer shall be eligible for re-election.

4. If the Office of the President becomes vacant, the President-Elect shall assume that office for the unexpired term.

5. A vacancy in the unexpired term of the President-Elect shall be filled by election at the next meeting of the Association.

6. The President shall appoint a Voting Member of the Association to fill a vanancy in the office of Secretary, effective for the unexpired term.

B. Ex-officio

For the purpose of coordinating Association activities with the functions of the National Climatic Center and related federal agencies, the Director of the National Climatic Center shall be invited to appoint an ex-officio, advisory member of the Executive Board.

VI. Council

1. The Council of the Association shall consist of all registered Voting members of the Association, including officers of the Executive Board, who shall be ex-officio officers of the Council.

2. Council members shall have the responsibility to promote communication between the Association and their respective State Governments.

3. The Council shall be the body which represents the Association in official transactions with federal, state, or private agencies and in announcements to the public at large.

4. All corporate powers of the Association shall be vested solely in the Council.

5. A majority of Council members voting may direct the Executive Board to act on behalf of the Council for specified purposes.

VII. Amendments

1. This constitution may be amended only by a mail ballot of the Voting Membership of the Association, or by Voting members attending the annual open meeting.

2. Submission of a proposed amendment to the Association shall require a majority vote at a scheduled meeting or a petition to the Executive Board signed by at least ten Members.

3. Adoption of an amendment shall require a two-thirds majority of Voting Members who cast a vote.

BY-LAWS

1. The rules contained in Robert's Rules of Order Revised shall govern the Association in all cases to which they are applicable, and in which they are not inconsistent with the Constitution or By-laws of the Association.

2. The Executive Committee shall levy membership dues. Any Association action which involves financial obligations shall incorporate a provision to meet each obligaion on an ad hoc basis.

3. Meetings

The time and place for each meeting of the Association shall be designated by the Executive Board. Ordinarily, the Executive Board will solicit the advice of members at one meeting to determine the time, place, and tentative agenda for the next meeting. A meeting at which a quorum is present shall constitute an official meeting of the Council.

4. Quorum

A quorum for a meeting of the Association shall be a majority of the voting membership.

5. Invited Participants

The Executive Board shall be empowered to invite non-voting observers or advisors to attend meetings of the Association for any purpose that is consistent with Association objectives.

6. Nomination of Officers

A Nominating Committee, consisting of three Voting Members and elected by a majority vote of the Council, shall prepare a list of candidates in advance of an announced election. A nomination for any office may also be made by the signed petition of five or more Voting Members. Officers of the Executive Board are not eligible to serve on the Nominating Committee, nor to sign a nominating petition.

7. Elections

Elections normally shall be held at meetings of the Association. The Executive Board shall be empowered to arrange an election by mail ballot when circumstances warrant.

AASC Meeting Attendance

August 12-13, 1982

James A. Amazan	National Advisory Commission on Oceans & Atmosphere
Charles Bach	Assistant State Climatologist - Tennessee (TVA)
William D. Bartlett	National Climatic Center
Tom Blackburn	Climate Program Leader, NWS, Silverspring, MD
George Bomar	Texas Dept. of Water Resources
Martha Buffum	University of Virginia
Norman Canfield	University of Maryland
Eugene A. Carter	State Climatologist - Maryland
Stanley Changnon	Director, Illinois State Water Survey
Charles Chimento	Assistant State Climatologist - Louisiana
Glenn Conner	State Climatologist - Kentucky
Margaret Courain	Acting Director - EDIS
Arnold Court	California State University, Northridge

Earl Kuehnast	State Climatologist - Minnesota
Kenneth Kunkel	State Climatologist - New Mexico
Jim Laver	CAC, NMC
David Ludlum	"Weatherwise"
John Mather	State Climatologist - Delaware
Thomas McKee	State Climatologist - Colorado
Patrick Michaels	State Climatologist - Virginia
David Miller	State Climatologist - Connecticut
Joseph Moyer	State Climatologist - Maryland
Robert Muller	State Climatologist - Louisiana
Allan Murphy	State Climatologist - Oregon
Fred Nurnberger	State Climatologist - Michigan
Gaylon Plummer	State Climatologist - Georgia
William Pogerman	National Weather Service
John Purvis	State Climatologist - South Carolina
James Rahn	Consulting Climatologist - Camp Hill, Pennsylvania
Malcom Reid	National Oceanic & Atmospheric Administration
Peter Robinson	National Climate Program Office/NOAA (Also represented the North Carolina State Climatologist)
Lawrence Schaal	State Climatologist - Indiana
Tom Schmidlin	Cornell University
August L. Shumbera	National Climatic Center
Art Snider	SNS, Baltimore, MD
Jerry Stenger	University of Virginia
Norton Strommer	USDA/WAOB
Ed Tiernan	EDIS/NOAA
John Vogel	RCCO/Illinois State Water Survey
Paul Waite	State Climatologist - Iowa
Chester Wayland	University of Virginia
Wayne Wendland	State Climatologist - Illinois

Donald Whitman	National Weather Service
James Wise	State Climatologist - Alaska

Alaska Climate Center

Arctic Environmental Information and Data Center
University of Alaska
707 A Street
Anchorage Alaska 99501
(907) 279 - 4523

David M. Hickok, Director

James L. Wise, State Climatologist

LOCATION

The Alaska Climate Center is located at AEIDC in downtown Anchorage 707 A Street, 907-279-4523, and is open to the public during regular business hours.

INFORMATION

Analysis of weather information is important for such things as the design of efficient heating systems in Alaska; the design and construction of buildings; the settlement of legal cases and insurance claims; the siting of energy facilities; and numerous other projects related to planning, construction, transportation, and resource development. Though the National Weather Service monitors the weather and makes forecasts around the clock, it is the state climatologist who responds to needs for historical data, defines long- and short-term trends, and applies that information to current problems.

The Arctic Environmental Information and Data Center has provided climate information and analysis in Alaska for nearly a decade and is home base for the state climatologist. Formerly, this was a position under the National Weather Service, but the federal government abandoned the program nationwide in 1973. In Alaska, climatology services were assumed and continue today through AEIDC.

SERVICES

The center houses complete records of climate information, including temperature and precipitation data, from several hundred official climate reporting stations in Alaska. The Center also contains aviation weather information from participating airports throughout the state and additional climate data from state and private sources outside the official network of reporting stations.

All information is available for in-house study. Some may be taken out on loan. For ease of research, a microfiche and microfilm reader/copier and a copier/duplicator are located in the center for public use. The state climatologist and his staff assist users in defining their information needs and finding data which best applies to particular questions. Inquiries may be made in person, by telephone, or by written correspondence. Most services are free of charge or for a nominal copying charge. Upon request, the state climatologist is prepared to give lectures statewide on Alaska's climate and all aspects of applied climatology.

In the past four years the number of requests for climate services in Alaska has more than doubled. With the establishment of a formal state climate center and program, AEIDC looks forward to greater expansion and improvement of its current climate services.

James L. Wise, Alaska State Climatologist discusses availability of data with user.

PUBLICATIONS

The Alaska Climate Center at AEIDC has produced the following publications which are used extensively throughout the state and outside.

Storm Surge Climatology and Forecasting analyzes the occurrence of storm surges in Alaska and discusses a new method for forecasting potential areas and times for flooding which might affect coastal communities.

Superstructure Icing is a forecasting guide for ships and drilling platforms in Alaska waters which outlines weather parameters conducive to heavy and dangerous icing on the rigging. In the past, this occurrence has caused the sinking of ships and loss of crews in a matter of only a few hours.

The Climatic Atlas of the Outer Continental Shelf and Coastal Regions of Alaska maps winds, waves, and frequency of storms off the coast of Alaska. This is an important document for planning of shipping, aviation, fishing, and the exploration and production of mineral resources.

Alaska Solar Radiation Analysis examines the daily radiation statewide during the past three decades to provide needed background information to alternative energy projects under consideration.

Climate Planning Advisory Group

James Barkshire
Polarconsult Energy Group, Inc.

William Long, Ph.D.
Division of Geological and Geophysical Surveys
Alaska Department of Natural Resources

Edward D. Diemer, Ph.D.
National Weather Service

George P. Clagett
Soil Conservation Service
United States Department of Agriculture

Gunter Weller, Ph. D.
Geophysical Institute
University of Alaska

Joseph E. Ostrom
Northern Technical Services

Richard Mikkelsen
Alyeska Pipeline Service Company

Vic Ferreros, Ph.D.
Division of Policy Development and Planning
Office of the Governor

E. Richard Logan, PH.D.
Habitat Protection Division
Alaska Department of Fish & Game

WEATHER MODIFICATION

by
E. Arlo Richardson
Utah State Climatologist

During the last 25 or 30 years much has been written and voiced about weather modification. At the Salt Lake City International Airport, nearly every winter during the last several years hundreds of pounds of dry ice have been spread across the top of the dense fog to clear an opening for commercial, as well as private, aircraft to land and take off under conditions which a few years ago would have been impossible.

During the last decade the Utah Department of Water Resources has, under the direction of the state legislature, supervised a cloud seeding program to increase the winter rainfall and/or snowpack in several areas of the state. In 1980 there were over 50 Weather Modification operations reported in the U. S. covering selected areas of some 20 states.

A more recent form of Weather Modification is that of hail suppression and/or lightning reduction. The U. S. and Canada have concentrated on the use of aircraft and ground seeders to reduce hail while other countries are testing small rockets and artillery shells to deliver the seeding material into the sensitive portions of the clouds. The Soviet Union reports that hail damage has been decreased by some 70%. In the U. S. the Forest Service feels that they have been able to reduce lightning-caused damage by some 30% during their experimental program.

In addition, tests are being run on the seeding of Hurricanes to decrease the impact of these storms on adjacent land masses as they sweep inland. The energy involved in such thunderstorms and hurricanes is indeed tremendous. It has been estimated that the energy released during a single day of the life of an average hurricane exceeds the equivalent of some 10,000 one-megaton hydrogen bombs. During the average 10 day life of such a storm system enough energy is released that, if it could be harnessed, it would provide enough electrical energy to meet the needs of the nation for the coming million years. The average thunderstorm releases the equivalent of some 20 weapons the size of those dropped on Hiroshima.

However, this form of weather modification is not all on the positive side. Many lawsuits have been filed by individuals as well as political entities in reference to Weather Modification. While, to date, none of these suits involving damage claims or alleged harm have been successful, the legal problems related to weather modification are almost as great as the problem of weather modification itself.

If man can increase the summer rainfall, for example, who will decide when the seeding should be done. The farmer with his hay down in the field or the one who urgently needs additional rainfall to fill out the grains of wheat or corn in his field? What about the flood that causes damage in the millions of dollars? Was it caused by cloud seeding or not? Does cloud seeding take away moisture that would normally fall further down stream? These are only a few of the legal implications that are already creating serious problems in the courts.

With all the emphasis on current mesoscale and possible macroscale modification of certain aspects of the weather, most of us have completely overlooked the fact that, in reality, man has been modifying the weather on a microscale for many thousands of years. Almost all of our building construction, for example, is done to modify the environmental conditions in which we live.

****

American Weather History Center

An American Weather History Center (AWHC) will be established in Princeton, New Jersey, to enccurage the study, analysis, and publication of materials relating to regional, state, and local weather history. The Center looks forward to stimulating the production of a "state weather book" for each of the fifty states, and pamphlets of lesser regional and local studies.

The purposes of the American Weather History Center will be:

- To encourage the writing and publication of regional, state, and local weather histories.
- To make available the data in the "Ludlum Collection" through photocopying to all serious students of the field.
- To serve as a source of historical weather information not available through the National Climatic Center in Asheville.
- To conduct annual prize essay contests in various colleges and universities that teach meteorology and climatology and to facilitate their publication in appropriate journals.
- To serve as a clearinghouse for the distribution of books in the field of American weather history.

The American Weather History Center will be organized as a tax-exempt education foundation. It will originally be funded through the publishers' royalties and local receipts of sales of the books written by David M. Ludlum. The AWHC will commence operations about January 1, 1983, when legal details and business organization have been completed. Meantime, the Center would be pleased to receive comments from the Weatherwise community as to ways to achieve the above goals. Address, Box 230, Princeton, NJ 08540.

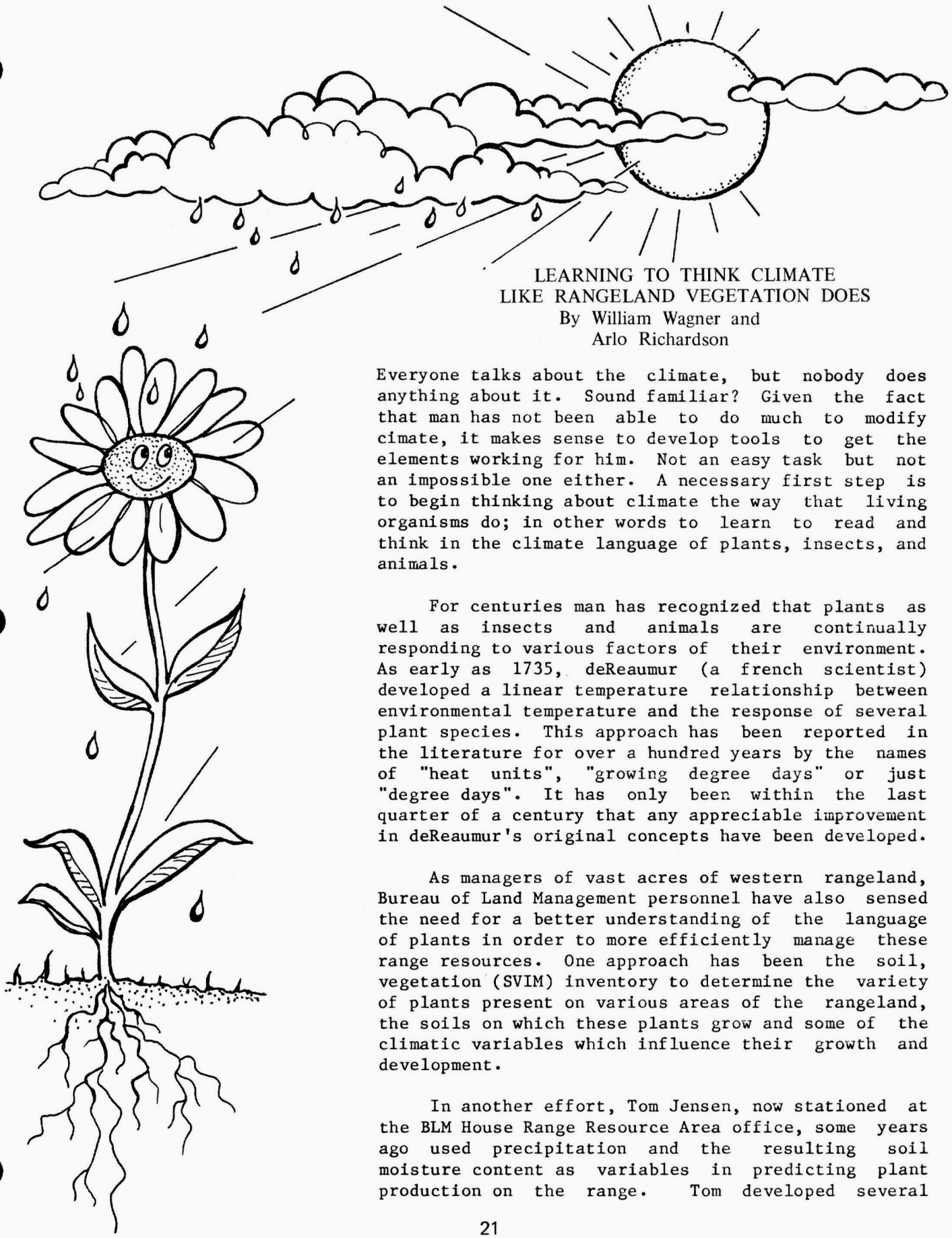
Edna Anderson of the Illinois State Water Survey Retires

Every organization has a few people who have the knack of remembering each of the many data sets that they have seen over the past years, remembering the parameters which were included, and furthermore remembering where it is stored. Edna Anderson has been with the Illinois State Water Survey for over 22 years and has completed much of the climatic data gathering and analysis for research and service, which has been published over that time. She retired at the end of August 1982 and will enter private business in Belleville, Illinois.

Over the years, Edna has contributed toward many research programs at the Survey, including analysis of raingage graphs from the many mesoscale networks which have been maintained over the past two decades; measurement and analysis of the hail pads also placed in mesoscale networks; and gleaning observations of the cooperative network. She is an absolute master at finding data sources, and probably knows the record of the Illinois Cooperative Staion as well as anyone.

We will miss her devoted service to the Survey and her smiling face.

****



LEARNING TO THINK CLIMATE LIKE RANGELAND VEGETATION DOES

By William Wagner and
Arlo Richardson

Everyone talks about the climate, but nobody does anything about it. Sound familiar? Given the fact that man has not been able to do much to modify cimate, it makes sense to develop tools to get the elements working for him. Not an easy task but not an impossible one either. A necessary first step is to begin thinking about climate the way that living organisms do; in other words to learn to read and think in the climate language of plants, insects, and animals.

For centuries man has recognized that plants as well as insects and animals are continually responding to various factors of their environment. As early as 1735, deReaumur (a french scientist) developed a linear temperature relationship between environmental temperature and the response of several plant species. This approach has been reported in the literature for over a hundred years by the names of "heat units", "growing degree days" or just "degree days". It has only been within the last quarter of a century that any appreciable improvement in deReaumur's original concepts have been developed.

As managers of vast acres of western rangeland, Bureau of Land Management personnel have also sensed the need for a better understanding of the language of plants in order to more efficiently manage these range resources. One approach has been the soil, vegetation (SVIM) inventory to determine the variety of plants present on various areas of the rangeland, the soils on which these plants grow and some of the climatic variables which influence their growth and development.

In another effort, Tom Jensen, now stationed at the BLM House Range Resource Area office, some years ago used precipitation and the resulting soil moisture content as variables in predicting plant production on the range. Tom developed several

relationships to predict total range production on ranges in northern Arizona and in the House Range Area. These relationships are quite site specific and new equation constants are required for each specific geographical area.

Researchers at Utah State University, cooperating with the Climatologist for the State of Utah have also been working on the problem. In trying to develop methods of protecting fruit trees from the damage caused by early spring frosts these researchers expanded man's understanding of the manner in which plants respond to their temperature environment.

They found that, in terms of growth or development, plants respond to certain limiting temperature values. The limits recognized by USU researchers, called cardinal temperatures are:

1. The lower lethal temperature - the temperature below which the plant tissue may be damaged or often killed.

2. The base temperature - the temperature above which growth and development of the plant occurs.

3. The optimum temperature - the temperature at which the maximum rate of development or growth occurs.

4. The critical temperature - the temperature above which little or no growth or development will occur.

5. The upper lethal temperature - the temperature above which damage to plant parts or death will occur.

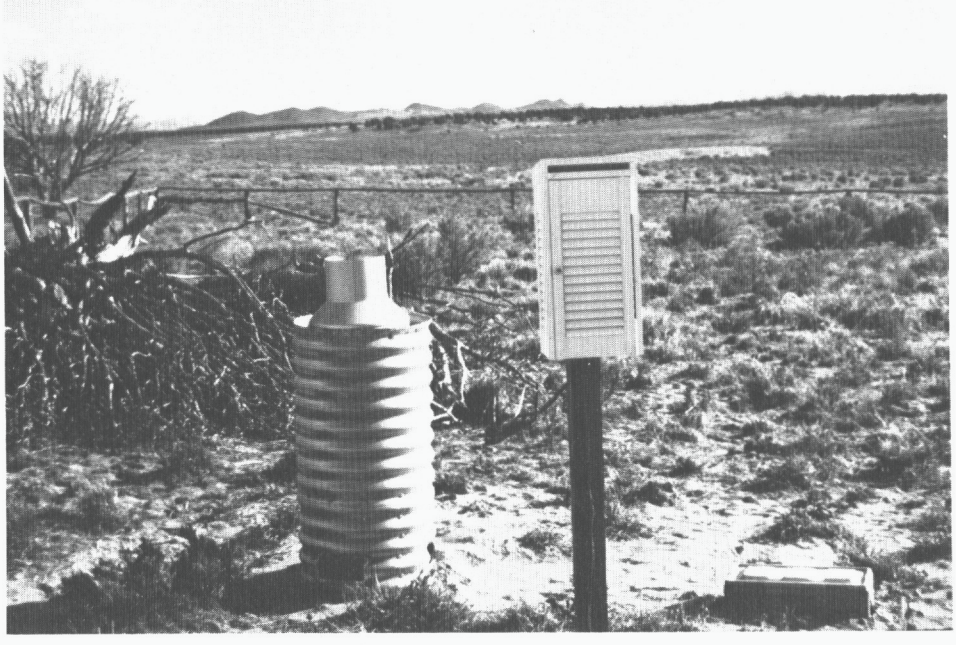
These cardinal temperatures are quite species specific and have been integrated into growth curves for several plant species. These growth curves define the rate at which average plants of the species will develop under any type of temperature environment.

It appears that over the centuries of plant evolution the language used by mother nature to control development has been that of establishing limiting conditions above and below which the plants do not respond. If for example, soil moisture is too limiting the plant cannot utilize all of the temperature energy (i.e., growing degree hours) with which it is supplied and its rate of development will decrease. If the moisture deficit becomes too great the plant will die. Conversely if the moisture content is too great (which doesn't happen too often on BLM ranges) the plant will be unable to survive because it cannot obtain the necessary oxygen and other nutrients from the soil.

Temperature and moisture are only two of the dialects used by mother nature to speak to plants. Other factors include nutrition, daylength, light quality, amount of incident solar radiation, soil character and condition, humidity, disease and insect damage and many others. To further complicate the language of mother nature many of these controlling factors are interactive and their influence on plant development must be integrated or combined.

Let's look, for example, at the influence of daylength on plant phenology. Some of the grasses whose fruiting stage is controlled by daylength cannot respond to mother nature's daylength dialect until the plant has reached a

Arlo Richardson, State Climatologist, with John Wullschleger and Jean Nitschke Sinclear of the Vernal District prepare a monitoring site.



A complete monitoring site model which will collect climate and weather information to be used in rangeland management decisions.

certain stage of maturity (that is, accumulated a certain number of energy units or degree days). Some grasses, for example, must develop 3 or 4 leaves which may require several weeks or even a month or more, depending upon the temperature. Further, the grass interprets the daylength signal in a somewhat different manner than the same plants that have a sharp yes or no trigger, the longer the duration of daylight at the time the plant becomes sensitive to the trigger, the greater the growth of the plant before it will develop its inflorescence.

The Utah State Climatologist, Arlo Richardson, and his co-workers have developed a response curve which includes the capability of combining the response of temperature and other limiting climatic variables once their interactive relationships are understood, or in more simple terms once we learn to reason and think in the language of plants.

As yet we have only scratched the surface in learning to read the language of plants but we now know many of the techniques required to improve our capability.

Three members of the Utah State Office staff, Steve Leonard, Bill Wagner and Mark Green are presently involved with Arlo Richardson in a cooperative project to develop and refine capabilities for predictng vegetative growth stages and total biomass production of key rangeland grass, forb and shrub species. The objective of the project is the development of comprehensive models that can be used effectively as an analytical tool by rangeland and other resource managers as an aid in planning and decision making in the management of rangeland resources and administrative programs. The project has included the development and operation of intensive climate monitoring stations to measure soil and air temperature, soil moisture, precipitation and solar radiation. Associated with each monitoring site has been an intensive effort to obtain plant phenotypic data on key rangeland species through the growing season. The climate and phenotypic data are being gathered through the intensive efforts of the district and resource area personnel in each of the five Utah districts. Based on encouraging results of a year long feasibility study in 1980 and 1981, the project was continued this year to pinpoint the more important soil and atmospheric factors which relate to phenology, growth, and production of specific range species. The project crosses a number of resource specialty lines with a need for soils, climatic, and vegetative information.

How do Arlo, Bill, Steve and Mark see the results being used? Perhaps the most important use is the prediction of rangeland phenological development and producton for use in grazing management. Grazing treatments are usually keyed to plant development and/or an allowable utilization of current year production of key species. In the past, timing of grazing treatments has been designed around dates representing plant development and production estimates for a "normal" year. To achieve maximum plant response or benefit to the user, grazing management could be flexible enough to allow treatments to be initiated as closely as possible to the actual occurrence of the phenological stage or utilization level desired.

Predictive capability can provide a valuable tool to supplement field observations by an experienced rangeland manager in making management decisions. An important use of the models will be the prediction of rangeland production. Climate and weather information is used to establish long-term averages or normal temperature and moisture data. The current year's information at the beginning of the growing season could be measured and the assumption made that beyond that period, normal temperatures and moisture conditions would occur. Using this assumption, it may be possible to predict at any desired time the stage of development of the desired species and the estimated production. As new current weather information becomes available, the predictions could be updated as frequently as desired to obtain more accurate predictive results for guiding the range manager in his decision making.

The models will also permit the range manager to evaluate the influence on a longer time scale of various cultural and management decisions. For example, the production on the range as evaluated by the model could be plotted in comparison with the observed information over a period of years. It would then be possible to detect trends in departures from the potential production or development which could be related to certain management decisions.

It may also be possible by use of the models to calculate production over the full period of weather records, to compare these with available observed production data and to analyze trends in production over a longer period of time than actual production data may be able to supply. Such a study will enable the range manager to better understand the potential influence on production of future periods of drought, excessive moisture, abnormally cold or warm temperatures or current grazing practices on total range production. The range manager would be better prepared to develop contingency plans for reducing the economic impact of such extreme weather occurrences on the users of the range. The immediate effects of the drought or other abnormal weather occurrences could also be quantified and analyzed as they relate to adjustments in livestock numbers, periods of use or supplemental feed requirements.

Since the models can predict the influence of varying temperatures and moisture regimes on range production, even if not perfectly, it would also be possible to utilize them in predicting the economic values of such practices as addition of fertilizer, reduction of competing nondesirable plant species and the impact of increased insect populations on production.

Much remains to be done to refine the preliminary models into working tools with acceptable accuracy and reliability to be used in management decisions but in learning to think climate like rangeland vegetation we are making progress and results are encourgaging.

USCOMM-NOAA-ASHEVILLE, N.C. 10/82/450

DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA AND INFORMATION SERVICE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801