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Academy Editors

ARKANSAS ACADEMY OF SCIENCE

p r o c e e d i n g s

Volume XII 1958

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ARKANSAS ACADEMY OF SCIENCE

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ARKANSAS ACADEMY OF SCIENCE

Forty-second Annual Meeting
Medical Center - University of Arkansas
Little Rock, Arkansas
April 25-26, 1958

OFFICERS

President . . . . J. R. Mundie
President-Elect . . . . Carl E. Hoffman
Secretary-Treasurer . . . . . . Lowell F. Bailey

PROGRAM COMMITTEE CHAIRMAN

Dr. Carl D. Douglas
Medical Center
University of Arkansas

MINUTES

The first business meeting was called to order by President J. R. Mundie at 11:05 a.m., April 25, with 47 members present. The secretary's report was presented and accepted as written. Ad hoc committees were appointed to report the next morning.

Executive Committee recommendations for changes in the Constitution and By-laws were accepted as follows:

1. Article VI - Change "Transactions" to "Proceedings."
2. By-law 7 - Change to read: "Expenditures exceeding $50 require an order signed by the President before payment can be made."
3. By-law 9 - Change to read: "The fiscal year and membership year shall begin January 1 and end December 31."
4. By-law 13 - Add "and a Collegiate Academy of Science."
5. Add By-law 15 - The Academy shall sponsor the State Science Fair.

It was voted to limit associate membership to graduate students and to increase the annual dues from $1.00 to $1.50 for this type of membership. Undergraduates may hold membership in the Collegiate Academy.

A discussion of the proposed plan of the State Department of Education to use agriculture and home economics teachers for science classes led to the appointment by the president of a committee to report back the following day on a proposed position for the Academy to take on this matter. The Committee consisted of I. A. Wills, Ruth Armstrong, T. J. Burgess, I. T. Beach, and Robert Siegfried.

The meeting adjourned at noon.

The second business meeting was called to order by J. R. Mundie at 10:30 a.m. Saturday. Forty members were present.

The treasurer reported all debts paid and a balance of $1,204.90. The balance after publication of the next issue of the Proceedings was estimated at approximately $500. Institutional memberships totaling $520 were reported for the following institutions: University of Arkansas, Arkansas Polytechnic, Hendrix College, Harding College, Ouachita Baptist College, and Arkansas College.

The Audit Committee (D. M. Moore, J. W. Sears, W. C. Munn) approved the Treasurer's Report.

Following the recommendation of the Committee on the meeting place for 1959 (Truman McEver, R. H. Austin, I. T. Beach), the invitation of John Brown University, made by I. A. Wills, was accepted.

The Resolutions Committee (L. B. Ham and S. J. Fields) report was submitted and accepted.

Dr. Neal D. Buffaloe, Arkansas State Teachers College, was elected as President-elect for the coming year.

Dr. W. K. Noyce, Editor of the Proceedings, reported the following recommendations of the Editorial Board:

1. That in order to be published in the Proceedings, the manuscripts of papers presented at this meeting must be in the hands of the editor not later than June 1, 1958.
2. That beginning in 1959, and continuing in subsequent years, manuscripts of papers to be published must be turned in to the section chairman at the time of the sectional meetings when the papers are presented.
3. That the present policy of not publishing abstracts be continued.
4. That the Academy Secretary's report be published in the Proceedings in an abridged form to include the essential items of business.

These recommendations were accepted unanimously.

Mr. Lyndal York reported the desire of the Collegiate Section to become a separate Academy of Science. He reported 45 members for the current year. The Collegiate Academy was authorized by the membership, with sponsorship of the Senior Academy.

Mr. Bogan proposed that the Academy authorize $100 for the National Science Fair fund, if such funds are needed for the current year. This action was taken.

The Committee concerned with the Academy position with respect to agriculture and home economics teachers of science reported a statement in which it was urged that such teachers should receive additional training in science. Summer Science Institute training was recommended. The report was adopted.

Dr. D. M. Moore called attention of the members to the meeting held 25 years previously in Little Rock. This was the first meeting of the reorganized Academy of Science.

Dr. Mundie officially installed Dr. C. E. Hoffman as the new president of the Academy. Dr. Hoffman expressed his desire for an active and profitable Academy year, and adjourned the meeting.

Respectfully submitted,

Lowell F. Bailey, Secretary
Arkansas Academy of Science

PROGRAM

Friday, April 25

9:00 a.m.	Registration.
11:00 a.m.	Business Meeting.
12:30 p.m.	Luncheon, Coral Room, Medical Center.
1:15 p.m.	General Meeting. Welcome to Medical Center, Dr. Paul L. Day, Professor of Biochemistry. Speaker, Dr. Carey Stabler, President, Little Rock University.
1:50 p.m.	General Lecture, Dr. James H. Stevenson, Head, Science Division, Little Rock University, "Fisheries Management of Lake Hamilton."
2:15 p.m.	Sectional Meetings.

6:00 p.m. Banquet, Central High School Cafeteria. Speaker, Dr. Paul Sharrah, Professor of Physics, University of Arkansas, "Satellites and Space Travel."

7:30 p.m. State Science Fair Exhibit, Central High School Field House.

Saturday, April 26

9:00 a.m. Film, "Our Friend the Atom," a Walt Disney Production.

10:00 a.m. General Meeting, jointly with Junior Academy.

10:45 a.m. Business Meeting. Announcement of next year's meeting place. Adjournment by new president.

12:00 noon Awards Luncheon, Central High School Cafeteria.

SECTIONAL PROGRAM

Biology and Agriculture

Chairman: Jack Wood Sears
Harding College

Occurrence of Tree Species as Related to Underlying Rocks in the Arbuckle Mountains, Oklahoma. Edward E. Dale, Jr., University of Arkansas.

A Report on a Cytological Study of Chlamydomonas. Neal Buffaloe, Arkansas State Teachers College.

New Records for the Arkansas Flora. Dwight M. Moore, Arkansas Agriculture and Mechanical College.

Comparison of Growth Rates of Game Fish in Lake Catherine, Lake Hamilton and Lake Ouachita, Arkansas. Andrew H. Hulsey, Arkansas Game and Fish Commission, and James Stevenson, Little Rock University.

The Influence of Organic Matter and Certain Anions on the Phosphorus Content of Oats. D. J. Albritton, Arkansas Agricultural, Mechanical and Normal College.

Spawning the Rainbow Trout. Film by Jack Atkins, University of Arkansas.

Chemistry

Chairman: E. S. Amis
University of Arkansas

Some Fundamental Reactions of Alkaloid Biogenesis. A. Smith, University of Arkansas.
A Study of the Decarbonylation of Ethyl Hydrogen Phenylmalonate in Aqueous Alcohol. Charles T. Adams and Arthur Fry, University of Arkansas.
Ionic Size. Kurt Stern, University of Arkansas.
A Study of a Zirconium Alloy. William K. Noyce, University of Arkansas.
The Stereochemistry of Copper (II). Robert Kruh, University of Arkansas.
The Kinetics of the Exchange of Oxygen Between Permanganate Ion and Water. H. O. McDonald, University of Arkansas.
The Isotope Effect in the Adsorption of Nitrogen. Marijon McClellan, University of Arkansas.
An Electron Exchange Study in Mixed Solvents. D. M. Mathews, E. S. Amis, J. D. Hefley, and J. O. Ware, University of Arkansas.
Speeding the Training of Chemists; Twenty-Four Years Experience with Twenty-Two Hundred Students. Otto Smith, Southern State College.
Utilization of Aminoethanol by the Chick on Glycine Deficient Diet. John H. Wikman, Robert L. Wixom, George E. Pipkin, and Paul L. Day, University of Arkansas Medical School.
Fungistatic Studies, William K. Easley and M. Fred Meyer, East Tennessee State College.

Collegiate

Chairman: Lyndal York
Harding College

Carotene, the Pigment, and Its Vitamin A Derivative. Lillian Blackmon, Ouachita Baptist College.
Determination of Particle Weights of Virus Mutants by Diffusion-Rate Studies. Gary Ackers, Harding College.
A Report on Spectrochemical Analysis. Franklin N. Horton, Ouachita Baptist College.
Prelude to Conflict: The Election of 1856. Mary Ann Faris, College of the Ozarks.

Psychopharmacology. Aubrey M. Worrell, Jr., Ouachita Baptist College.
The Interrelation of Genes, Enzymes and Viruses. Lyndal York, Harding College.
Derivation and Application of Beer's Law. Harris Lloyd, Ouachita Baptist College.
Determination of the Color Reduction Properties of Hydroxylamine in Polybutadiene Latex. Lyndal York, Harding College.

Geology

Chairman: James H. Quinn
University of Arkansas

Regional Metamorphism of Basic Rocks in Northwestern Maine. Robert J. Willard, University of Arkansas.
Geology of a Portion of Prairie Township, Washington County, Arkansas. Kern C. Jackson and Ross Henry Pohlo, University of Arkansas.
Loess Deposits of Northern Arkansas. Harry L. Brown, Jr., University of Arkansas.
Multi-Channel Discharge of Rio Caroni, Venezuela, H. F. Garner, University of Arkansas.
Millerite-Violarite Relationships at the Eastern Metals Mine, Montmagny County, P.Q. D.W.T. Pollock, University of Arkansas.
Geology of the Southwestern Portion of Washington County, Arkansas. Ruey A. Ault, Charles E. Hollyfield, and James R. Ratliff, University of Arkansas.
Surfaces of Planation in the Paleozoic Areas of Arkansas. Harry Emerson Thomas, University of Arkansas.

History and Political Science

Chairman: Keith K. Petersen
University of Arkansas

Benjamin Franklin: From British Reformer to American Revolutionary, 1706-1790. Thomas Blossom, Southern State College.
The Social Ideas of Thomas Jefferson. Charles G. Hamilton, College of the Ozarks.

William G. D. Worthington: Special Agent for the United States Government in South America, 1817-1819. John Pine, University of Arkansas.

The Leadership Principle of the National Socialist State. Murray Abend, Southern State College.

The Agendas of the United National General Assembly: A Content Analysis. Keith S. Petersen, University of Arkansas.

Mathematics

Chairman: Lee Lorch
Philander Smith College

The Discriminant Function, Its Associated Procedures and Applications. G. D. Kyle, Arkansas A. M. and N. College.

On Numerical Methods of Solving Linear Equations, Collin Hightower, University of Arkansas.

The Undergraduate Honors Program at the University of Arkansas. John Keesee, University of Arkansas.

A Student Looks at a Visiting Lecturer. Robert Robinson, Philander Smith College.

Physics

Chairman: L. B. Ham
University of Arkansas

History and Purpose of the IGY. P. C. Sharrah, University of Arkansas.

Correlation of Auroral Displays and Terrestial Magnetic Disturbances. C. Y. Fan, University of Arkansas.

Cosmic Ray Neutron Burst on February 26, 1958. E. H. Cathey, University of Arkansas.

The Semi-Conducting Properties of Gray Tin as an Introduction to Solid-State Research in Physics. G. F. Powers, G. E. Louallen, and R. M. Rickett, Arkansas State Teachers College.

Instrument for X-Ray Study of Liquids. J. I. Petz, University of Arkansas.

Review of Recent Conferences on Laboratory Instructions. L. B. Ham, University of Arkansas.

Psychology and Sociology

Chairman: Robert C. Cannon
V. A. Hospital, Little Rock

Panel Discussion: A Proposal for a Doctoral Program in Psychology at the University of Arkansas. Panel: John Anderson and Philip Trapp, University of Arkansas. Moderator: Hardy Wilcoxon, University of Arkansas.

Science Education

Chairman: Robert Siegfried
University of Arkansas

The United States Position in World Science Education. Raymond R. Edwards, Graduate Institute of Technology, University of Arkansas.

Education Program of the Central Arkansas Section American Chemical Society. Robert L. Wixom, School of Medicine, University of Arkansas.

Education Committee Activities of the South Arkansas Section, American Chemical Society. R. M. Engelbrecht, Lion Oil Company.

Panel Discussion: Toward a Better Utilization of High School Science Courses in Beginning College Science Courses. Panel: John M. Smith, Horace Mann High School; B. C. Dodson, Crossett High School; Robert F. Kruh, University of Arkansas. Moderator: Robert Siegfried, University of Arkansas.

Geography

Chairman: O. O. Maxfield
University of Arkansas

(Presented by Title Only)

NEW RECORDS FOR THE ARKANSAS FLORA. IV

Dwight M. Moore
Arkansas Agriculture and Mechanical College

During the past months further study of the Arkansas Flora has yielded some interesting new records for the state, and some new distribution and size records for ligneous species. These will be presented in the usual taxonomic order.

PTERIDOPHYTES

1. Ophioglossum crotalophoroides Walt., which was first found in Arkansas at Prescott in 1945,(3), then in Faulkner County by Misses Jewel Moore and Inez Hartsoe,(7), and later by the author in several other southern counties,(4, 6), has more recently been found in Ashley, Bradley, and Drew Counties. This strengthens the conviction of the writer that with further close observation, this tiny Addertongue Fern may be found in nearly all the counties of the Coastal Plain region.

SPERMATOPHYTES

GRAMINEAE

2. Aira elegans Willd. ex. Gaud., has been found with A. caryophyllea L. in nearly all counties. The latter was reported in a previous paper,(4), but both species, which had not been included in the Check list(2), should have been included at that time.

3. Aristida virgata Trin., previously reported from Independence County, was found September 23, 1957, in a forest area three miles southwest of Monticello, Drew County, (DMM # 57.411).

4. Erianthus brevibarbis Michx., which is reported in Hitchcock and Chase,(1) as on "Dry hills, southern Ills. (type) and Ark. (Pulaski Co.,) rare." has now been found in nearly all the southern counties with collections made in Drew, Hempstead, Logan and Polk.

5. Gymnopogon brevifolius Trin., which is much

more rare than G. ambiguus (Michx.) B.S.P., has been found in the Ouachita National Forest about fifteen miles northwest of Mount Ida, Montgomery County, October, 1957, (DMM # 57.490), in addition to Garland County.

LEMNACEAE

6. Lemna minor L., which is almost never seen in the flowering state, was found in late October, 1957, on small pools below the Mississippi River levee at Arkansas City, in an area that was heavily pastured. These plants were in "full bloom," and this was the first time the writer had ever collected them in this stage. This raises the question: Do these plants seldom flower, or do collectors seldom get to them at the right time? As is noted above, this was late in the season, when collectors are not commonly looking for such plants. Further study may help to answer this question.

LILIACEAE

7. Oxytria texana (Scheele) Pollard, was found April 17, 1958, about eleven miles southwest of Monticello, Drew County, on what is locally known as "Warren Prairie," (DMM # 58.88). Another specimen had been collected there a year before and included in a student collection in Botany at Arkansas A. & M. College, but it had been erroneously identified as Ornithogallum umbellatum.

IRIDACEAE

8. In a previous paper, (5), the writer has, without specific identification, referred to an interesting species of Sisyrinchium appearing white, but having lavender veining. Recently, through the help of Dr. Lloyd H. Shinners of Southern Methodist University, this has been identified as S. laxum Otto. It is now reported from Ashley, Bradley, and Drew Counties, in addition to Union County where it was first found.

9. Another species of this genus having tiny yellow flowers with brown markings in the center, was reported from Union County as S. Brownei Small, (4). Shinners has pointed out, (9), that this should be designated as S. micranthum Cavanilles. It is now

reported also from Bradley and Drew Counties.

ORCHIDACEAE

10. Listera australis Lindl., Southern Twayblade, was found at the edge of a small cypress swamp in southeastern Bradley County, April 17, 1958, (DMM #58.92). This curious little orchid is a resident of the coastal plain from New England to Louisiana, so it is not surprising to find it on this part of this plain.

FAGACEAE

11. Quercus arkansana Sarg., which has previously been reported from only Hempstead and central Nevada Counties, has been found in some quantity in northeastern Nevada County and adjacent Ouachita County, in and near Chidester. Here was found one specimen which is a new size record: dbh, 31.9 inches, circumference, 8.35 feet; spread, 45 feet; and height, 45 feet.

12. Quercus incana Bartram, (Q. cinerea Michx.), the Bluejack Oak, which has been known on sandy ridges in Alabama and adjacent territory, was reported in Arkansas for the first time October, 1957, (DMM #57.383), in northwestern Ouachita County about eleven miles from Camden, growing on similar sandy hills. At Chidester, one tree, which is the largest observed to date and may be a record, measured: dbh, 24.7 inches; circumference, 6.47 feet; spread, 25 feet; and height, 30 feet.

13. ×Quercus capesii W. Wolf, often called Capesius Oak, and supposed to be a hybrid between Q. nigra and Q. phellos, was found in October, 1957, (DMM #57.541), about one-half mile southeast of the A. & M. campus in a wood along a small creek with numerous trees of both putative parents. Several specimens of this supposed hybrid were found here.

14. Quercus Nuttallii Palmer, the Nuttall Oak, has been reported from much of the lower Mississippi River Valley, but in October, 1957, it was found in some quantity in a forested flat, one mile south of Arkadelphia, Clark County, on the north side of U. S. Highway #67. This is considered a westward extension of its known range. At this place some large specimens were measured, and a new size record

obtained: dbh, 40.5 inches; circumference, 10.6 feet; spread, 75 feet; and height, 80 feet.

CARYOPHYLLACEAE (AIZOACEAE)

15. One of the most important and surprising discoveries, however, was Geocarpon minimum Mackenzie. Until 1957 this had been found in only a single small place in Jasper County, Missouri. In 1957, Steyermark found it in St. Clair County,(10). On April 11, 1958, on a flat, sandy-clay "prairie" area about five miles southeast of Warren, Bradley County, Arkansas, some were found, which have been identified as this species, (DMM #58.31). The following day further search revealed it in considerable quantity in the adjacent area of Drew County as well, (DMM #58.32). Thus it occurs in an area of a half-mile diameter, and there is probably more of it here than has been found in Missouri, where it has been supposed to be strictly endemic.

GENTIANACEAE

16. Gentiana clausa Raf., one of the Closed Gentians, has recently been shown to be distinct from G. Andrewsii Griseb, with which it has long been confused. In October, 1957, some good specimens of this species were found in a wet depression in a wooded area in the southwestern part of Yell County, (DMM #57.479). Examination of the material of this genus in the University of Arkansas Herbarium disclosed that other collections, some identified as G. Andrewsii, were really G. clausa. The following collections should be thus designated: Conway County, Petit Jean Mountain, Alcorn place, (DMM #51.821); Logan County, Magazine Mountain, (DMM #480320); Saline County, Alexander, (10 mi. SW of Little Rock), (DMM #410436).

RUBIACEAE

17. Hedyotis crassifolia var. micrantha Shinners (Houstonia). This tiny form bearing white or creamy-white flowers was reported without name in an earlier paper,(5), and has since been found in most of the counties of southern Arkansas. Shinners,(8), has designated it as a variety of H. crassifolia (Houstonia minima Beck). I would like to suggest that it be raised to specific rank, possibly as Hedyotis micrantha (or Houstonia). My primary reasons for

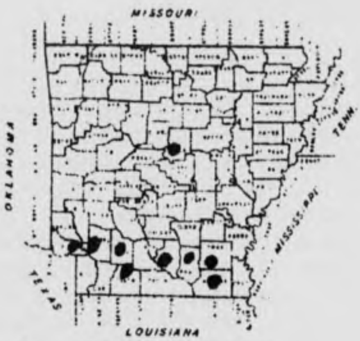
this are: *H. crassifolia* has leaves which are finely scabrous, at least on the margins, while the other is entirely glabrous. The former has a corolla tube which is narrowly funnel-shaped 1 mm. or less in diameter at the bottom, and abruptly widened about half-way up to twice this figure, and the whole tube about twice the length of the calyx. The latter has a short tube, 2 mm., which is about 1 mm. in diameter for its full length, and hardly as long as the calyx. The former may grow as isolated plants or in groups, while the latter commonly grows in large crowded mats. With these as distinct differences, and others which could be listed, I am strongly of the belief that this should be considered a separate species.

18. *Hedyotis rosea* Raf. (*Houstonia pygmaea* Mueller & Mueller), the small but striking species with large (1 cm. diam.) pink flowers with hairy yellow centers, which has been reported from a few places in southwestern Arkansas (as well as in Oklahoma and Texas)(11,8), has been found in Ashley, Bradley and Drew Counties.

COMPOSITAE

19. *Facelis retusa* (Lamarck) Schultz-Bipontinus, which was reported from much of the southern part of the state, (5, 6), under the synony *F. apiculata* Cassini, was found May 17, 1957, at the foot of a cliff along the Mulberry River near Yale in the northwestern part of Johnson County. This appears to be a considerable northern extension of its previously known range.

The accompanying maps will help interpret these reports.

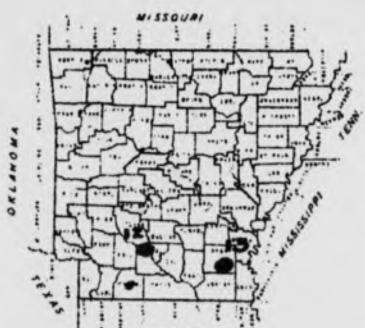


1. Ophioglossum crotalophoroides

5. Gymnopogon brevifolius

7. Oxytria texana and
10. Listera australis

8 and 9. Sisyrinchium sp.



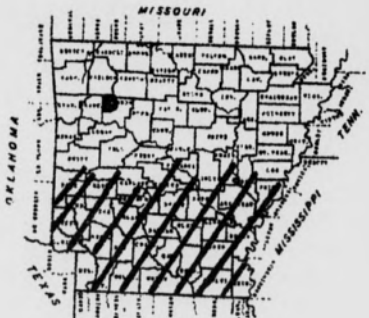
12. Q. incana
13. Q. capesii

16. Gentiana clausa

NEW RECORDS FOR THE ARKANSAS FLORA. IV

15. Geocarpon minimum

15. Geocarpon minimum



19. Facelis retusa

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(2) Moore, Dwight M. 1942. A check list of the grasses of Arkansas. Proc. Ark. Acad. Sci. I:57-62.

(3) ______. 1950. A new fern record for Arkansas. Proc. Ark. Acad. Sci. III:33-34.

(4) ______. 1951. Some new records for the Arkansas Flora. Proc. Ark. Acad. Sci. IV:61-63.

(5) ______. 1952. Additional new records for the Arkansas flora, II. Proc. Ark. Acad. Sci. V:91-93.

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(7) Moore, Jewel and Inez Hartsoe. 1955. A new location for *Ophioglossum crotalophoroides* in Arkansas. Proc. Ark. Acad. Sci. VII:63.

(8) Shinners, Lloyd H. 1949. Transfer of Texas species of *Houstonia* to *Hedyotis* (*Rubiaceae*). Field and Lab. XVII, #4, 166.

(9) Shinners, Lloyd H. 1958. Spring Flora of the Dallas-Fort Worth area, Texas. Pub. by author, S.M.U., Dallas.

(10) Steyermark, Julian A. 1958. Another station for *Geocarpon minimum*. Bul. Tor. Bot. Club. 85, #2, 124.

(11) Waterfall, U. T. 1953. The identity of *Hedyotis rosea* Raf. Rhodora. 55:201-203.

COMPARISON OF GROWTH RATES OF GAME FISH IN LAKE CATHERINE, LAKE HAMILTON, AND LAKE OUACHITA, ARKANSAS

Andrew H. Hulsey
Arkansas Game and Fish Commission
James H. Stevenson
Little Rock University

Studies of the fishery resources of three lakes located in series on the Ouachita River in West Central Arkansas were conducted during the summers of 1955, 1956 and 1957. Lake Catherine, the lower lake, is a 3000-acre lake that was impounded in 1923 by the Arkansas Power and Light Company. Lake Hamilton, created just above Lake Catherine in 1931, by the same company, consists of 7200 acres. Lake Ouachita, which covers approximately 40,000 acres, was impounded in 1952 by the Corps of Engineers and is located just above Lake Hamilton.

The pattern of high original reservoir productivity followed by gradual decline (in terms of angling success and desirable fish production) has been evidenced in these lakes. Reports from residents and fishermen on Lake Catherine have indicated that fishing was excellent for the first few years following impoundment, but has declined in recent years. Many believe that the same course is true in Lake Hamilton. On the other hand, Lake Ouachita, since it has been constructed, has attracted hundreds of thousands of fishermen as a result of the angling success that can be had in this new lake.

The Arkansas Game and Fish Commission recognized that here was an unusual opportunity to study factors pertaining to fish production and fishing success in three lakes of widely different ages, all located in the same watershed. Therefore, in June, 1955, the Game and Fish Commission inaugurated a Dingell-Johnson Federal Aid To Sport Fish Restoration Project (F-5-R) which was a three-year comparative fisheries study of Lake Catherine, Lake Hamilton and Lake Ouachita. The objectives of this study were to investigate and compare fishing resources of these lakes of different ages and to make recommendations for management.

Since the growth rates of fish reflect the nature of the environment, one segment of this investigation consisted of a study of the age and growth of the important game species. This paper deals with data obtained from the analysis of scale samples collected during the summers of 1955, 1956 and 1957.

Methods

Scales were collected from fish during periods of rotenone population sampling and from fishermen's creels. Extensive population sampling with rotenone was conducted in all lakes every summer and, in order to obtain representative samples for each month, these periods were staggered for each lake during the three summers. The data obtained from the three summers' collections were combined so as to have composite age-growth characteristics of each species of fish from each lake for comparison.

Scale collections, taken over the three summers, were grouped together and analyzed as to year classes. Scales from each fish were soaked in water to soften and remove the dried mucous after which they were placed between glass slides and magnified 45 times by a standard scale reading microprojector for examination. During the first year of study, tabulations of the age versus the total length at the time of capture were made. Scales collected during the summers of 1956 and 1957 were further analyzed in that the length of the fish at the time of each annulus formation was determined. For comparative purposes, all calculated lengths were based on the assumption that the body-scale relationship is that of a straight line.

The term "age-group" refers to completed years of growth plus the period to time of capture. Approximately an equal number of scales were collected each month during June, July and August over the three-year period. Since these scales were grouped together, it appears possible to assume that the average lengths represent growth as of July for each age group. A young-of-the-year fish was placed in age-group 0, and fish with one annulus plus growth to the time of capture, in age-group 1, etc.

Comparison of Growth Rates

The average age at which a fish reaches a harvestable size is of significance in fisheries management. Another index that may be used is the average length at the end of a selected year of growth. Since the rate of growth per year is directly related to the available food and space, it should be possible to modify, or "thin," the population so that the game fish will reach harvestable size in a shorter period of time.

Table I gives a comparison of the total lengths of the different age groups of largemouth bass, Micropterus salmoides, spotted bass, Micropterus punctulatus, smallmouth bass, Micropterus dolomieu, and white bass, Lepibema chrysops, taken from the three lakes. No smallmouth bass scales were collected from Lake Catherine or Lake Hamilton, and white bass were absent from the Lake Ouachita collections.

Largemouth bass showed a more rapid rate of growth in Lake Ouachita during the first year than in the other lakes. Young-of-the-year fish, at the time of capture, averaged 3.5 inches, 4.0 inches and 5.9 inches, and fish in their second summers' growth averaged 7.4 inches, 8.5 inches and 10.3 inches in Lake Catherine, Lake Hamilton and Lake Ouachita, respectively. During the third summer (age-group 2) largemouth bass averaged 10.0 inches in Lake Catherine, 11.9 inches in Lake Hamilton and 12.5 inches in Lake Ouachita. Fish captured in their fourth summers' growth (age-group 3) averaged 12.4 inches, 13.6 inches and 15.3 inches respectively in the three lakes. There appeared to be a decrease in growth increment of this age group in Lake Hamilton. Those of age-group 4 in Lake Hamilton appeared to have grown quite rapidly during the preceeding growth period. However, scales from only three fish in this age group were analyzed. Largemouth bass in Lake Ouachita showed a steady rate of growth.

Spotted bass showed a slower rate of growth than largemouth bass in all lakes. Only a slight difference was noted among the fish in the three lakes in the first two summers. However, the growth increments were greater in Lake Ouachita. Age-group 2 showed an average length of 8.9 inches in Lake Catherine, 9.7 inches in Lake Hamilton and 10.9 inches in Lake Ouachita.

White bass grew faster than largemouth or spotted bass in Lake Catherine and Lake Hamilton, averaging 4.1 inches and 4.5 inches, respectively. During the second summer, white bass averaged 8.8

Age-Growth Comparison of Largemouth Bass, Spotted Bass, White Bass and Smallmouth Bass Collected from Lakes Catherine, Hamilton and Ouachita. (Average Time of Collection, July. Total Length in Inches. Number in Parentheses Indicate Number of Fish.) Years 1955 through 1957

Average Growth Average Growth Average

		LAKE CATHERINE			LAKE HAMILTON			LAKE OUACHITA		
Species	Age Group		Average Total Length	Growth Increment		Average Total Length	Growth Increment		Average Total Length	Growth Increment
Largemouth Bass	0	(19)	3.5	3.5	(30)	4.0	4.0	(37)	5.9	5.9
	1	(54)	7.4	3.9	(61)	8.5	4.5	(86)	10.3	4.4
	2	(21)	10.0	2.6	(23)	11.9	3.4	(44)	12.5	2.2
	3	(11)	12.4	2.4	(10)	13.6	1.7	(13)	15.3	2.8
	4	----	----	---	(3)	20.9	7.3	(3)	18.0	2.7
	5	----	----	---	(8)	21.5	0.6	----	----	---
	6	----	----	---	(2)	22.0	0.5	----	----	---
Spotted Bass	0	(2)	3.5	3.5	(3)	3.5	3.5	(14)	3.7	3.7
	1	(10)	6.4	2.9	(14)	6.5	3.0	(25)	6.9	3.2
	2	(5)	8.9	2.5	(9)	9.7	3.2	(13)	10.9	4.0

(Continued)

TABLE I (Continued)

Species	Age Group	LAKE CATHERINE			LAKE HAMILTON			LAKE OUACHITA		
			Average Total Length	Growth Incre-ment		Average Total Length	Growth Incre-ment		Average Total Length	Growth Incre-ment
White Bass	0	(3)	4.1	4.1	(5)	4.5	4.5	----	----	---
	1	(18)	8.8	4.7	(9)	9.1	4.6	----	----	---
	2	(13)	12.0	3.2	(2)	11.8	2.7	----	----	---
	3	(8)	13.1	1.1	----	----	---	----	----	---
	4	(4)	14.5	1.4	----	----	---	----	----	---
Smallmouth Bass	0	----	----	---	----	----	---	----	----	---
	1	----	----	---	----	----	---	(7)	7.4	---
	2	----	----	---	----	----	---	(9)	11.5	4.1
	3	----	----	---	----	----	---	(1)	12.5	1.0
	4	----	----	---	----	----	---	(5)	16.1	3.6

inches and 9.1 inches in the two respective lakes. During the third summer, age-group 2 showed 12.0 inches in Lake Catherine and 11.8 inches in Lake Hamilton. The greatest growth rate occurred during the first two summers.

No young-of-the-year smallmouth bass scales were collected from Lake Ouachita. Age-group 1 averaged 7.4 inches; age-group 2, 11.5 inches; age-group 3, 12.5 inches and age-group 4, 16.1 inches. The growth increment of age-group 3 was small, but this data is not considered significant since only one fish in this age group was collected.

Table II gives a comparison of the age and length of crappies collected in the three lakes. No white crappie, Pomoxis annularis, were captured in Lake Ouachita, and it is possible that some of the black crappie, Pomoxis nigromaculatus, scales recorded from fishermen's creels from Lake Catherine may have been white crappie.

White crappie showed little difference in rate of growth in Lake Catherine and Lake Hamilton with the exception of a slightly larger growth increment of those in Lake Hamilton between age-group 0 and 1. In age-group 2, the average length was 8.3 inches and 8.4 inches respectively. It appeared that white crappie in these lakes were not of practical harvest size until they reached their fourth summer (age-group 3). White crappie in age-group 3 were 9.7 inches in Lake Catherine and 9.2 inches in Lake Hamilton. In age-group 4, fish averaged 11.6 inches in both lakes.

Little difference was noted in the rate of growth of black crappie as compared with white crappie in Lakes Catherine and Hamilton. The lengths of black crappie in age-group 3 were 9.6 inches and 9.7 inches, respectively, as compared with white crappie of 9.7 inches and 9.2 inches of the same age-group. The growth increment between age-group 3 and age-group 4 was 1.3 inches in Lake Catherine and 1.1 inches in Lake Hamilton, which was smaller than other age-group increments and also smaller than growth increments of the same age-group of white crappie. The average total lengths of black crappie in age-group 4 were 10.9 inches and 10.8 inches in these two lakes, as compared with white crappie of 11.6 inches in the same age-group. Black crappie grew faster in Lake Ouachita than in the other lakes. Age-group 2 black crappie were 9.4 inches, with the greatest growth increment occurring between age-group 1 and age-group 2. Black crappie

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TABLE II

Age-Length Comparison of Crappies Collected from Lakes Catherine, Hamilton and Ouachita. (Average Time of Collection, July. Total Lengths in Inches. Numbers in Parentheses Indicate Number of Fish.) Years 1955 through 1957

Species	Age Group	LAKE CATHERINE			LAKE HAMILTON			LAKE OUACHITA		
			Average Total Length	Growth Increment		Average Total Length	Growth Increment		Average Total Length	Growth Increment
White Crappie	0	(2)	3.3	3.3	(3)	3.2	3.2	----	----	---
	1	(9)	5.6	2.3	(5)	7.8	4.6	----	----	---
	2	(21)	8.3	2.7	(11)	8.4	0.6	----	----	---
	3	(10)	9.7	1.4	(4)	9.2	0.8	----	----	---
	4	(7)	11.6	1.9	(2)	11.6	2.4	----	----	---
Black Crappie	0	(1)	3.0	3.0	(7)	3.2	3.2	(13)	3.3	3.3
	1	(6)	5.7	2.7	(28)	5.9	2.7	(24)	5.7	2.4
	2	(4)	7.5	1.8	(18)	8.6	2.7	(33)	9.4	3.7
	3	(2)	9.6	2.1	(9)	9.7	1.1	(25)	10.7	1.3
	4	(5)	10.9	1.3	(8)	10.8	1.1	(19)	11.3	0.6

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in this lake reached a harvestable size in their third summer, or one year earlier than those in the other lakes. Those in age-group 3 averaged 10.7 inches and in age-group 4, 11.3 inches.

Table III presents the growth rates of bluegill sunfish, Lepomis *macrochirus*, redear sunfish, *Lepomis microlophus*, and longear sunfish, *Lepomis* megalotis.

Age-group 1 of bluegill sunfish were of a harvestable size (5.0 inches) in Lake Hamilton, whereas, those of the same age-group were 4.1 inches in Lake Catherine and 4.3 inches in Lake Ouachita. However, bluegill in Lake Ouachita of age-group 2 were 7.1 inches, surpassing those in Lake Hamilton which averaged 6.0 inches and in Lake Catherine, 5.7 inches. The growth increment of bluegill in Lake Ouachita was high (2.8) between age-group 1 and 2 as compared with increments of 1.6 inches in Lake Catherine and 1.0 inches in Lake Hamilton. Bluegill in Lake Catherine and Lake Hamilton in general appeared to grow at about the same rate. Growth in Lake Ouachita was faster. A comparison of age-group 4 showed lengths of 7.3 inches in Lakes Catherine and Hamilton and 8.6 inches in Lake Ouachita.

Redear sunfish showed faster rates of growth than bluegills in all lakes. Age-group 1 were of usable size in Lake Hamilton (5.0 inches) and Lake Ouachita (5.8 inches). Age-group 1 redear (4.5 inches) in Lake Catherine were slightly small for harvesting. Age-group 2 showed continued growth in all lakes with the largest growth increment exhibited by those in Lake Ouachita. Age-group 2 averaged 6.8 inches in Lake Catherine, 7.0 inches in Lake Hamilton and 8.5 inches in Lake Ouachita. Age-group 3 showed the highest growth increment in Lake Hamilton. This age group averaged 8.2 inches, 10.1 inches and 10.6 inches in the three lakes respectively.

The number of scales obtained from longear sunfish was relatively small and significant conclusions cannot be made. It appears from the data, however, that they are not of usable size until their third summer (age-group 2). Age-group 2 showed lengths of 5.3 inches in Lake Catherine, 5.0 inches in Lake Hamilton and 6.5 inches in Lake Ouachita.

Table IV gives the calculated length at the end of indicated years of growth, as determined by the

TABLE III

Age-Length Comparison of Bluegill, Redear and Longear Sunfish Collected from Lakes Catherine, Hamilton and Ouachita. (Average Time of Collection, July. Total Lengths in Inches. Numbers in Parentheses Indicate Number of Fish.) Years 1955 Through 1957

Species	Age Group	LAKE CATHERINE			LAKE HAMILTON			LAKE OUACHITA		
			Average Total Length	Growth Increment		Average Total Length	Growth Increment		Average Total Length	Growth Increment
Bluegill Sunfish	0	(13)	2.4	2.4	(9)	2.9	2.9	(10)	3.2	3.2
	1	(22)	4.1	1.7	(24)	5.0	2.1	(26)	4.3	1.1
	2	(10)	5.7	1.6	(16)	6.0	1.0	(17)	7.1	2.8
	3	(18)	6.8	1.1	(6)	7.3	1.3	(17)	8.0	0.9
	4	(9)	7.3	0.5	(4)	7.3	0.0	(7)	8.6	0.6
	5	(4)	8.5	1.2	----	---	---	----	---	---
Redear Sunfish	0	(5)	2.2	2.2	(6)	2.4	2.4	----	---	---
	1	(16)	4.5	2.3	(13)	5.0	2.6	(3)	5.8	---
	2	(14)	6.8	2.3	(9)	7.0	2.0	(10)	8.5	2.7
	3	(11)	8.2	1.4	(3)	10.1	3.1	(10)	10.6	2.1
	4	(3)	8.3	0.1	(4)	10.0	---	----	---	---
Longear Sunfish	0	----	---	---	(3)	2.3	2.3	(4)	2.6	2.6
	1	(2)	3.1	---	(2)	3.8	1.5	(5)	3.7	1.1
	2	(2)	5.3	2.2	(2)	5.0	1.2	(6)	6.5	2.8
	3	----	---	---	(6)	5.6	0.6	(3)	6.8	0.3

direct proportion scale measurement method, for the six most important game fish found in the three lakes. Terminal lengths for any period were not as large as those obtained by direct measurement. Direct measurement values, however, were those from fish where the average time of collection was July for each age group. These calculated values represent a closer indication of length at the end of each growing season. The number of fish listed in the first column refers to the total number of fish aged by calculation. As previously stated, calculated lengths were not determined for the fish collected in the summer of 1955.

Largemouth bass show the same general trend as was observed from direct measurement of different age groups. Fish at the end of their third year showed a length of 14.3 inches in Lake Ouachita, 13.1 inches in Lake Hamilton and 10.3 inches in Lake Catherine. Growth of largemouth bass in Lake Hamilton indicated fairly even growth rates. Growth rates in Lake Ouachita appeared to drop below those in Lake Hamilton between the third and fourth years, which may indicate the relative population density of these particular age-groups in the two lakes.

Growth rates of spotted bass in the three lakes were approximately the same for the first year. The second year, fish showed a steady and greater growth in Lake Hamilton, averaging 9.1 inches. Length of spotted bass at the end of their second year averaged 7.0 inches in Lake Catherine and 8.0 inches in Lake Ouachita.

The number of scales collected from white bass in Lake Hamilton was small. From those analyzed, however, the first year's growth of 7.9 inches was greater than white bass (6.4 inches) in Lake Catherine. Growth rates in Lake Catherine showed a steady increase reaching 14.1 inches at the end of their fourth year.

White crappie grew more rapidly for the first two years in Lake Hamilton. Their calculated length at the end of three years was approximately the same in Lake Catherine (8.4 inches) and Lake Hamilton (8.3 inches).

Black crappie grew most rapidly in Lake Ouachita, followed by those in Lake Hamilton and Lake Catherine during their first three years. Calculated growth rates at the end of three years showed lengths of 7.9 inches in Lake Catherine, 8.5 inches in Lake Hamilton and 9.0 inches in Lake Ouachita. Lengths

TABLE IV

Comparison of Calculated Growth Rates. Total Length of Fish, in Inches, at End of Each Annulus Formation. Years 1956 and 1957 Only

Species	Lake	No. of Fish	Average Calculated Length: First Year	Second Year	Third Year	Fourth Year	Fifth Year
Largemouth Bass	Catherine	49	4.9	8.0	10.3	----	----
	Hamilton	75	5.9	9.9	13.1	17.6	20.7
	Ouachita	108	6.6	10.7	14.3	16.9	----
Spotted Bass	Catherine	13	4.8	7.0	----	----	----
	Hamilton	9	5.0	9.1	----	----	----
	Ouachita	14	4.9	8.0	----	----	----
White Bass	Catherine	32	6.4	10.1	12.9	14.1	----
	Hamilton	5	7.9	----	----	----	----
	Ouachita	---	---	----	----	----	----
White Crappie	Catherine	47	2.5	5.8	8.4	10.6	----
	Hamilton	20	3.5	6.4	8.3	----	----
	Ouachita	---	---	----	----	----	----
Black Crappie	Catherine	17	2.6	5.6	7.9	9.3	----
	Hamilton	62	3.1	6.2	8.5	9.3	----
	Ouachita	75	4.3	6.8	9.0	9.7	----
Bluegill Sunfish	Catherine	42	2.5	4.5	6.0	7.1	8.2
	Hamilton	45	3.0	4.6	6.1	6.9	----
	Ouachita	54	3.3	5.8	7.4	8.1	----

at the end of four years' growth showed a smaller increment for those in Lake Ouachita and the total lengths almost equal (9.3 inches, 9.3 inches and 9.7 inches).

Bluegill sunfish grew most rapidly in Lake Ouachita. The growth rates of bluegill sunfish were fairly uniform during the first four years in all lakes. However, growth increments of those in Lake Ouachita were the greatest. At the end of three years' growth, the average lengths were 6.0 inches in Lake Catherine, 6.1 inches in Lake Hamilton and 7.4 inches in Lake Ouachita. At the end of the fourth growing season, lengths were 7.1 inches, 6.9 inches and 8.1 inches in the three lakes respectively.

Summary and Conclusions

Composite age-growth studies were conducted on certain game fish collected from Lake Catherine, Lake Hamilton and Lake Ouachita during the summers over a three-year period. Evaluations were made on the basis of comparing the lengths of similar age-groups of each species from the three lakes. Total lengths in inches of fish at the time of collection were recorded and later the fish were placed in an age-group as determined by scale analysis. In addition, lengths of a number of fish for each year of life were calculated and these values recorded.

Largemouth bass in Lake Ouachita showed a steady and more rapid growth pattern than in the other lakes. At the end of their second year of growth, calculated lengths were 8.0 inches, Lake Catherine; 9.9 inches, Lake Hamilton; and 10.7 inches in Lake Ouachita.

Greatest calculated growth of spotted bass was exhibited in Lake Hamilton, with a length of 9.1 inches at the end of the second year, followed by those in Lake Ouachita with 8.0 inches and Lake Catherine with 7.0 inches.

Calculated lengths of white bass revealed more rapid growth at the end of the first year in Lake Hamilton (7.9 inches) as compared with Lake Catherine (6.4 inches). Measured lengths of white bass in their third summers' growth showed growth rates approximately the same (12.0 inches, Lake Catherine, and 11.8 inches, Lake Hamilton).

Measured lengths of smallmouth bass in Lake

Ouachita were 7.4 inches, 11.5 inches, 12.5 inches and 16.1 inches during the second, third, fourth and fifth summers' growth.

A correction factor needed to be used on calculated lengths of crappie. Values obtained, however, gave a comparison of growth rates in the three lakes. Measured lengths of white crappie revealed that harvestable size was not reached until the fourth summer. During the fourth summer, measurements of 9.7 inches in Lake Catherine and 9.2 inches in Lake Hamilton were obtained. Black crappie grew more rapidly in Lake Ouachita than in the other lakes. They were of harvestable size in Lake Ouachita (9.4 inches) during the third summer. Comparisons during the fourth summer revealed lengths of 9.6 inches, Lake Catherine; 9.7 inches, Lake Hamilton and 10.7 inches in Lake Ouachita.

Growth of bluegill sunfish was the most rapid in Lake Ouachita. Calculated lengths showed more consistent growth patterns than measured lengths. Calculated lengths indicated a harvestable size was reached in Lake Ouachita during their second summer. Those in the other lakes, however, were slightly undersize. At the end of the second year of life, calculated lengths were: 4.5 inches, Lake Catherine; 4.6 inches, Lake Hamilton and 5.8 inches in Lake Ouachita.

Measured lengths of redear sunfish indicated those in Lake Hamilton and Lake Ouachita were of harvestable size during the second summer (5.0 inches and 5.8 inches). Comparisons during the third summer showed lengths of 6.8 inches in Lake Catherine, 7.0 inches in Lake Hamilton and 8.5 inches in Lake Ouachita.

Measured lengths of a limited number of longear sunfish show the slowest growth in these of all fish checked. Harvestable size is not attained until the third summer. Measured lengths during the third summer were 5.3 inches, Lake Catherine; 5.0 inches, Lake Hamilton; and 6.5 inches in Lake Ouachita.

The data show that, generally speaking, the fish in the old lake (Lake Catherine) grew the slowest, and those in the newest lake (Lake Ouachita) exhibited the most repid growth.

The rate of growth of fish in these lakes was found to be in inverse relationship to the standing crop measured in total pounds per acre and more specifically to the total pounds of so-called "forage and rough" fish per acre. This indicates that the forage and rough fish, when too plentiful, compete with the sport species for food and space. In addition, the individual fish making up the bulk of the poundage of forage and rough fish found in Lake Catherine and Lake Hamilton were too large to be available as food for the predaceous sport species.

Since this age-growth study was a part of a larger investigation to determine why fishing was better in the newer lake and poorer in the older lakes, it stands to reason that management designed to increase the growth rate of the fish in the two older lakes would result in improved sport fishing. In this connection, a "selective fish thinning operation" was carried out in Lake Hamilton on October 31, 1957,(1) during which an estimated 650,000 pounds of fish were killed. Most of the fish killed were gizzard shad and drum.

The above paper deals only with length of fish versus age of fish and does not take into consideration the condition, or "plumpness," of the fish. Due to the limited nature of the study, data on plumpness was not recorded. Field observations indicate, however, that the fish in Lake Catherine were the poorest and those in Lake Ouachita the fattest.

LITERATURE CITED

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GEOLOGY OF A PORTION OF PRAIRIE TOWNSHIP WASHINGTON COUNTY, ARKANSAS

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Other than the Geologic Folio of Adams and Ulrich (1905) the immediate area of Fayetteville has never been adequately mapped. The structure of the Fayetteville fault and particularly anamolous dips into the fault trace have never been understood. The present study indicates that these dips are a product of a reversal of movement along the fault during Pleistocene and post-Pleistocene time due to isostatic readjustment. This readjustment is interpreted as being the result of stripping of the thick sediments of the Arkansas Valley.

Initial field work in the Fayetteville area was done by J. C. Branner in 1891. The most recent detailed geologic map of the area is the Adams and Ulrich (1905) Folio of the Fayetteville quadrangle. Subsequent work has been limited either to detail work on single formations in the area (W. H. Easton 1942 on the Pitkin and L. G. Henbest 1953 on the Hale) or regional studies (Croneis, 1930).

GEOGRAPHY

A portion of Prairie Township was mapped which includes all of Township 16 North, Range 30 West. The city of Fayetteville lies approximately in the center of this area. Access to the area is excellent due to the well-developed road network surrounding Fayetteville, Physiographically the area is at the northern limit of the Boston Mountain Province. Flat topped hills which are erosion remnants, stand at 1700 feet above sea level surmounting a nearly flat erosion surface at 1200 feet above sea level. The remnants represent a former surface of planation which has been interpreted by J. H. Quinn (1958) as having been initiated in Aftonian time. This surface is extensively developed throughout the Boston Mountains and the Ouachita Mountains and is sparingly represented in the Arkansas Valley. The lower surface has been interpreted by Quinn as having been initiated in Yarmouth time. The lower (1200 foot) surface has been dissected by recent stream activity. The depth of dissection is approximately 50 feet and gives rise to relatively narrow bottom valleys. Some alluviation took place in these valleys probably during Altithermal time and these deposits are now being stripped. The maximum relief of the area is approximately 500 feet. Mt. Sequoyah is the highest point and the river valley south of Mt. Sequoyah is the lowest point.

The northwestern part of the township is dotted by numerous small circular hills called "prairie mounds." These mounds will be discussed in detail by Quinn (ms. in preparation). He interprets them as the result of accumulation of wind-blown dust around circular clumps of vegetation on a leeward desert margin (J. H. Quinn personal communication).

STRATIGRAPHY

The stratigraphy of the area is summarized in the accompanying table. The rocks are Mississippian and Pennsylvanian in age. The correlations of the Mississippian are from Weller (1948).

STRUCTURE

The strata, according to Croneis (1930, p. 163), dip gently to the south and southeast, but this is not verified locally. The beds are nearly horizontal or randomly dipping a few degrees, and no definite trend was established. The only steep dips were recorded along the Fayetteville fault zone, otherwise they never exceed 6 degrees and are usually only 1 or 2 degrees. In the fault zone the beds dip steeply toward the fault trace. This structure was termed the Price Mountain syncline by Croneis (1930, p. 190).

FOLDS

Synclines: Two small synclines are located in opposite corners of the township, one in section 1 and the other in the SW¼ of section 31. The syncline in section 31 has an axis that strikes N30E and dips 4 degrees on the limbs. The syncline in section 1 is more difficult to identify because most of the interval is covered with soil and outcrops are rare. Three dips were measured in a stream that traverses this structure, but from this information alone it was difficult to define the structural axis. The general structural trend of the area was used to estimate an axial strike of N35E. The limbs of this syncline have a maximum dip of 10 degrees.

A larger syncline is present on Mount Sequoyah, including parts of sections 10, 11, 14, and 15. The axis trends N35E and extends from the center of section 15 to the NW¼ of section 11. The dips of the limbs are gentle, from 3 to 6 degrees.

An anticline lies to the west of the Mt. Sequoyah syncline and to the east of the Fayetteville fault. The axis roughly parallels the axis of the Fayetteville fault as does that of the syncline on Mt. Sequoyah. This anticline extends from the eastern half of section 16 to the NW¼ of section 11. The fold is asymmetrical with the western limb strongly folded and dipping toward the fault at an angle of 35 degrees or more, while the eastern limb dips gently with a maximum of 5 degrees.

FAULTS

Fayetteville fault: The Fayetteville fault crosses the township from section 2 on the northermost margin through section 31 in the south where it continues out of the area. This extends the fault 3 miles beyond the limits mapped by Adams and Ulrich (1905). Croneis (1930, p. 202) stated that the fault extends from the NE¼ of section 20 of Township 16 North, Range 30 West, northeastward to the eastern half of Section 2, Township 17 North, Range 29 West, that both ends of the fault pass into synclines, and that this is only a central area of a larger zone of disturbance that includes the Glade, Onda, and Cove Creek faults.

The fault follows a sinuous course as it trends N35E through the area. The fault trace is observable only at scattered points. The covered sections have been represented by straight line segments on the map. As the fault traverses the area, it passes through numerous discontinuous synclines collectively called the Price Mountain syncline. In the Fayetteville Fm and Bloyd Fm the beds have a gentle dip of 5 degrees at distances of as little as 20 feet from the fault trace but become highly deformed at the fault trace. Thus in these shales the syncline dies out.

In the SW¼ of section 20 the bedding of the Fayetteville shale has the appearance of being a faulted anticline, but in the NE¼ of section 31 it is expressed as a faulted syncline. The width of the deformed zone in these areas is less than 50 feet, but in sections 10, 20, and 29 the dipping beds have a breadth of more than 300 feet on either side of the fault.

On the summits of hills in sections 3, 10, 16, 20, 29, and 31 these "synclinal" features are well displayed. In the NW¼ of section 10 beds of the Atoka formation dip into the fault at an angle of 35 degrees from the southeast and 45 degrees from the northwest and both limbs steepen until they become vertical at the fault. In this area the dipping beds form an arcuate pattern that appears as a plunging synclinal nose. In the SW¼ of section 29 beds of the Atoka are downfaulted from an elevation of 1600 to 1400 feet, and on both sides of the fault the Atoka plunges into the fault trace. These rocks were formerly mapped as the Hale formation by Adams and Ulrich (1905). Finally, the fault passes through what Branner (1888, p. 116) termed the Cate's syncline and continues out of the report area. In the center of Cato's syncline the Bloyd shale appears almost undisturbed, but beds of Brentwood limestone, directly under the Bloyd, dip into the fault at an angle of 38 degrees. This would suggest that the "synclinal" features are lost in less competent beds.

The fault "syncline" assumes an asymmetrical character in the SE¼ of section 9, and also on a hill in the NW¼ of section 20. In the former the western limb dips at an angle of 7 degrees, but the eastern limb dips at angles up to 45 degrees. In section 20 the Pitkin formation dips at an angle of 17 degrees to the east, while the Hale formation dips into the fault center at an angle of 60 degrees to the west.

The total vertical displacement along the fault is rarely measurable, but at a railroad cut in the SE¼ of the NW¼ of section 16 the displacement is approximately 50 feet. Here the beds of the Hale formation dip gently into the fault zone at an angle of 8 degrees from the north, and abut against the down-faulted Brentwood limestone. This area shows that the eastern side of the structure is down-thrown, a fact elsewhere difficult to verify due to the "synclinal" dips and similar structures. In sections 20 and 31, where displacement is in the

Fayetteville formation there is no way to estimate the amount of movement.

It appears anomalous that a fault measured in tens of miles ($6\frac{1}{2}$ miles in Fayetteville Township alone) should have so little displacement, i. e. approximately 50 feet. Considerable faulting and downwarping in the southern Boston Mountain region seems to have been associated with Atokan deposition. During Pleistocene time much of this material has been removed from the area of its thickest accumulation (Thomas 1958). If isostacy works it seems probable that some recovery may have occurred with reverse movement on the old faults formed by the initial downwarping. The downthrown side would reverse its movement and normal drag features would be reversed. Thus, the reversal of drag on the southeast side and normal drag on the northwest would give the structure the appearance of being a faulted syncline. The local anticlinal structure in the SW$\frac{1}{2}$ section 20 would indicate reverse drag on the NW side and normal drag on the SE side of the fault.

Reversal of movement seems to be taking place today. Evidence for this is that foundations of homes that straddle this structure have been subject to cracking, and Pleistocene gravels seemingly have been faulted on a similar structure to the east near Huntsville, Arkansas (Dr. H.F. Garner, oral communication).

GEOLOGIC HISTORY

The following climatic-sedimentary interpretations are the direct result of extrapolation of the mechanisms of alternate humid-arid climatic cycles as developed by J.H. Quinn (1956). His ideas have been extended to include marine sediments by H.F. Garner (manuscript, 1958).

The Boone chert and limestone probably is the product of leaching under hot humid land conditions. However, the environment of deposition was in water that was relatively cool with a pH flucuating around 7.8 in order to have alternate deposition of limestone and chert (Pettyjohn, 1957, pp. 597). The chert must be primary, or largely so, because pebbles of the chert are found in the overlying lower Batesville. There hardly seems sufficient time for the development of secondary chert in such a short interval.

Following Boone deposition the area was exposed to sub-aerial erosion. In nearby areas relief of as much as 30 feet is observable on the Boone surface and relief of 6 to 8 feet is common. During Moorefield time no sediments were deposited in the Fayetteville area or they were subsequently removed. Sediments of Moorefield age have been reported by Edmonson (1954) in western Washington County, but their age has been questioned by Ault (1958).

The Batesville sediments probably represent the products of stripping of the sub-aerially derived A zonal soil material. The sea was warm as evidenced by the limestone deposition. Fayetteville time continued the long humid period of the Mississippian. Highly organic black shales were being stripped from the land mass and deposited in a shallow sea. The Weddington sandstone probably represents sand-bar-type deposition off the mouth of a major drainage system. The sand thins rapidly to the east, south, and west of the type area in the Weddington Mountains of Washington County. The shallow water character is clearly indicated by cross bedding, and ripple marks, and the near shore character by the abundance of continental plant fossils. Upper Fayetteville time was apparently somewhat less humid as evidenced by the diminution of carbonaceous material and the presence of silt in the shale. This silt was probably derived from wind-transported material from arid deflation regions.

The Pitkin limestone seems to represent the initiation of greater aridity locally. Humid leaching of calcareous material elsewhere introduced lime into the sea to be deposited in the Fayetteville area from a warm sea. The conglomeratic character of the formation in the northern portion of the area would indicate slight uplift to the north and probable sub-aerial erosion. However, the fact that the pebbles are composed of limestone would indicate an arid climate, otherwise they would have been dissolved during sub-aerial leaching and transportation. Locally, the entire Pitkin formation was removed and is represented by scattered limestone pebbles in the base of the Hale.

The Hale sediments represent a continuation of the semi-arid climate. Sands accumulated on the land area to the north and clays with an admixture of aeolian silt accumulated in the seas. In upper

Hale time the humid climates returned. Streams stripped the sand accumulated on land during the lower Hale and carried it to the sea. The humidity is again indicated by the abundance of plant fossil fragments in these sands. A subsidence of a trough to the south in the present Arkansas Valley region probably began at this time. Freeman (1957) found that the relatively thin upper Hale sandstones could be traced laterally into part of the very thick Jackfork formation. The evidence of this subsidence is present in the Boston Mountains in the form of numerous slump structures in the Hale with movement to the south.

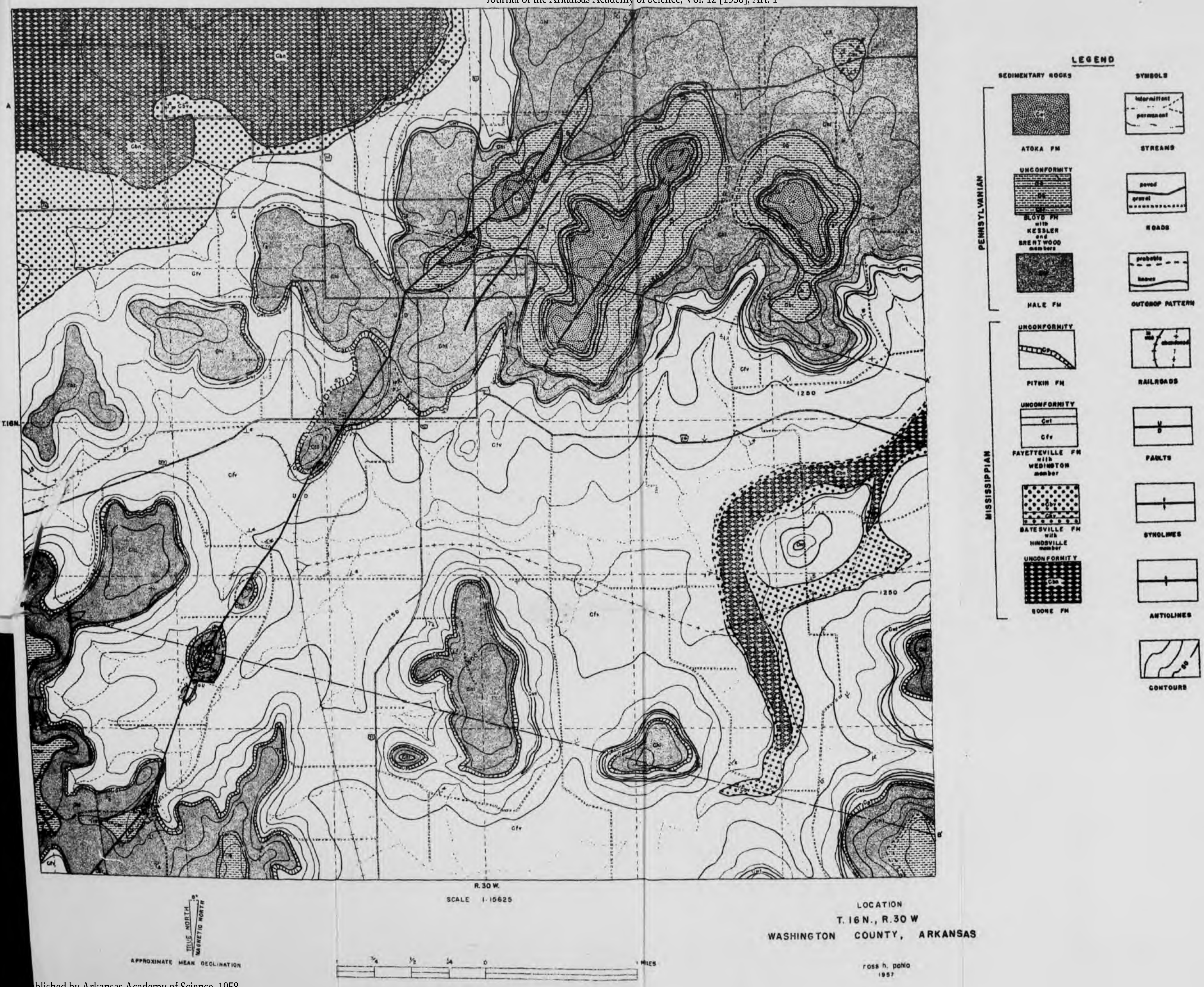
The lower Bloyd members indicate continued high humidity. The Basal Shale and Woolsey shales are again highly carboniferous and the thin Baldwin coal in the Woolsey indicates humidity. Faulting began to take place at the end of Brentwood time as found by Case and Conolly (1955) and by Knox (1957) but did not occur in the Fayetteville area. By Kessler time, however, arid climates had returned to the area as indicated by the limestone pebbles in the Kessler in the Fayetteville area and as reported by Knox (1957) and others.

The Atoka sands and silts represent alternating arid-humid climates. Silts representing arid aeolian transported materials and sands and pebbles representing more humid stripping of coarse continental residuals. A thick accumulation of Atoka sediments in the Arkansas Valley region caused loading of the crust and isostatic downwarping. This caused the development of monoclinal folds and faults in the Boston Mountains and southern Ozark region with downwarping or displacement to the south and southeast. During this dislocation the Fayetteville fault developed. At that time it undoubtedly had a much greater displacement than at present. It does not seem likely that a fault of such length would have only minor displacement. The NE trend of the structure was controlled by the earlier development of a series of N37° E trending anticlines and syncline demonstrated by Ault (1958), Hollyfield (1958), and Ratliff (1958). According to them these structures began developing in Hale time.

The presence at the beginning of Pleistocene time of a broad topographic arch with a NNE axis extending across the entire Arkansas Paleozoic area was postulated by Quinn (1957). J. E. Clements (1958) and H. E. Thomas (1958) have investigated

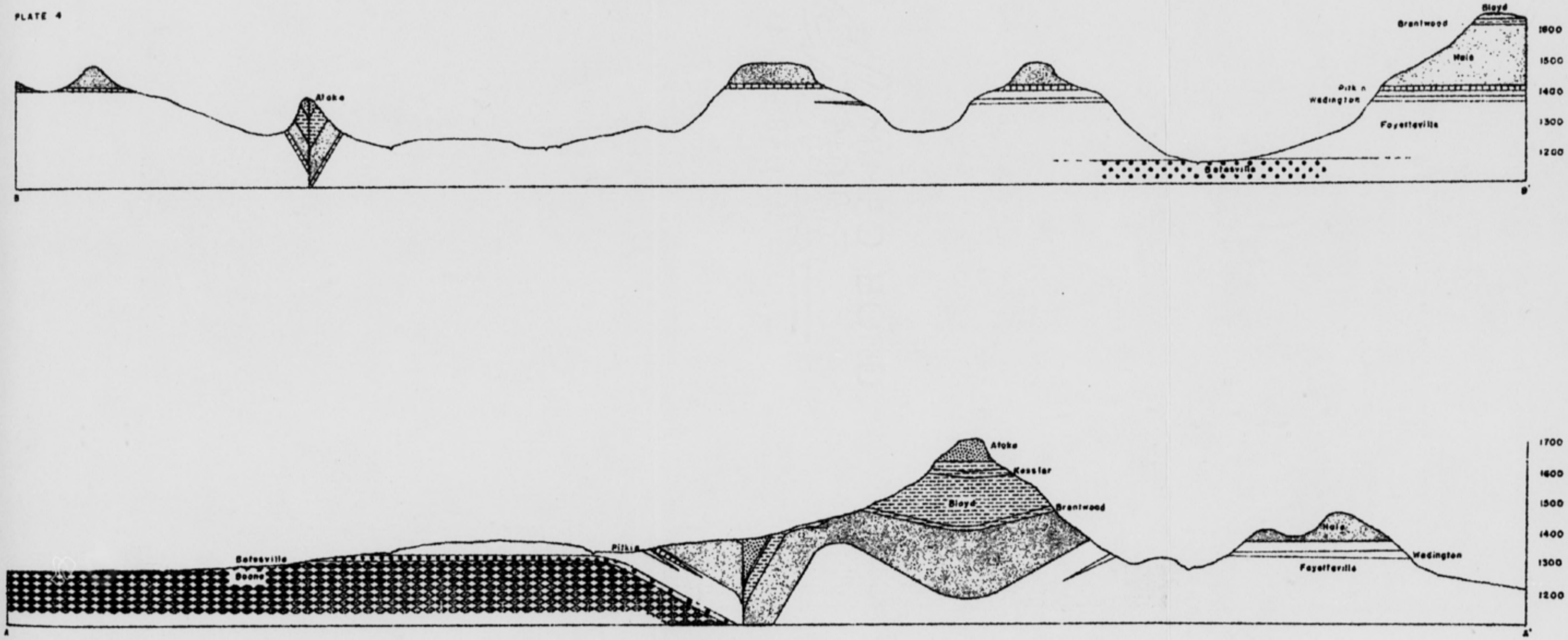
				LOCAL FORMATION OR MEMBER	LOCAL LITHOLOGY	LOCAL AREA OF EXPOSURE	LOCAL THICKNESS
PLEISTOCENE AND RECENT					Loessal soils, prarie mounds, locally derived and transported soils, sand and silt sized, boulders to 6' from ss		0 - 6'
PENNSYLVANIAN	POTTSVILLE			ATOKA FM.	Quartz silt and sand beds, flaggy, cross bedded and ripple marked. Intricate bedding in silt, green when fresh, weathers brown. Sand brown, Coarse sand grit 50' above base.	Mt Sequoyah and Pierce Mt.	68' rest removed by erosion
PENNSYLVANIAN	POTTSVILLE	MORROW GROUP	BLOYD FM.	UPPER MEM	Black fissle shale, no concretions	Mt Sequoyah Pierce Mt and hills in SE and SW corners	10'
PENNSYLVANIAN	POTTSVILLE	MORROW GROUP	BLOYD FM.	KESSLER MEM	Blue-black to red-black fossiliferous, sandy and conglomeratic limestone. Weathers dirty brown and slabby		2'-6" to 7'
PENNSYLVANIAN	POTTSVILLE	MORROW GROUP	BLOYD FM.	WOOLSEY MEM	Black fissle shale, weathers to brown and red clay. No concretions. Local Baldwin Coal in middle up to 12" thick. Sand bed 2' to 4' above coal		90'
PENNSYLVANIAN	POTTSVILLE	MORROW GROUP	BLOYD FM.	BRENTWOOD MEM.	Crystalline, highly fossiliferous, blue limestone. Weathers light gray. Some sand in limestone. Pentremites !		16'-6" ave.
PENNSYLVANIAN	POTTSVILLE	MORROW GROUP	BLOYD FM.	BASAL MEM.	Black fissle shale, no concretions.		0' to 20'
PENNSYLVANIAN	POTTSVILLE	MORROW GROUP	HALE FM.	PRARIE GROVE MEM	Flaggy, cross bedded, ripple marked, calcareous sandstone. Weathers to pitted surface in calcareous zones. Brown. Local limestone lenses	Extensive in NW and center Caps hills in south.	85'
PENNSYLVANIAN	POTTSVILLE	MORROW GROUP	HALE FM.	CANE HILL MEM	Wavy bedded clayey to sandy shale, weathers redish tan. Fissle when not sandy. Thin streaks of coarse sand		15' — 45'
MISSISSIPPIAN	CHESTER	ELVIRA GROUP		PITKIN FM.	Formerly called Archimedes Limestone. North part of area. Thin; red-brown, fossiliferous limestone pebble conglomerate. South part of area; massive fossiliferous gray limestone, thickening to the south. Weathers to fine granular, dark blue-gray rounded surfaces. Archimedes !	On most hills except Sections 13, 14, 15, & 16	0' to 30' Cong 3"-18"
MISSISSIPPIAN	CHESTER	ELVIRA GROUP	FAYETTEVILLE FM.	UPPER FAYETTEVILLE MEM	Upper shale; may be absent, more brown and less carbonaceous than base, fissle, argillaceous shale.	Extensive in bottom lands except in NW	Total Max 184' Sec. 33, Min 144' Sec 8 Upper Shale 0 - 70 Weddington 0 - 25
MISSISSIPPIAN	CHESTER	ELVIRA GROUP	FAYETTEVILLE FM.	WEDDINGTON MEM.	Weddington sand; ranges from dense black siliceous sandstone to brown friable sandstone, flaggy, cross bedded		
MISSISSIPPIAN	CHESTER	HAMBE-RG GRP	FAYETTEVILLE FM.	LOWER FAYETTEVILLE MEM	Basal shale; black, argillaceous and carbonaceous fissle shale. Ironstone and septarian concretions in middle and base. Well jointed.		
MISSISSIPPIAN	CHESTER	NEW DESIGN GROUP		BATESVILLE FM.	Sandstone, coarse to fine grained; cross bedded, brown to tan, fossiliferous	NW corner and stream valleys in SE	10' - 12'
MISSISSIPPIAN	CHESTER	NEW DESIGN GROUP		HINDSVILLE MEM.	One to two limestone beds, light blue gray, sandy, petroliferous odor. Basal Chert conglomerate with limestone matrix, pebbles to 5", 30%		0 - 2' 0 - 8"
MISSISSIPPIAN	OSAGE - MERIMEC			BOONE FM.	Thin oolite at top, dark gray, oolites up to 1/8" 70% of rock. Wavy bedded chert, bedded 3-12" thick, white on fresh surface, weathers red-brown, highly fossiliferous	NW corner and stream beds in SE	0 - 2' 38' exposed 341' drilled Sec. 34

PLATE 3. AREAL GEOLOGIC MAP



CROSS SECTIONS

PLATE 4



VERTICAL SCALE 1:3125

planation surfaces in this area and have demonstrated the presence of such an arch. They have further demonstrated the removal of at least 2200 feet of sediments from the Arkansas Valley since early Pleistocene time. The removal of such a load should result in an isostatic rebound in the same manner as the removal of an equivalent weight of ice. On a local scale this isostatic rebound would be accommodated by movement along old planes of weakness such as the Fayetteville fault. This in turn would reduce the displacement and where the beds are competent it would develop a reverse drag.

There are several additional lines of evidence for the recency of this movement. First, along many such faults the rocks are badly shattered, and the joints are fresh and completely unhealed. Such a situation would not be expected if the total fault movement were of Pennsylvanian age. Second, Dr. H. F. Garner of the Geology Department, University of Arkansas, reports faulted Pleistocene gravels south of Huntsville, 22 miles east of Fayetteville. Third, the senior author's house straddles the trace of the Fayetteville fault and has a crack in its foundation paralleling the fault and with a measurable displacement! Unloading and isostatic readjustment seemingly is still going on today.

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WILLIAM G. D. WORTHINGTON: UNITED STATES SPECIAL AGENT, 1817-1819

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The Latin American Wars of Independence, 1810 to 1824, were of great and immediate consequence to the government of the United States. The disruption of the Spanish empire and the creation of new sovereign nations caused the United States to examine its Latin American foreign policy. During the wars for independence the United States chose to maintain a policy of neutrality concerning the belligerents and a policy of nonrecognition toward the patriot governments. This cautious policy was based to a large extent upon reports from State Department special agents in South America.

Presidents James Madison and James Monroe sent quasi-diplomatic officials known as special agents for four reasons: (1) to obtain pertinent data relative to the revolution, (2) to explain the policy of neutrality and nonrecognition, (3) to encourage commerce and trade, and (4) to propagate democratic and republican ideals.[1] Altogether thirteen special agents were dispatched on such missions. Their voluminous reports assisted the government to create and maintain a Spanish American policy.

The special agents varied widely in the performance of their missions. They differed in following diplomatic protocol and in many instances completely ignored the meaning of the word. Some special agents became self-styled diplomats and ignored the formal instructions altogether. All of them, however, tackled their missions with enthusiasm. Their politics was Jeffersonian; their philosophy was humanitarian. They viewed the patriot cause as a continuation of the American Revolution—as the cause of liberty versus tyranny, as new world freedom versus old world despotism.

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[1] James Monroe to Alexander Scott, May 14, 1812, State Department, "Special Agents," MSS. IV; Monroe to _____, May 19, 1817, "Monroe Papers," MSS. Library of Congress. XXIV.

One of the most representative and at the same time one of the most spectacular special agents was William G. D. Worthington. His enthusiasm, his audacity, his attitudes, and his schemes were typical of other special agents. He was on the whole well-educated and cosmopolitan in interest. Like other special agents he was not a professional diplomat and had no training for foreign missions. Interested in many aspects of humanity, Worthington above all believed in the democratic tradition and the involability of republican institutions. The assignment to South America he hoped would be an opportunity to propagate his beliefs.[2]

President Monroe appointed Worthington as special agent in 1817. Patriot victories in 1816 had encouraged the President to dispatch a special agent to the United Provinces of Río de la Plata, Chile, and Peru. To say the least Worthington's instructions were general and vague. He was to promote liberal and stable regulations in the field of commerce and to explain the mutual advantages of commerce between the United States and the South American provinces. In addition he was to report on matters of political and economic interest. He was instructed to divide his time between the three provinces as the interest of the United States might require. Finally he was requested to report frequently.[3] Perhaps these instructions were clear to the State Department but to an amateur diplomat like Worthington they were less than thin sign posts in a blizzard.

Shortly after landing at Buenos Aires, the capital of the United Provinces of the Río de la Plata, Special Agent Worthington presented his credentials to Supreme Director Juan de Pueyrredon and to Secretary of State Gregorio Tagle. At this meeting

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[2] Eugenio Pereira Salas, La Misión Worthington en Chile (1818-1819), (Santiago: Imprenta Universitarian, 1936), 1.

[3] Henry M. Wriston, Executive Agents in American Foreign Relations, (Baltimore: The Johns Hopkins Press, 1929), 415; Worthington to Miguel Zañartú, March 13, 1818, Worthington to John Quincy Adams, Dec. 31, 1817, July 4, 1818, State Department, "Dispatches from United States Ministers to Argentina," MSS. I.

Worthington stated the purposes of his mission. He told the government officials that it was the character of the United States to be without mystery and assured them that he would act in a plain and open manner. Worthington wrote:

> I am convinced that the open candid mode of proceeding allowed me to take a part in affairs of which a more cunning policy might have deprived me.[4]

Candor was never lacking in Worthington. He freely discussed the disavowal of previous agents, the neutral position of the United States, the status of commercial relations, and his own limited authority to deal with the question of recognition.

The question of formal recognition of the United Provinces was somewhat embarrassing. It was particularly a sore point with the officials of Buenos Aires. In July 1816, a year prior to Worthington's arrival, the patriot government had officially declared its independence. They had expected immediate recognition by the great Northern Republic. Members of the Buenos Aires government were therefore disappointed that Worthington was not a full-fledged minister. Worthington realized that expectations ran high so he assiduously avoided the impression that he was an accredited minister. He wrote the State Department that the disappointment of the people was very great. It would be in the best interest of the United States to announce recognition before the good will began to ebb. Furthermore, immediate recognition, he thought, would guarantee the United States treatment as the most favored nation.[5]

Why did the United States refuse to grant recognition, officials in Buenos Aires inquired? Worthington explained that recognition had been withheld in favor of a policy of neutrality. There were advantages in neutrality for both parties: If the United States were to throw her resources to the insurgents, Spain might retaliate by enlisting the

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[4] Worthington to Adams, July 4, 1818, State Department, "Dispatches from United States Ministers to Argentina," I.

[5] Gregorio Tagle to Worthington, Oct. 3, 1817, Worthington to Adams, Oct. 4, 1817, *ibid*., I.

aid of the European powers. A policy of neutrality, Worthington explained, would interpret the struggle as a civil war. This in turn would allow all combatants access to the ports of the United States. Worthington was emphatic that neutrality was not injurious to the patriot cause.[6]

An item of major concern to both parties was the status of commercial relations. Worthington had expressed a desire that the New World should constitute a system different from that of Europe. By this he meant an economic system as well as a political system. To this end the Special Agent, apparently oblivious to his instructions, proposed a commercial treaty. His personal desire to excel and a wish to assist the patriot cause led him into this major diplomatic blunder.

In December of 1817, Worthington submitted to the government of the United Provinces "Forty-five Articals on the Subject of Commerce and Seamen."[7] The project was designed to place the United Provinces of the Rio de la Plata and the United States on a perfect reciprocity. Anxious to cooperate, the Buenos Aires government appointed an agent to confer with Worthington. The two agents agreed on twenty-four articles of commerce and the proposed treaty was submitted to the respective governments.

Worthington's justification for participation in the proposed commercial negotiation was one rationalization after another. He presumed that if his government had known the political and economic state of affairs in Buenos Aires he would have been vested with different and more definite powers. The political stability of the patriot government and the predominance of the English commerce were factors which Worthington felt changed the whole situation. He was aware of his limitations to negotiate such a treaty but he felt circumstances justified his actions. He trusted that no ill would result.[8] As matters stood, the proposed commercial treaty was not formally exchanged, as an exchange would have been tantamount to recogni-

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[6]Worthington to Tagle, Oct. 6, 1817, Worthington to Adams, Oct. 1, 1817, <u>ibid</u>., I.
[7]Worthington to Tagle, Dec. 17, 1817, <u>ibid</u>., I.
[8]Worthington to Tagle, Dec. 17, 1817, Worthington to Adams, Jan. 1, 1818, <u>ibid</u>., I.

tion and a direct violation of the United States policy of neutrality.

As a special agent per se, Worthington had a variety of tasks to perform. Civil war and revolution often result in violation of legal rights. In many instances Worthington interceded for United States citizens whose rights were violated. It was usually seamen, ship captains, and businessmen and in one instance it was an United States consul to whom Worthington's efforts were directed.

Much time was spent in gathering pertinent data. His reports from Buenos Aires included data on: (1) the progress of the revolution, (2) the threat of Brazilian expansion, (3) the influence and power of Great Britain in South America, and (4) the future role of the United States in the Western Hemisphere.

Leaving the United Provinces of the Rio de la Plata for Chile in January 1818, Worthington jumped from the frying pan into the fire. Chile was wild with revolutionary fervor. Spanish forces had been defeated and independence had been proclaimed by the Supreme Director Bernardo O'Higgins. While in Chile Worthington proved himself to be an energetic supporter of American interests and an apostle of American liberty. If he had been diplomatically indiscreet in Buenos Aires, he was downright indecorous in his relations with the Chilean government. He often disregarded his instructions and fell into one blunder after another.

After being officially received by the Chilean government, Worthington began to ply his diplomatic wares. He kept himself occupied much as he had done in Buenos Aires. He appointed consuls, intervened for seamen, explained the neutrality policy of the United States, introduced commercial negotiations, and presented a plan of government to the Chilean assembly.

First on his agenda was the famed project for commerce and seamen. The draft he submitted to the Chilean authorities was almost identical to that submitted to the government in Buenos Aires. Supreme Director O'Higgins showed considerable interest and had the commercial project forwarded to the assembly. Months passed; no action was taken. Worthington frequently inquired of government officials concerning his commercial project. The Chilean government, though seemingly interested, failed to inaugurate negotiations.[9] Undoubtedly the unsettled revolutionary conditions and the preparations for another attack on Spanish forces were responsible. Worthington was disappointed. Nevertheless he pressed on to other endeavors.

Despite the demands of war, Worthington believed that there existed a rising spirit of liberty among the Chilean people--a spirit that would not be satisfied until a constitutional form of government had been adopted. Since no such constitutional movement was apparent, Worthington jumped into the breach. For humanity and for the people of Chile he submitted to the government his outline for a constitution. He titled the document "The Free Constitution for the State of Chile."[10] He explained his actions to the Supreme Director on the ground that the "venerable institution" had preserved the liberties of Great Britain for many years. When the institution had been adopted by the United States they had modified it and had given to the world a more perfect system of civil polity than had previously existed. The constitutional system, he assured O'Higgins, had withstood the intrigues of peace, the shocks of war, and had afforded protection and happiness to the citizens of North America. He said:

> A well-organized form of Government will assure [Chile] Peace and Security at home, and respect abroad; it will tend to harmonize the discord and bind up the wounds.[11]

The constitution of the United States was a prototype for Worthington's constitution. It was modified, however, to meet conditions in Chile. As usual Worthington rationalized concerning his actions. In his report to the State Department he wrote, ". . . no ill could come of it" and that the "purity" of his intentions had justified the measure.[12] As might be expected, Worthington's

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[9] Worthington to Zañartú, March 2, 12, 1818, Worthington to Adams, Nov. 4, 1818, ibid., I.

[10] Worthington to Bernardo O'Higgins, May 5, 1818, ibid., I.

[11] Worthington to O'Higgins, May 5, 1818, ibid., I.

[12] Worthington to O'Higgins, May 5, 1818, Worthington to Adams, Nov. 4, 1818, ibid., I.

constitution for the state of Chile was given little credence by the Chilean authorities.

Fortunately for Worthington the whole constitutional affair was not a detriment to his obtaining information from governmental officials while he was in Chile. However the fiasco will loom as one of the most amazing diplomatic <u>faux paus</u> ever performed by a special agent of the United States. His actions were compromising to say the least. Chile had not requested such a document, and it could have been construed as an unfriendly gesture. If the constitution had been endorsed, it would have been interpreted as a tacit promise of recognition.

Barring his diplomatic blunders, Worthington capably reported on the state of affairs in Chile. He contacted leading government officials, military figures, commercial merchants, and outstanding civilians. He described both the domestic and foreign affairs of Chile. He pointed to the apparent stability of the O'Higgins government despite its military character. Much time was spent in obtaining statistics on the military and naval campaigns against the Spanish. He wrote on the Chilean attitude toward foreign nations and especially the United States.

Worthington reported that the North American republic was held in high esteem. The People of Chile he noted:

> . . . appear to have a natural and instinctive partiality for the Citizens of the United States--Even the most uninformed of them seem to be gratefully aware that we have aided them in their struggle for Independence.[13]

He thought that when Chile became a republic and enlightened, they would see the "Good effects of free government." Then the result would be the establishment of a civil government similar to that of the United States. For this reason, as well as commercial, political, and moral reasons, the United States, he wrote, ought to recognize the government of Chile.[14]

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[13] Worthington to Adams, July 4, 1818, <u>ibid</u>., I.
[14] <u>Ibid</u>.

After almost a year in Chile, Worthington returned to Buenos Aires and then to the United States terminating his mission. He considered his venture to have been a "political pilgrimage" for the "great cause" of the South American people.[15] In a nut shell Worthington summed up his individualistic conception of the mission. "I never was and never will dwindle down into a mere diplomatic machine--a mere knight or rook upon the great political chessboard of this life."[16]

For a great part of Worthington's tenure in South America his superiors in Washington were chafing at the bit. When Secretary of State Adams told President Monroe of Worthington's commercial negotiations, the President retorted, "Dismiss him instantly! Recall him! Dismiss him!"[17] A remark in Adams' diary reveals his attitude. This representative ". . . has been swelling upon his agency until he has broken out into a self-accredited plenipotentiary."[18] Worthington was recalled and summarily dismissed by the government in February 1819.[19]

The achievements and the failures of Worthington were similar to those of other special agents. Most of the agents had been selected on the basis of their political prestige: Few of them had any diplomatic training or experience. Further factors like inadequate instructions and difficulty in communications added to the confusion. Pro-patriot sympathies colored their reports and directed their actions. They were successful in obtaining pertinent data relative to the revolution, explaining the policy of neutrality and nonrecognition, encouraging commerce and trade, and propagating democratic and republican ideals.

The mission of Special Agent Worthington proved

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15 Worthington to Adams, July 9, 1818, ibid., I.

16 Worthington to Adams, March 7, 1819, ibid., I.

17 John Quincy Adams, Memoirs of John Quincy Adams, Comprising Portions of His Diary from 1795-1848, edited by Charles Francis Adams, (12 vols., Philadelphia: J. B. Lippincott, 1874-1877), IV, 70.

18 Ibid., IV, 158-159.

19 Adams to Worthington, Feb. 7, 25, 1819, State Department, "Dispatches to Consuls," II.

valuable to the Monroe administration. The United States policy of neutrality and nonrecognition was partly based upon an accumulation of many reports sent by agents such as Worthington. His relations with patriot officials and his promotion of commerce were in the best interests of the United States. Oddly enough many aspects of future commercial relations were premised upon Worthington's ill-famed commercial project. As a missionary of democracy, Worthington appeared unredoubtable. His diplomatic decorum was not that of an impartial agent, but his heart was sympathetic for the cause of the patriots.

THE LEADERSHIP PRINCIPLE OF THE NATIONAL SOCIALIST STATE

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The leadership principle of the National Socialist state was accompanied by the inevitable mysticism surrounding concepts of political absolutism. Particularly, the link between Hitler and the biologically-construed German folk was avowedly intangible. The theory held that this people, possessed of a common blood in themselves and set apart, therefore, from all other peoples, contained a spirit--the Volksgeist--which evolved from the peculiar national character of their peculiar status in the family of mankind. From this Volksgeist the special laws of the people are secreted, but this subjective material cannot of itself govern; it is similar to the Rousseauistic general will which must be sensed and defined from the invisible haze of popular desire by a man who is inherently qualified to determine the form and direction of the will of millions, a man who is most thoroughly permeated with the inmost and highest desires of his people. This leader, Hitler, yet cited the transitionalistic nature of life of the people under his guidance until such distant time as the new hopes had been realized and a true German Constitution was established. The aim of the people and forces under his command was to be ". . . the construction of a constitution combining the people's will with authority of real leadership."[1] Again, on another occasion, Hitler declared himself merely commissioned in the task of effecting reforms which would eventually enable the nation to determine the final constitutional form.[2]

The nearest this trustee elaborated upon the relation between himself, his party and his government was delivered in a speech of 1935. He noted the necessity for party authority in the watch over

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[1] Norman Baynes ed., Speeches of Adolph Hitler, April 1922-August 1939, Oxford University Press, 1942. Vol. I, p. 462.

[2] Ibid., p. 425.

the proper development of the growing National Socialist doctrine, and proceeded to compare his idea of authority with that of the military. An army checks the individual to attain the will of all; especially in emergency, a state proclaimed by the leader.[3] Pertinent to this claim the logical question of infallibility was sidestepped with the essentially mystical observation that the subject of the leader's possibility of error was "not under discussion." The order of the political life was one of complete obedience. And ". . . this need not imply separation between the party and Leader. The Leader is the Party and the Party is the Leader. As I feel myself to be only a part of this party, so the party feels itself to be only a part of me."[4]

Thus, the Leader, through his personality, demonstrates his independent title to leadership. The unquestioning loyalty of party and people is forthcoming, and it is through his interpretation of the needs of the blood community that that homogeneous group is brought to fuller realization of itself and its needs. Through him the people recognize their duties in the world and history; through the leadership principle, the Fuehrertum, the people are brought to political unity. From this unity, already established by Nature, the leader creates a political consciousness of the dictates of the unity. And from this there arises that totality of power in the state which accrues to the Leader. This results in practical assertions of might such as that which is encountered in the learned journal, the Constitutional Law of the Greater German Reich, written by Max Huber: "The Fuehrer is the bearer of the people's will; he is independent of all groups ... but he is bound by laws which are inherent in the nature of his people ... He is ... the bearer of the collective will of the people... He transforms the mere feelings of the people into a conscious will... Thus it is possible for him, in the name of the true will of the people . . . to go against the subjective opinions and convictions of single individuals . . . He shapes the collective will of the people within himself. . . In the Fuehrer are manifested the natural laws inherent

[3] Baynes, op. cit., p. 441.
[4] Ibid., p. 440.

in the people . . . The Fuehrer principle rests upon unlimited authority."[5]

The Reichstag members were, in Nazi Germany, elected in the one-party system, but it was frankly explained that their approval of bills submitted by the Leader was "purely formal." The Reichstag, dissolved at the will of the Fuehrer, reassembled as the result of a plebiscite, not to discuss proposed legislation, but to reassert its confidence in the Leader and his policy, nothing more.[6]

Political irresponsibility was a necessary concomitant with the special nature of the supreme leader of the Nazi state; unlike the ordinary dictator of history in previous centuries who usually rested content with personal power and paid at least verbal homage to a supernatural God and to theological restraints upon his earthly mandate, Hitler was that particular, modern product of the scientific age who sought power not of itself but as a means to the grim effectuation of his distinctive approach to reality, as a means for the realization of the promise of his special key to history. Power, infinitely multiplied by technological advance, was placed behind a remorseless program for the resetting of the social order. Theological restraints and the concept of the Christian God fell before the logic of the new faith. The old morality collapsed as Hitler privately derided the old faith as ridiculous and even a Jewish plot to spread the poison of universalism through St. Paul.[7]

Hitler understood his God as that will which is evident and implicit in the laws of Nature. This essential pantheism was concentrated in Hitler's numerous reiterations upon the Darwinistic theories of natural selection and the survival of the fittest in the eternal struggle of life. The Divinity he claimed to obey was not the Biblical but the natural. In one of many of his specific speeches he states that "Our humility is the unconditional submission before Divine laws of existence as they

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[5]Department of State, Division of European Affairs, National Socialism, U. S. Govt., p. 34.

[6]Baynes, quoting Deutsches Verfassungsrecht, pp. 146-147.

[7]Hitler's Table-Talk, 1941-1944. London. Weidenfeld, Nicolson. 1953. Entry Dec. 16, 1941.

are known to us...Our worship is exclusively the cultivation of the natural, and for that reason, because natural, therefore God-willed. Our commandment is the courageous fulfillment of the duties arising from those laws."[8]

This belief in a scientifically-guided morality gave force to the Leader's will in his inflexible adherence to the logical commands of the perceived immanent laws of the Darwinian doctrine in the realm of society and states. The imperatives of the new revelation of nineteenth century research transcended every other consideration. The highest meaning of life, the welfare of the folkic body, subordinated all else. Hitler mentioned in a speech that "the State itself is but one of the forms of the organization of the volkic life; it is set in motion and dominated by the immediate expression of the volkic vital will, the Party, the National Socialist Movement...Party, State, Army, Economics, Administration are all but means to an end, and that end is the safeguarding of the nation. That is a fundamental principle of National Socialist theory."[9] As the unique leader and determiner of national decisions, Hitler was verbal in his categorization of interests and behaviour. In tones that are almost similar to passages from the Prince Hitler averred that before the standard of folk interests "considerations of party politics, of religion, of humanity--in a word every other consideration--can have no place whatever."[10]

Yet, notwithstanding his basic anti-Christianity and subscription to the absolute supremacy of natural law as he interpreted it, Hitler entertained a paradoxical belief--at first mild, then strong--that he was an agent of Divine intervention and special providence in his role as leader of the new order. This curious combination of Scripturally-influenced beliefs in his Prophetic destiny by a supernatural God, and the scientifically-immutable Nature which he often viewed as a God unto itself was evidently the product of Hitler's personality splits rather than any formal National

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[8] Baynes, op. cit., p. 462.
[9] Ibid., p. 446.
[10] Adolph Hitler, Mein Kampf, Zentralverlag NSDAP, Munich, Franz Eher Nachf. 1938. p. 107.

Socialist theory, since the idea of Divine intervention or special designation of a man is clearly outside the typically National Socialist idea of blood ties between folk and leader. As the war progressed Hitler entertained the notion of his Divine stamp more strongly as each threat to his personal safety failed. Alfred Rosenberg wrote that Hitler's belief in his Divinely-entrusted mission to save Germany was noticeable from the beginning of Hitler's career until, towards the end of the war, it assumed positively painful proportions.[11]

Impelled by such a belief in himself--that of selection by a mystical tie of blood, and by a God above Nature--Hitler manifested the two traits which are always evident in modern times among dictators possessed of comprehensive myths of reality--that of urgency in action and the problem of succession. Who would succeed the first leader was a serious matter to Hitler and he named them soon after accession to power. The myth of the folk, of which he was the sole propounder in his lifetime, needed men as absolute and as awesome before the folk-millions as himself, once he was gone. Hitler thus used his living influence to bind the loyalty of the people upon his successor. Of course he did the selecting; Goering and Hess were named respectively in 1933. Hitler bade all to consider themselves as dutifully bound to blind loyalty to his appointees as they were to him. Of the power of ascertaining the men of worth to lead the people after his death Hitler was not silent. Before a festive crowd Hitler claimed: "I am nothing but a magnet that continually sweeps over the German nation and draws out the steel from among the people . . ."[12]

But the obvious drawbacks of succession were not lost upon Hitler. With the task of reforming all society set by the dictates of the myth and with the uncertainty that, once he was dead, a successor would indeed execute the necessary requirements of the new faith, Hitler was impelled to accomplish as much as possible in his own lifetime. Drastic

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[11]Alfred Rosenberg, Memoirs, trans. Eric Posselt (Chicago: Ziff-Davis 1949), p. 259.

[12]Speech of Adolph Hitler in Munich on the Occasion of the 20th Anniversary, NSDAP, p. 11.

decisions were the result of this certainty in himself and lack of certification of future actions after his death. A letter to Mussolini outlines Hitler's concern with this: "I know as well as you, Duce, how difficult it is to make historic decisions, but I am not certain that after death another will be found with the necessary force of will. . ."[13] And on another occasion, that of an address to his generals about starting the war, Hitler declared that he had to name himself as irreplaceable. "Neither a civil nor a military person could replace me...I am convinced of the powers of my intellect and of decision...The fate of the Third Reich depends only upon me . . . No one knows how long I shall live, therefore conflict is better now. In the struggle I see the fate of all things. Nobody can avoid a struggle if he does not want to lose out."[14]

The phenomenon appears here as in all doctrines of the absolute leader, that of a justification of present action in the name of a future good--an eventuality usually beyond the verification of any person living in the time of the present action. Hitler set forth in this pattern to establish and maintain the base of his lifework. The needed human material for the ranks of the elite of the future was to be drawn, in true keeping with the National Socialist creed of folk and honor, from every social and economic class. The natural aristocracy of the people was to be sought out among every corner of the biological organism of the people. Hitler noted, in 1933, the necessity for a special minority, the best of the National Socialists, to find the organic leaders of the future. This selection was to be based upon the theme that leadership was to be given "To those who have a natural right to lead."[15] This obviously precluded considerations of traditional rank and privilege. Indeed the abolition of classes became one of Hitler's logical goals. He underlined the sole glory of unity in common nationality. "Youth is not growing up," Hit-

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[13] Adolf Hitler, _Les Lettres Secretes Echangees par Hitler et Mussolini_. Paris, 1946, p. 151.

[14] _Nazi Conspiracy and Aggression_. _Volume III_, p. 574.

[15] Baynes, _op. cit._, p. 481.

ler said, "in the belief that status, classes, professions are of importance; its faith is in a single German nation. In their hearts there is no room for prejudice . . ."[16]

In the new state the poorest peasant child, if discovered to be destined by native talent for higher places, was to be the chief concern of the National Socialists. With leadership drawn from all corners the mass of the German people would feel themselves never in conflict with their leaders, for every man would know that they are people of his own flesh and blood. Hitler, in more private conversations, bitterly castigated the petty princes and monarchs in German history who had divided the land. He even declared himself opposed to class distinctions on ships and trains and once mentioned that army mess tables should be occupied in common by officers and men.[17]

The recruitment program for leaders in party and government indicated at least partial application of the socialist portion of Hitler's theory. In the Hitler Youth, observation was made of all physical and mental characteristics of the children, and by the age of eighteen a complete file was had on every member. Those selected for Leadership schools numbered 1000 a year by 1937. These were the most perfect physical and ideological specimens. Social rank and family ties apparently played no part in the selection of candidates. These potential leaders were sent to schools for four years, during which time they underwent the most vigorous training possible for the future elite of the nation.

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[16] Baynes, op. cit., p. 628.

[17] Table-Talk, op. cit., entries of November 11, 1941 and September 23, 1941.

THE SEMI-CONDUCTING PROPERTIES OF GRAY TIN AS A LABORATORY INTRODUCTION TO SOLID STATE PHYSICS[1]

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Gene E. Louallen
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As the title of this paper indicates, an attempt sill be made here to discuss some aspects of laboratory work with semi-conductors and the values to the small college of exploring this area of solid state physics. In the hope that it might stimulate further activity in this important area of physics and perhaps influence other small institutions not presently engaged in such projects to establish this type of a program, the equipment requirements of the project will be emphasized

It is well known that experiments in certain areas of physics many times involve equipment of such elaborate and expensive nature as to preclude any attempt by the small college to indulge in such pursuits. Fortunately this is not the case with laboratory work with gray tin.

The most important and expensive item of equipment involved is a potentiometer. Among other items required are a reasonably sensitive galvanometer, a standard cell, ten ohm standard resistor, Dewar flask, and access to a deep freeze. Ideally the freezer would be located near the research area since the gray tin specimen to be examined is attached to the potentiometer circuit with a low-melting point solder which becomes liquid at room temperature. Table I contains a partial list of equipment required along with catalog numbers of the items being used here. Naturally, equivalent items from other supply houses could be substituted. Common laboratory items such as switches and rheostats are omitted from the list.

Completing the equipment requirements is a "home-

[1]The authors are indebted to Dr. E. E. Kohnke at Oklahoma State University, Stillwater, Oklahoma, for furnishing some of the information contained herein.

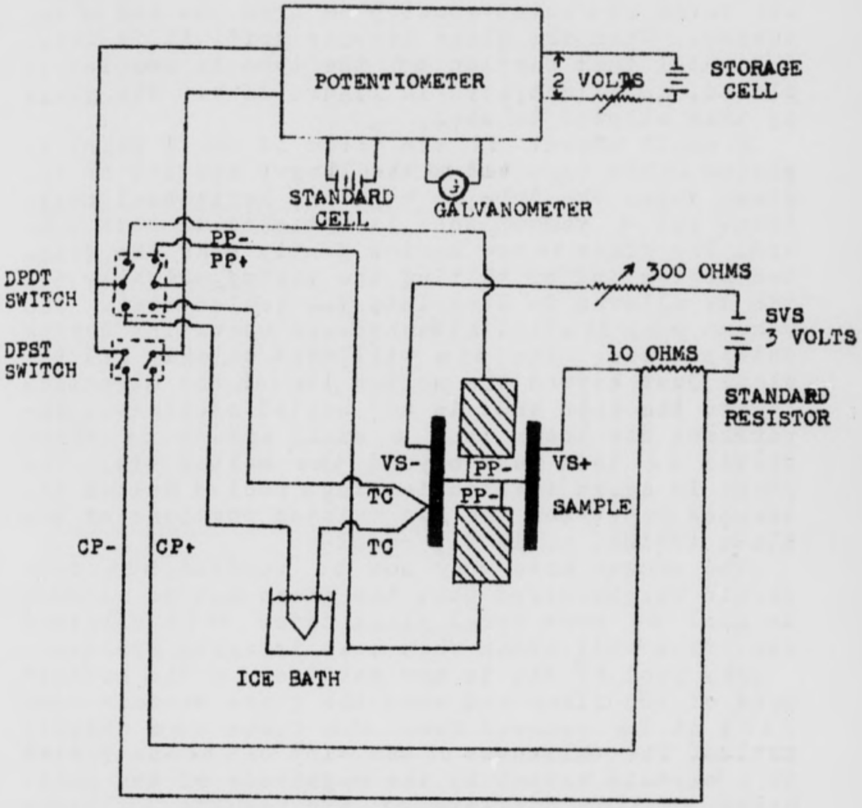
TABLE I

PARTIAL LIST OF APPARATUS REQUIRED

Supplier	Type	Nomenclature	Catalog	Number
Leeds and Northrup	K-2	Potentiometer	L N	7552-B
"	10.0002 ω	Standard Resistor	L N	4025-B
"	Nbr 30	Cu-constantan thermocouple wire	L N L N	
"	R	High sensitivity stovepipe galvanometer	Cenco	82095
"	-	Table bracket with telescope, arm, scale	L N	2148
Eppley	Precision unsaturated	Standard Cell	Cenco	79430
Cenco	C 1000 cm^3	Pyrex, Dewar flask	Cenco	15830
"	Hy Vac	Vacuum pump	"	91100
L N	Pinch	DPDT switch	"	84335

made" piece that is easily constructed with only the barest of instrument-making facilities. The essential components are two "L" shaped brass blocks which were hack-sawed from a piece of three-inch rolled stock. These blocks are connected mechanically but insulated electrically from each other and constitute the mounting saddle for the specimen of gray tin. Lead wires from these blocks are connected to the potentiometer, thermocouples, and other parts of the circuit. Figure I is a schematic of the apparatus and the wiring.

The gray tin sample is prepared by a method developed in 1953 by Dr. A. W. Ewald at Northwestern University(1) and further explored by Dr. E. E. Kohnke(2) and others at Oklahoma State University. The object of this method of preparing gray tin is to obtain a sample in the form of a thin, uniform wire. A piece of glass tubing about 6 mm in out-



Legend:
CP-, CP- : Current Probes
DPDT Switch: Double Pole Double Throw Switch
DPST Switch: Double Pole Single Throw Switch
PP-, PP- : Potential Probes
SVS : Sample Voltage Supply
TC : Thermocouples
VS-, VS- : Sample Voltage Supply Leads

FIGURE I. Schematic of apparatus and wiring.

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side diameter and 15 cm long is heated over a gas-air torch at a point about 5 cm from one end of the tubing. When the glass becomes soft, it is twisted until that portion of the tube is completely closed, as illustrated in figure II-b. The glass is then allowed to cool.

A small amount of tin (from .2 to 1 gram) is placed in the open end of the longer section of the glass tube, the tube is kept in a horizontal position, and a vacuum hose is attached to this same end. The glass is now heated gently near the twisted region and by tilting the tubing slightly the tin is allowed to drop into the heated area. The vacuum pump is still attached and operating during this process. The tin will melt quickly and the glass just beyond the molten tin (in the direction toward the open end) is now heated strongly. Experience has shown that a small amount of space should be left just beyond the molten tin. The glass is again twisted leaving a pool of molten tin trapped in between the two twisted portions of the glass tubing, as in figure II-c.

The vacuum hose may now be removed but care should be exercised that the glass not be allowed to cool as even Pyrex glass under this strained condition will break when heat is again applied.

The pool of tin is now rotated in the hottest part of the flame and when the glass becomes very soft it is removed from the flame and quickly pulled. The thickness of the wire can be controlled to a certain extent by the magnitude of the pull. Using smaller portions of tin results in finer wires. Figure II-d illustrates this step.

The wire is now cut into convenient lengths of about 10 cms and the glass is removed by bathing in hydrofluoric acid. After all glass is removed the samples are washed for about one minute in sulfuric acid and then rinsed in distilled water.

A great deal of difficulty is encountered in obtaining samples that are uniform in diameter, and free from cracks and pits as determined by inspecting them with a traveling microscope. The more promising samples are placed in the deep-freeze where they transform to the gray tin form after about twenty-four hours at a temperature between zero and minus twenty degrees Centigrade. This transformation is apparently accompanied by mechanical stresses and strains leaving the sample quite disfigured. After transformation into the gray form

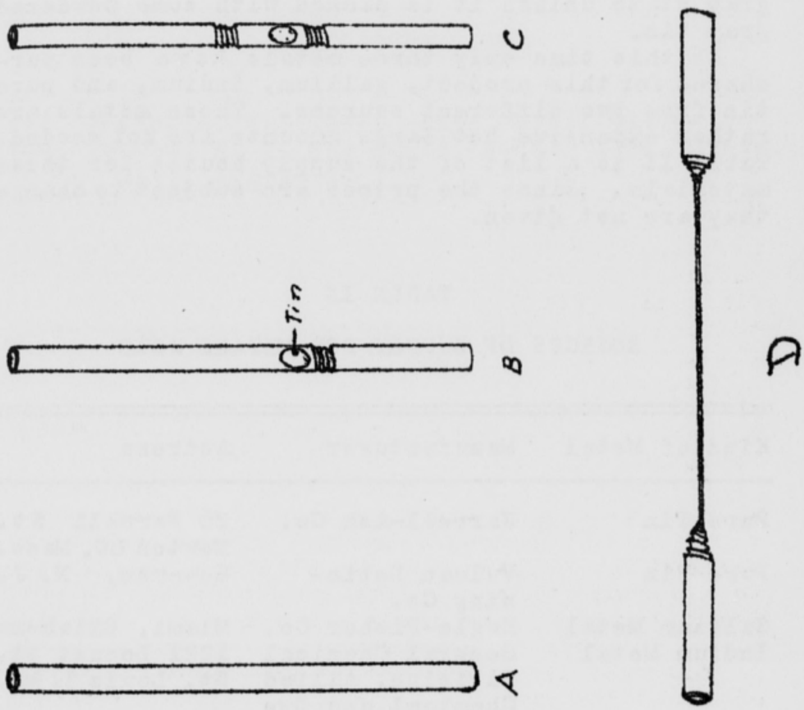

FIGURE II. STEPS IN DRAWING A TIN WIRE.

RMR

the tin also becomes very brittle. The authors have obtained wires of uniform diameter and from fifty cms to approximately one meter in length. When cut into sections about seven cms long and placed in the deep-freeze these specimens occasionally disintegrated into coarse powder.

Sometimes a sample will not transform into the gray state unless it is packed with some powdered gray tin.

At this time only three metals have been purchased for this project, gallium, indium, and pure tin from two different sources. These metals are rather expensive but large amounts are not needed. Table II is a list of the supply houses for these materials. Since the prices are subject to change they are not given.

TABLE II

SOURCES OF SUPPLY FOR METALS USED

Kind of Metal	Manufacturer	Address
Pure Tin	Jarrell-Ash Co.	26 Farwell St. Newton 60, Mass.
Pure Tin	Vulcan Detinning Co.	Sewaren, N. J.
Gallium Metal	Eagle-Picher Co.	Miami, Oklahoma
Indium Metal	General Chemical Division, Allied Chemical and Dye Corporation	1221 Locust St. St. Louis 3, Mo.

When satisfactory samples of gray tin are obtained, they are soldered to the brass clips and the conductivity measurements are made with the potentiometer in the usual manner. A switch allows readings to be made of the emf of a thermocouple, one junction of which is attached to the sample, while the other junction is immersed in melting ice. By means of tables furnished by the Leeds and Northrup Company, the temperature of the sample can be obtained and its conductivities at various temperatures plotted.

It is felt that this type of laboratory introduction to solid state physics is of particular benefit to the student in the small college, for it serves among other things to introduce him to certain aspects of physics which he will encounter later if his future endeavors include research.

LITERATURE CITED

(1) Ewald, A. W. 1953. Phys. Rev., 91:244.
(2) Kohnke, E. E. and Ewald, A. W. 1956. Phys. Rev., 102:1481.

THE SYNTHETIC FIBER INDUSTRY
A STUDY IN INDUSTRIAL LOCATION

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During the past three or four decades, the use of man-made fibers for textiles has had a phenomenal increase in the United States. Per capita consumption of synthetic fibers rose from just under 0.8 per cent of all textile fibers used during the period, 1920-24, to a high of 20.61 per cent of all fibers used by the textile industry in the period, 1950-1954.[1] In terms of the total amount of man-made textile fibers consumed, 459 million pounds were used in 1939, and approximately 2,243 million pounds in 1953.[2] The 1954 Census of Manufactures gives the total value of products shipped by the synthetic fiber industry as 1,244.5 million dollars for that year. The value added by manufacture was approximately 447.9 million dollars in 1947 compared with 720.5 million for 1954, or an increase of about 60 per cent.[3] From the forecast made in April 1955 in a leading trade publication for the synthetic fiber industry, it is estimated that by 1965 synthetics will supply almost 30 per cent of the textile fibers used in the United States.[4]

Increased use of synthetic fibers has had a salutary effect on the textile industry in several ways. Man-made fibers have considerably more price stability than do natural fibers. A stable cost

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[1] Robert C. Shook, "You Can Expect Big Future Gains for Man-Made Fibers," Modern Textiles, 36:39, April, 1955.

[2] Ibid., p. 40.

[3] 1954 Census of Manufactures, Advance Report, Series MC-28-2.1, Bureau of Census, Department of Commerce, Washington, D. C., p. 1.

[4] U.S. Consumption of man-made fibers for 1956 was 26% of total fibers consumed, and for the first half of 1957 (latest figures available), it was approximately 27% of the total. Encyclopedia Americana, Annual for 1958, p. 764. New York, Americana Corporation. 1958.

of raw materials makes for more stable industry, all other things being equal. Mill operators like to use these new fibers because of their greater price stability. Their use helps to reduce some of the risk and uncertainty in textile manufacturing. Better working conditions have come to the industry, too, in part because of the use of synthetics. Mills are cleaner, air conditioning is more widely used and textile machinery has been improved for use in processing the new materials.[5] Thus, both directly and indirectly, benefits have come to the industry as a whole through the use of these new fibers.

We have then, a rapidly expanding new industry which in a few decades has become an important supplier of textile fibers. Where this industry has located, the factors which influenced its location and which are likely to influence the location of its continuing expansion, are questions which present a challenge for investigation and research.

Geographers have long used methods of visual correlation to determine whether or not there is any apparent association between different factors on mapped data. This has been done often simply by comparing two sets of mapped data side by side or by superimposing transparent tracings of mapped data one upon another or upon a more finished map. There has, however, long been felt a need for some more quantitative method than these for determining something of the degree of association between two or more sets of factors having areal variation in their distributions. Among other attempts along this line, a study was conducted in 1956 at the Geography Department of the State University of Iowa, using statistical techniques as a method of quantifying the association observed to exist between different industries. The results of this study are published in a monograph entitled _The Measurement of Association in Industrial Geography_.[6]

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5 ______, "Synthetics Threaten to Take Over," _Business Week_, Sept. 4, 1954, p. 93.

6 Harold H. McCarty, John C. Hook, and Duane S. Knos, _The Measurement of Association in Industrial Geography_, Department of Geography, State University of Iowa, Iowa City, Iowa, 1956.

It seemed desirable to use such statistical correlation methods as described in this monograph for the measurement of association between the synthetic fiber industry and such industries and other factors as might be expected to be found in varying degrees of association with it. However, this method requires quantitative data by either counties or metropolitan areas, for the industries and other factors between which we expect to find an association. And the Census of Manufactures, even the most recent one, that for 1954, does not have such data for the synthetic fiber industry except for two or three states, and then only for the state as a whole rather than at a county or other level. It was at once apparent that even though data might be available for associated industries in the Census of Manufactures, some other source of information would have to be sought for data on the synthetic fiber industry.

Two sources were found which together yielded the necessary information. Davidson's Rayon, Silk and Synthetic Textiles,[7] a handbook published for the textile industry, gives a complete listing of all manufacturing plants producing synthetic textile fibers in the United States and Canada. Editor and Publisher Co.'s Market Guide,[8] an advertisers' service covering the circulation areas for most of the newspapers published in the United States, was the other. From this source it was possible to compile, by counties, the number of workers employed in almost all manufacturing plants producing synthetic textile fibers in a twelve-state area along the Atlantic seaboard. The output of such manufacturing establishments was not obtainable, but the number of workers employed in manufacturing has for some time been recognized as a fairly reliable measure or index of a given industry. In the first study ever made of the manufacturing belt of North America, it was observed that the percentage of total workers employed at manufacturing in cities of over ten thousand pop-

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[7] Davidson's Rayon, Silk and Synthetic Textiles, Ridgewood, N.J., Davidson Publishing Co., 1957, pp. 344-359.

[8] ______, Market Guide, New York: Editor and Publisher Co., Inc., Issues for 1954 and 1955.

ulation varied, fairly constantly, with the percentage of total value of manufactures of the state which was produced in those cities.[9] Careful consideration of that investigation reveals that its conclusions were reached scientifically and objectively. The University of Iowa study on the measurement of association in industrial geography also used the number of workers employed in manufacturing, by counties and metropolitan areas, as a measure of the various industries.[10] This index was used for both the dependent variable and the independent variables for measuring, by statistical correlation, the association between the various iron and steel and machinery industries.

It is assumed, therefore, that the number of workers employed in an industry is a fairly reliable measure of the variations in the distribution of that industry. For our investigation of the synthetic fiber industry the number of workers, by counties, was chosen as the measure to be used. The number of workers employed in the various associated industries, by counties, was also used as a measure of these independent variables for the measurement of geographical association by statistical correlation.

As listed by Davidson's Handbook of synthetic fiber manufacturing, the industry is located in twenty-one states east of the Mississippi with plants in seventy counties scattered throughout these states. Since complete data on workers employed by the industry could be obtained for only twelve of these states it was necessary to confine the study to the forty-eight counties having synthetic fiber manufacturing within the twelve states.[11]

The 1954 Census of Manufactures classifies under industry 2825, Synthetic Fibers, only the chemical and cellulosic fibers. Metallic and glass fi-

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[9] DeGeer, Sten, "The American Manufacturing Belt," Geografiska Annaler, Stockholm, 1927, pp. 248-249.

[10] McCarty, op. cit., p. 67.

[11] Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Delaware, Maryland, Pennsylvania, West Virginia, Virginia, North Carolina, South Carolina.

bers, which also are used in the manufacture of textiles, are classified in other categories. The industry itself, however, as represented by its leading periodical, regards all man-made fibers used in textile manufacturing as synthetic textile fibers. The reason for this seeming discrepancy is the fact that the census grouping of Industry 2825, Synthetic Fibers, is a further breakdown of the secondary census group 282, Organic Chemical Products. Since metallic and glass fibers are mineral rather than organic chemical products they must be classified otherwise than with the synthetic fiber group in the Census of Manufactures.

Rayon is a generic name applied to all man-made fibers made from cellulose. Viscose and acetate are names applied to processes for making rayon and also to the fibers so produced. Originally cotton linters were the main source of cellulose for production, but now about three-fourths of the cellulose used in synthetic fibers comes from wood pulp.

Non-cellulosic is a term usually applied to the newer synthetics, which are sometimes also called "miracle fibers" or "true synthetics" in order to distinguish them from the older fibers produced from cellulose. Nylon and several of the other new synthetics are made from hydrocarbons derived from coal, petroleum and natural gas.[12] "From petrochemicals comes an ever-increasing number of new fibers."[13] Such products as orlon, dacron, mylar, and acrilan fall in this category. There are also the synthetics produced by chemical processing of certain proteins. Vicara is a fiber made from corn protein. Casein fibers derive their protein raw material from milk. Other fibers have been produced using protein from peanuts and soybeans.

For purposes of this paper, synthetic textile fibers are defined as they are by the textile industry. That is, metallic and glass fibers, as well as the cellulosic fibers and the newer synthetics or "miracle fibers" are classed as synthetic textile fibers.

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[12] Product Information, Fibers by DuPont, Wilmington, Delaware: E. I. DuPont de Nemours & Co., Inc., 1957, p. 7.

[13] ______, "Clothed in Oil and Gas," Science News Letter, 61:242, April 19, 1952.

As was previously noted, the value of output in manufacturing has been found to vary directly with the number of workers employed. In like manner, a given industry may be found to vary, fairly constantly, with another industry or with some other factor which has areal differentiation in its geographic distribution. Thus, it may be hypothesized that where X is found Y will also be found in a greater or lesser degree of association with it. Or the correlation may be in an inverse order so that where a large degree or concentration of X occurs a small degree of Y will be found, and vice versa.

For statistical measurement of associations of this kind, the Pearson product moment coefficient of correlation has been found to be the best suited.[14] The symbol r is used to designate this coefficient in simple correlation, that is, where the association between only two variables is being tested as in the X and Y example above. The symbol R is used to designate this coefficient in multiple correlation where the association between a given dependent variable and several other independent variables is being tested. The symbols r^2 and R^2 designate the square of the coefficient of simple or multiple correlation and represent an index which is sometimes called the coefficient of determination. This is a measure of the degree of association also, and indicates the per cent of variation in the dependent variable which can be "explained" by the variations of the independent variable, or independent variables in the use of multiple correlation.

The dependent variable in this study is the number of workers employed from county to county in the synthetic textile fiber industry. As to the independent variables, it is necessary at this point to formulate certain hypotheses regarding the association between this industry and other industries or other factors which may be associated with it in areal distribution. Since the synthetic fiber industry may be expected to be part of an in-

[14] Harold H. McCarty, John C. Hook, and Duane S. Knos, The Measurement of Association in Industrial Geography, Department of Geography, State University of Iowa, Iowa City, Iowa, 1956, p. 67.

dustrial complex, it should be found in areas where there are other industries, especially where there are industries providing it with raw materials and where there are industries (namely, the textile and apparel industries) constituting a market for its production. With these probable associations in mind the following associations are hypothesized for the synthetic fiber industry.

"The Industrialized Location Hypothesis." The number of workers employed in the synthetic fiber industry will vary directly with the total number of workers employed in manufacturing and with the number of workers employed in the chemicals industry. (1954 Census of Manufactures Major Group No. 28.)

"The Raw Materials Orientation Hypothesis." The number of workers employed in the synthetic fiber industry will vary directly with the number of workers employed in the pulp and paper industry, (Major Census Group No. 26); and with the number of workers employed in the petroleum and coal processing industries, (Major Census Group No. 29). This latter group includes by-product coke ovens and petroleum refineries.

"The Market Orientation Hypothesis." The number of workers employed in the synthetic fiber industry will vary directly with the number of workers employed in the textile industry, (Major Census Group No. 22); and with the number of workers employed in the apparel industry, (Major Census Group No. 23).

Sub-hypothesis: The number of workers employed in the synthetic fiber industry will vary inversely with the average annual wage. The rationalization behind this sub-hypothesis is the fact that low wages are usually given as a principal reason for the location of the textile industry; especially of the flight of textiles to the southern states. Thus the sub-hypothesis is considered to be a part of the market of orientation hypothesis.

Values for the Pearson product moment coefficient of correlation theoretically may vary from 1.00, indicating a perfect correlation between the variables, to -1.00, indicating a perfect negative or inverse correlation or association between them. The smaller the value of the coefficient (that is, the nearer 0.00), the smaller is the amount of association between the variables. A coefficient value of 0.00 would indicate a total lack of correlation or no association whatever between the variables. The following table lists the values obtained for r, the coefficient of correlation computed separately in simple correlation of each of the independent variables with the dependent variable, the synthetic fiber industry.

COEFFICIENTS OF CORRELATION AND DETERMINATION FOR SIMPLE CORRELATION OF INDEPENDENT VARIABLES WITH THE SYNTHETIC FIBERS INDUSTRY (1954)

	Variable	r	r^2
X_{01}	Total Workers in Manufacturing	.3366	.1133
X_{02}	Textiles (22)	.3749	.1406
X_{03}	Apparel (23)	.2947	.0868
X_{04}	Pulp and Paper (26)	.2871	.0624
X_{05}	Chemicals (28)	.5755	.3311
X_{06}	Petroleum and Coal (29)	.1933	.0373
X_{07}	Average Annual Wage	.2223	.0494

Since the average annual wage showed a positive value of .2223 for r this indicated a direct variation rather than indirect as hypothesized in the sub-hypothesis. For this reason the sub-hypothesis had to be abandoned. A multiple correlation was then computed using the remaining six independent variables and an R value of .6690 was obtained. Squaring this R the value of R^2 was found to be .4475. This is taken to indicate that approximately 45 per cent of the variation in the synthetic fiber industry, by county units, in 1954, can be "explained" statistically or accounted for by the variations in the six independent variables taken together in multiple regression or correlation.

Limited space forbids the inclusion of raw data for the 493 counties in the twelve-state area covered in the study. Computations were made on an electric calculator to obtain the sums of squares and sum of products needed to compute coefficients of correlation. The following formula was used to compute both the coefficients of simple correlation and also coefficients of partial correlation between the various independent variables which were needed to compute the R or coefficient of multiple correlation.

$$r = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}} = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N}}{\sqrt{\left[\Sigma X^2 - \frac{(\Sigma X^2)}{N}\right]\left[\Sigma Y^2 - \frac{(\Sigma Y^2)}{N}\right]}}$$

In these equations the sums of squares and sum of products of the deviations from the mean represented by the small x and y are derived from the second equation in which the capital X and Y represent the raw score data computed on the calculating machine.

The following table or correlation matrix gives the coefficients of partial correlation between the various independent variables.

Consideration of the table of coefficients computed for simple correlation of the several independent variables taken one by one to measure their association with the synthetic fiber industry leads to several conclusions. The fact that the highest degree of association is found with the chemicals industry may be partially discounted since the synthetic fiber industry is itself a part of the chemicals industry. The next highest degree of association is found to be with the textile industry indicating that the orientation towards its market is stronger than towards the suppliers of raw materials for the synthetic fiber industry.

In other words, there is a tendency for synthe-

		(TWM) X_1	(22) X_2	(23) X_3	(26) X_4	(28) X_5	(29) X_6
X_1	(TWM)	1.0000	.5449	.2174	.7675	.4907	.5373
X_2	(22)		1.0000	.3215	.5021	.3710	.6450
X_3	(23)			1.0000	.4661	.3322	.1652
X_4	(26)				1.0000	.6442	.4901
X_5	(28)					1.0000	.4567
X_6	(29)						1.0000

The formula for computing the R or coefficient of multiple correlation is:

$$R_{X_{0.1,2,3,4,5,6}} = \sqrt{1-(1-r^2_{X_{0.1}})(1-r^2_{X_{0.2,1}})(1-r^2_{X_{0.3,2,1}})(1-r^2_{X_{0.4,3,2,1}})(1-r^2_{X_{0.5,4,3,2,1}})(1-r^2_{X_{0.6,5,4,3,2,1}})}$$

X_0 here is equivalent of Y above.

tic fiber manufacturing plants to be located with respect to their raw materials supply, but the tendency is even stronger for them to be located with respect to the market for their product. As to future location of this expanding industry, it seems likely that it will tend to be drawn towards the textile industry where the market for its product is found.

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