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Volume 41 April 1987

NORTH DAKOTA ACADEMY OF SCIENCE
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1986-87

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79th ANNUAL MEETING

April 23-25, 1987

Moorhead, Minnesota

(Joint Meeting with Minnesota Academy of Science)

Editor's Notes

The Proceedings of the North Dakota Academy of Science was first published in 1948, with Volume I reporting the business and scientific papers presented to the fortieth annual meeting, May 2 and 3, 1947. Through Volume XXI, the single yearly issue of the Proceedings included both Abstracts and Full Papers. Commencing with Volume XXII the Proceedings were published in two Parts. Part I, published before the annual meeting, contained an Abstract of each paper to be presented at the annual meeting. Part II, published later, contained full papers by some of the authors.

Commencing in 1979 with Volume XXXIII of the Proceedings of the North Dakota Academy of Science, a new format appeared. The Proceedings changed to an 8½ x 11 format, it is produced from camera-ready copy, and it is issued in a single part prior to the annual meeting (*i.e.* in mid-April). Each presentation at the annual meeting is represented by a full page "Communication" which is more than an abstract, but less than a full paper. The communications contain results and conclusions, and permit data presentation. The communication conveys much more to the reader than did an abstract, but still provides the advantage of timeliness and ease of production.

The 79th Annual Meeting of the North Dakota Academy of Science is a joint, integrated meeting with the Minnesota Academy of Science. In 1976 the two Academies held a very successful first joint meeting in Fargo and thereby provided a special opportunity for scientists from the two states to interact. The memory of that event led to plans for a repeat joint meeting this year. While the program is joint, it was agreed that each Academy would publish its own Proceedings in order to maintain continuity of publication. Thus, this Proceedings includes only those student papers and professional papers emanating from North Dakota, but also all symposia papers.

The first section of this volume of the Proceedings contains all 38 papers presented in the six symposia at the 1987 annual meeting of the Academy. The papers are presented in the same sequence as presented at the meeting, and are numbered as they appeared in the meeting program.

The second section of this volume of the Proceedings contains 41 of the 62 communications presented in the Professional section of the 1987 annual meeting of the Academy. All professional communications were reviewed for conformity with the instructions by the Editorial Committee prior to their acceptance for presentation and publication herein. The professional communications have been grouped together in this volume, and are numbered in the sequence in which they appear in the meeting program.

The third section of this volume contains 15 of the 33 collegiate communications, representing all those papers presented in the A. Rodger Denison Student Research Paper Competition. Undergraduate and graduate students reported on the results of their own research activities, usually carried on under the guidance of a faculty advisor. While the student competitors were required to prepare a communication similar to those prepared by their professional counterparts, these communications were not subject to review prior to publication herein. The Denison Awards Committee judged the oral presentation and the communication in arriving at their decision for the first place and runner-up awards in both the graduate and undergraduate competition. The collegiate communications are numbered in the sequence in which they appear in the meeting program.

Readers may locate papers by presentation number within the major sections of these Proceedings or by referring to the author index in this volume for a page reference.

A. William Johnson
Editor

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NORTH DAKOTA ACADEMY OF SCIENCE

I. Rules for Preparation of Proceedings Communication

1. Each paper presented at the annual meeting of the Academy must be represented by a communication in the Proceedings, including A. Rodger Denison student research competition papers.
2. Only communications intended for presentation at the annual meeting will be considered for publication. They must present original research in as concise a form as possible. Quantitative data should be presented with statistical analyses (i.e., means with standard errors). Papers which merely summarize conclusions or ideas without supporting data are discouraged and will not normally be accepted. The communication should include the purpose of the research, the methodology, results, and conclusions.
3. Authors are encouraged to utilize the full space available in order to provide sufficient information to fully describe the research reported.
4. Communications must be prepared on the special blue-line form and sent, with three legible xerox copies, by first class mail to the Secretary, North Dakota Academy of Science, University Station, Grand Forks, ND 58202. The form must not be folded; a cardboard backing should be used to avoid damage. The Proceedings will be published by direct photo-offset of the submitted communication. No proofs will be prepared.
5. All typing, drawing and secured art or photographic materials must be within the boundaries of the blue-line form. Consult the example on the reverse side of the special form for proper style (i.e., titles, authors, address, tables, figures, references, indentations, headings, and punctuation). *Indicate the author to present the communication by an asterisk (*) after that person's name.*
6. Tables, diagrams, and photographs are acceptable provided they are secured to the special form and do not occupy a total area of more than 100 square centimeters.
7. Only essential references should be cited, and should be indicated in the text by numerals and quoted at the end of the communication. Up to three authors' names may be cited in full; with four or more authors only the first should be cited. The following form of citation should be used:

   Journals: Neary, D., Thurston, H. and Pohl, J.E.F. (1973) *Brit. Med. J.* 3, 474-475. (Abbreviate titles.)

   Books: Batsone, G.F., Blair, A.W. and Slater, J.M. (1971) *A Handbook of Pre-natal Paediatrics*, pp. 83-90. Medical and Technical Publishing, Lancaster.

   Individual chapters in books: Farah, A.E. and Moe, G.K. (1970) in *The Pharmacological Basis of Therapeutics* 4th edition (Goodman, L.S. and Gilman, A., eds.), pp. 677-708. Macmillan, New York.

   Conferences and symposia: Rajewsky, M.F. (1973) Abstr. 2nd Meeting European Association for Cancer Research, Heidelberg, Oct. 2-5, pp. 164-5.

8. Use a typewriter with elite type and with a carbon or good quality black silk ribbon. Single space and begin paragraphs with a 3 space indentation. Special symbols, not on the typewriter, must be hand lettered in black ink.
9. Abbreviations: Only standard abbreviations should be used, and should be written out the first time used with the abbreviation following in parentheses.
10. Titles: It is suggested that authors select a sufficient number of keywords to describe the full content of their paper and then construct a title using as many as these as practicable. Titles normally should not exceed 140 characters in length. In particular, they should be free from unnecessary phrases such as "a preliminary investigation of" or "some notes on" which add little or nothing to their meaning.
11. Session Assignment: In order to assist the program committee in organizing the presentations, please indicate on the reverse side of the blue-line form your 1st, 2nd, and 3rd preferences for the topical classification of your paper.
12. The authors' permission for the North Dakota Academy of Science to publish is implied by a submission. The Academy does not restrict the right of authors to include data presented in a communication in full papers submitted at a later date to other publishers.

II. Rules for Oral Presentation of Paper

1. All papers are limited to 15 minutes total time, for presentation and discussion. It is suggested that the presentation be limited to 10 minutes with an allowance of 5 minutes for discussion. It is also suggested that major emphasis be placed on the significance of the results and the general principles involved rather than on the details of methods and procedures.
2. Academy members represent a variety of scientific disciplines; therefore, speakers should avoid "jargon" and briefly explain or define such specialized terminology as may be judged to be indispensable to the presentation.
3. Projectors for 2" x 2" slides only will be available in all session rooms. Opaque projectors will NOT be provided. Only slides which can be read easily on projection should be used. Authors who desire suggestions for preparation of slides are referred to Smith, Henry W. 1957. "Presenting information with 2 x 2 slides." Agron. J. *49*. pp. 109-113.
4. Timed rehearsals with slides are highly recommended. There is usually time for a *maximum* of 6 or 7 slides for a presentation of this kind.

SYMPOSIUM

on

GRAZING SYSTEMS IN NORTH DAKOTA

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North Dakota State University-Bottineau
Bottineau, ND

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Department of Animal and Range Sciences
North Dakota State University
Fargo, ND

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Dickinson, ND

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Streeter, ND

5. Influence of Grazing Systems on Waterfowl Production
D. Hertel* and W. T. Barker
Department of Animal and Range Sciences
North Dakota State University
Fargo, ND

(1) COMPLEMENTARY ROTATION GRAZING IN NORTH DAKOTA

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Grazing of grass by herbavores is a natural process. Grasses of the Great Plains evolved with grazing pressure. The effects of grazing are not different between domestic livestock and wild ungulates. Grazing is an important component in proper ecological management of grasslands.

Settlement of the prairies has eliminated free roaming bison herds and open range grazing of livestock. Now we are restricted to management of relatively small parcels of land of individual ownership. Even public owned land is divided into small parcels. Until recently, each individual parcel of grazing land was managed as a single unit and grazed continuously for the entire grazing season. Several problems develop in the grassland ecosystem with this type of grazing management. A. The health and vigor of the plants are reduced. This reduces herbage production which reduces available forage for livestock and habitat for prairie wildlife. B. Grazing early in spring (May) reduces total herbage production by 40-60%. C. Nutritional quality of grasses drops below crude protein requirement for lactating cows after July. This reduces cow weights, available milk and decreases calf weight gains.

We will never go back to range management by large free roaming herds. We will always be restricted to manage relatively small parcels of land. Also the economics of modern society prohibits low productivity from any parcel of land regardless of ownership or whether the production is wheat, livestock, or waterfowl. An increase in production requires an increase in intensity of the management. This means using sound ecological principles to reduce detrimental effects and enhance the positive effects.

Using a complementary rotation grazing system is one type of intensive management available that can be used to benefit the grass, livestock, wildlife and landowner. Complementary rotating grazing uses domesticated grass pastures to add to or complement the native range pastures. Crested wheatgrass pastures are grazed from early to late May. Native range pastures are grazed from the first of June through mid October. Altai wildrye pastures are grazed from mid October to mid December (Manske and Conlon, 1986). A rotation grazing system based on the phenology of the major grasses is used on the native range. This rotation system improves the health and vigor of the grass which increases herbage production. The nutritional quality of the available forage at the end of the growing season is increased so the cow weight loss and reduction in lactation is delayed one to two months and calf gains are maintained for a longer period. Habitat for wildlife is improved. Using domesticated grass pastures in spring provides nutritious forage earlier than native range, so grazing can start earlier and it delays the early spring use of native range. This eliminates the detrimental effects of early grazing which increases total herbage production on native range. Using domesticated grass pastures in fall provides forage of higher nutritional quality at a time that native range grasses are below the livestock requirements. This maintains cow weights, cow lactation and calf weight gains at a higher level. The early spring and late fall grazing of domesticated grasses extends the grazing season more than one month longer than can be grazed on native range alone. This reduces the amount of acres required for harvested forage for winter feed. Stocking rates on domesticated grass pastures and native range grazed in a rotation system can be increased above native range grazed continuously for the season. This reduces the number of acres required to carry a cow and calf. Calves maintain a good weight gain for a longer period of time and are weaned at a heavier weight. This increases saleable production per acre. Habitat for wildlife is improved and populations can increase if winter food is available. Intensive management of grasslands by using a complementary rotation grazing system can benefit grasses, livestock, wildlife, and landowners.

1. Manske, Llewellyn L., and Conlon, Thomas J. (1986) Complementary rotation grazing system in western North Dakota. North Dakota Farm Research 44, 6-10

(2) COMPLEMENTARY GRAZING IN EASTERN NORTH DAKOTA

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Complementary grazing systems use various forages to complement or enhance native range pastures. The four-pasture complementary grazing trial at the Central Grasslands Research Station utilizes crested wheatgrass for spring, native mixed grass prairie for summer, Russian wildrye for late summer and early fall and Altai wildrye for late fall grazing. The 12-hectare crested wheatgrass, Russian and Altai wildrye pastures were seeded in the fall of 1982 and spring of 1983. The native pasture adjoining the seeded pastures consists of 32 hectares.

The purpose of the trial is to compare herbage and livestock production and grazing season length on a complementary grazing system with alternative systems such as short duration and twice-over grazing rotation. Herbage production is measured by clipping inside a 0.25 m^2 frame placed on representative sites within each of the four pastures. All forage samples collected are then placed in paper bags, oven-dried and weighed.

Herbage production on the complementary system has increased on all pastures during the three years of the trial (table 1). The seeded introduced pastures have increased in stand density during this time. In 1985, 56 kg/ha of nitrogen from ammonium nitrate was applied to the three seeded pastures. In addition to this, the precipitation has been above normal especially in 1986. These data combined with observations during the course of the study indicate that crested wheatgrass becomes established faster than either Russian or Altai wildryegrass. Although Altai is a higher producing grass, there has been more encroachment of annual and perennial weeds in the stand indicating that it has yet to fully occupy the site even after four years.

None of the introduced pastures were grazed the first season following seeding. In 1984, 19 cow/calf pairs were grazed on the system starting on June 5. This late starting date allowed the crested wheatgrass another month of growth in the second season. Mean average daily gains and production per hectare for the calves for 1984 were .97 kg/hd/day and 34 kg/ha respectively. In 1985, mature stands of the seeded pastures, coupled with the application of fertilizer, permitted a longer grazing season and higher stocking rates. Mean average daily gains and production per hectare increased substantially over 1984 with 1.05 kg/hd/day and 65 kg/ha respectively. In 1986, the calves were weaned and removed from the system following 182 days. Calf production during this time averaged 74 kg/ha (table 1).

Average daily gains for the complementary, short duration, twice-over and seasonlong show no significant differences during the three years of the trial. Calf gains per hectare did vary depending on season length and stocking rate. During the 1984 grazing season, per hectare gains were slightly lower on the complementary than on the seasonlong with 34 kg/ha and 43 kg/ha respectively. During the same season, the short duration and twice-over systems produced 58 kg/ha and 55 kg/ha respectively. During the 1986 season, however, the higher herbage production and longer grazing season increased the calf production on the complementary system to 74 kg/ha compared with 47 kg/ha on the seasonlong 66 kg/ha on the short duration and 68 kg/ha on the twice-over.

Table 1. Four pasture complementary grazing trial herbage and beef production, CGRS, 1984-1986.

Pasture	Year	Grazing Period	Days Grazed: Cows	Days Grazed: Calves	Pasture Size (ha)	Cow/calf Pairs	Herbage Prod. (kg/ha)	Percent Disappearance	ADG/Cow (kg)	ADG/Calf (kg)	Calf Prod. in kg/ha
Crested Wheatgrass	1984	6/05-7/13	38	38	12	19	2264	52	0.66	1.03	62
	1985	4/23-6/17	55	55	12	25	4292	59	0.42	1.01	114
	1986	4/23-6/03	41	41	12	30	3056	75	-0.27	1.06	108
Native Pasture	1984	7/13-9/18	67	67	32	19	1487	38	0.57	1.01	39
	1985	6/17-9/09	84	84	32	25	1481	54	0.23	1.14	74
	1986	6/03-8/26	84	84	32	30	2697	54	0.51	1.24	96
Russian Wildrye	1984	9/18-10/02	14	14	12	19	758	69	-0.44	1.01	22
	1985	9/09-10/14*	35	32	12	25	2149	86	0.13	0.87	57
	1986	8/26-09/29	34	34	12	30	2413	84	-0.39	0.27	22
Altai Wildrye	1984	10/02-10/23**	21	7	12	19	1604	60	-1.01	0.07	1
	1985	10/14-11/21	38	38	12	25	2702	70	0.59	--	--
	1986	09/29-11/09***	41	23	12	30	5102	70	0.38	0.59	34
			Total		Mean	Mean	Mean	Mean	Mean	Mean	Mean
	1984		140	126	68	19	1516	55	0.25	0.97	34
	1985		212	171	68	25	2311	68	0.33	1.05	65
	1986		200	182	68	30	3135	71	0.17	0.93	74

(3) FOUR PASTURE, TWICE-OVER ROTATION GRAZING IN NORTH DAKOTA

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A study to compare cow-calf performance and forage production and utilization on a four pasture, twice-over rotation grazing system to seasonlong grazing was initiated in 1985. This paper reports the 1985 and 1986 results. This study was conducted at the Central Grasslands Research Station (CGRS) which is located 11.3 kilometers northwest of Streeter, ND. The study area is located in the glaciated region of the state known as the Missouri Coteau.

In the Northern Great Plains of the US and adjacent plains of Canada seasonlong and once-over rotation grazing systems have been compared (1, 2, 3, 4, 5, 6, and 7). Most of these studies were done using steers rather than cows and calves. Rotation grazing usually favors the performance of vegetation over seasonlong grazing. Results have been mixed on whether or not livestock performance is better on seasonlong or rotation grazing systems. Weinhold and Barker reported on a comparison of a three pasture, twice-over rotation grazing system and seasonlong grazing (8).

The four pasture rotation system is replicated twice. Each replication consists of four pastures which are 32.4 hectares (ha). The seasonlong pasture is 129.6 ha in size. In 1985 and 1986 each replication of the twice-over rotation system was stocked with 60 and 65 cow-calf pairs, respectively. The seasonlong pasture was stocked with 45 cow-calf pairs. The grazing season in 1985 began on May 28 and continued for 160 days for the cows and 136 days for the calves. In 1986 grazing began on May 23 and continued for 161 days for the cows and 138 days for the calves. Calves were weaned early as the vegetation began to dry up to prevent weight loss or reduced daily weight gains.

Each pasture of the four pasture, twice-over rotation was grazed so that each pasture was grazed for two 20 day periods with two 60 day periods of rest. Cows and calves were weighed when placed on the pasture and then at 20 day intervals beginning in July until they were removed from the pastures. Vegetation sampling was carried out on silty and overflow sites to determine floristic composition and structure, production and utilization. Table 1 shows the production and utilization of forage and the livestock performance for 1985 and 1986.

Favorable livestock performance and proper utilization under higher stocking rates indicate that the four pasture, twice-over grazing system used in this study may lead to more efficient use of our forage resource. In most instances producers need only to alter the way they move their cattle to adopt twice-over rotation grazing.

Table 1. Forage production and utilization and livestock performance on seasonlong and four pasture, twice-over grazing treatments on the CGRS in 1985 and 1986.

		Forage		Livestock			
				Cows		Calves	
System		Production[3]	Utilization %	ADG[1,4]	AG/ha[2,3]	ADG[4]	AG/ha[3]
Seasonlong	1985	3174	58	.3	16.9	.95	45.1
	1986	3839	59	.4	23.9	1.0	47.5
Four pasture, twice-over rotation	1985	2909	52	.36	27.6	1.0	64.0
	1986	3505	48	.43	34.8	.98	67.9

[1]ADG = Average Daily Gain
[2]AG/ha = Average Gain/hectare
[3]Figures are presented in Kg/ha
[4]Figures are presented in Kg

1. Sarvis, J.T. (1923) USDA Bull. 1170
2. Sarvis, J.T. (1941) N.D. Agr. Exp. Sta. Bull. 308
3. Rogler, G.A. (1944) N.D. Agr. Exp. Sta. Bimonthly Bull. 6, 20-27
4. Rogler, G.A. (1951) J. Range Manage. 4, 35-41
5. Smoliak, S. (1960) J. Range Manage. 13, 239-243
6. Campbell, J.B. (1961) J. Range Manage. 14, 72-77.
7. Hubbard, W.A. (1951) J. Range Manage. 4, 25-29
8. Weinhold, B.J. and W.T. Barker. (1985) Proc. N.D. Acad. Sci. 39, 30

(4) SHORT DURATION GRAZING IN NORTH DAKOTA

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Grazing management practices and systems have contributed significantly to improvement of rangelands (3). Specialized systems such as short duration (SD) grazing have been suggested for increased forage and livestock productivity from rangelands (1, 2, 4). However, due to the recent introduction of this grazing method into North America, limited evaluation has occurred. This long-term study was designed to compare SD grazing to conventional seasonlong (SL) grazing in the mixed grass prairie of North Dakota.

Grazing trials were initiated at the Dickinson Experiment Station Ranch Headquarters (DESR) in 1981 and at the Central Grasslands Research Station (CGRS) in 1982. At both locations, the SD treatment was established as eight-16.25 ha paddocks grazed 5 days and rested 35 days and compared to a 130 ha pasture grazed seasonlong. Stocking rates were 1.26 and 0.9 AUM/ha at the DESR and 2.67 and 1.75 AUM/ha at the CGRS for the SD and SL treatments, respectively. Portable exclosures were used to estimate forage production and disappearance while livestock performance was determined by monthly weighings.

Forage production has ranged from 759 to 1978 kg/ha at the DESR (table 1). Forage availability has been consistently greater on the SL treatment, yet year-to-year variation in forage production within treatments has been greater, exceeding 100%. Forage disappearance has been similar despite 40 to 75% more cow-calf pairs annually grazing the SD treatment. Cows maintained more gain on the SL treatment while calf gains have been similar. Increased calf production per ha on the SD treatment is a reflection of the greater stocking rate on this treatment.

Forage production has also been consistently greater on the SL treatment at the CGRS (table 1). Forage production on both grazing treatments has averaged over 2000 kg/ha during the trial. As at the DESR, forage disappearance has been similar between the grazing treatments despite 45 to 50% more cow-calf pairs grazing the SD treatment. Cow and calf average daily gains have been similar between the grazing trials. Calf gains per ha have been greater for the SD treatment which is a reflection of the greater stocking rate on this treatment.

Table 1. Forage production and disappearance and livestock performance

Treatment		Forage		Livestock			
				Cows		Calves	
		Production (kg/ha)	Disappearance (%)	Average daily gain (kgs)	Average gain/ha (kgs)	Average daily gain (kgs)	Average gain/ha (kgs)
Dickinson Experiment Station Ranch Headquarters (1981-1985)							
SD	Avg	1244	53	.09	3.9	.95	29.1
	Range	759-1967	41-61	0-.18	0-5.6	.86-1.0	17.9-37.0
SL	Avg	1486	52	.14	2.8	1.0	20.2
	Range	760-1973	36-61	0-.32	0-5.6	.86-1.04	11.7-26.9
Central Grasslands Research Station (1982-1986)							
SD	Avg	2486	54	.32	21.3	.86	56.0
	Range	1620-3997	41-62	.23-.41	15.7-32.5	.73-.95	34.7-66.1
SL	Avg	2828	53	.32	16.8	.91	32.5
	Range	1847-3835	41-67	.18-.41	10.1-24.6	.73-1.0	21.1-47.0

1. Heitschmidt, R.K., et. al. (1982) J. Range Manage., 35, 367-372.
2. Heitschmidt, R.K., et. al. (1982) J. Range Manage., 35, 372-374.
3. Kothmann, M.M. (1980) in Digestive Physiology and Nutrition of Ruminants (Church, D.C., ed.), pp. 56-90. O&B Books, Inc., Corvallis, Ore.
4. Savory, A. and S. Parsons. (1980) in Beef Cattle Science Handbook, (Ensminger, M.E., ed.) pp. 215-221. Agri. Services Found., Clovis, Ca.

(5) INFLUENCE OF GRAZING SYSTEMS ON WATERFOWL PRODUCTION

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Range scientists of the N.D. Agricultural Experiment Station have initiated studies of seasonlong, short duration, twice-over rotation and complementary grazing systems at the Central Grassland Research Station (CGRS) near Streeter, N.D. These range studies began in 1981 and are continuing. This has provided the opportunity to compare the success of upland nesting waterfowl in relation to these grazing treatments. Idle mixed-grass prairie areas were also compared to the grazing systems in 1985 and 1986.

The seasonlong grazing pasture consists of 129.6 ha which was grazed continuously in 1985 and 1986 from May 28 and May 23 for 160 and 161 days, respectively. The short duration system consists of eight 16.2 ha pastures in which cattle were allowed to graze for 5 days and then rotated to the next pasture. Four complete rotations were carried out in 1985 and 1986 for 160 and 161 days, respectively, beginning on May 28, 1985 and May 23, 1986. The complementary system consists of three tame grass pastures and one native grass pasture. Cattle begin grazing on about April 23 on a crested wheat grass pasture (12.2 ha) and remain there until the middle of May. Then the cattle graze from the middle of May until the second week in September on a native grass pasture (32.4 ha) when they graze Russian wildrye (12.2 ha) until the middle of October. The cattle graze altai wildrye (12.2 ha) from the middle of October until snow dictates the removal of the cattle, usually around mid-November. The twice-over rotation system consists of four 32.4 ha native grass pastures (replicated twice) which are grazed for two twenty day periods with 60 days or more of rest between each grazing period. In 1985 and 1986 the twice-over system of grazing was grazed for 160 and 161 days beginning May 28 and May 23, respectively. The idle areas were not grazed and consisted of 56.7 ha.

Reported declines of prairie chicken, sharptail, sage grouse and waterfowl due to intensive grazing pressure are frequent in the literature (1 and 2). Glover, Kirsch, and Gjersing cite the reduction of residual cover as being the main cause of the declines (3, 4, and 5).

In April of each year the amount of residual cover on the various range sites were determined prior to vegetation greenup, and at vegetation greenup by the Robel method (6). Nest dragging was carried out three times at three-week intervals by pulling a chain between two all terrain vehicles to locate nests. After the nests were located data was taken on each nest to determine site characteristics around the nest, the species nesting and the stage of development of the nest. Follow-up visits were made to each nest to determine the ultimate success or failure of the nest. Table 1 shows the average number of nests, average number of successful nests, and percent success on the grazing treatments for the combined years 1985 and 1986. Seven species of waterfowl nested in the idle areas and grazing systems.

It appears that more residual vegetation is left in some of the grazing treatments and that some grazing treatments are preferred over others by nesting birds. Predators appear to be most successful in the idle areas.

Table 1. Average number of nests, average number of successful nests and percent success on the grazing treatments for 1985 and 1986.

Treatment	Number of nests	Number of successful nests	Percent success
Twice-over rotation (259.1 ha)	56.0	36.5	65.2
Short Duration (129.6 ha)	27.0	18.0	66.7
Seasonlong (129.6 ha)	14.5	9.5	65.5
Complementary (68.8 ha)	7.5	3.0	40.0
Idle (56.7 ha)	20.0	8.0	40.0

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SYMPOSIUM

on

PLANT TISSUE CULTURE

Presiding: David G. Davis
USDA/ARS Metabolism and Radiation Research Laboratory
Fargo, ND

6. Plant Tissue Culture - Recent Developments. Introduction and Historical Developments
David G. Davis*
USDA/ARS Metabolism and Radiation Research Laboratory
Fargo, ND

7. Tissue Culture as a Tool in Plant Physiological Research
Donald S. Galitz*
Botany/Biology Department
North Dakota State University
Fargo, ND

8. Anther Culture of Wheat and Triticale
Murray Duysen* and Cathy Medich
Botany Department
North Dakota State University
Fargo, ND

9. Dihaploid Plant Production From Ovule Cultures of Sugarbeet
Margaret S. Gibson*
Research Center - American Crystal Sugar Company
Moorhead, MN

10. *In Vitro* Screening of Ponderosa Pine for Resistance to Western Gall Rust
G. A. Tuskan*
Department of Horticulture and Forestry
North Dakota State University
Fargo, ND

J. A. Walla
Department of Plant Pathology
North Dakota State University
Fargo, ND

11. Potato Tissue Culture - Tool for Studying the Mechanism of Starch Synthesis
Joseph R. Sowokinos*
Red River Valley Potato Research Laboratory
East Grand Forks, MN

12. Properties of Potato Tuber Cell Culture Respiration
Edward C. Lulai* and Joseph R. Sowokinos
Red River Valley Potato Research Laboratory
East Grand Forks, MN

(6) PLANT TISSUE CULTURE - RECENT DEVELOPMENTS
Introduction and historical developments

David G. Davis*, Plant Physiologist
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This symposium has been organized to cover some of the aspects of plant tissue culture that are presently being used in plant research to help in our understanding of fundamental biological processes. This introduction will give the beginner a feeling for the general area of plant tissue culture and will describe some of the techniques used to obtain in vitro, aseptic plant cultures that can be manipulated in ways that cannot be done with intact plants. Descriptions of standard media and methods, the use of plant growth regulators to obtain and control plant growth processes, and the isolation and potential uses of plant protoplasts will be described briefly. Other speakers will address some of these procedures in more detail. Topics such as the biochemistry, physiology and genetic applications of plant tissue cultures will be discussed. No attempt will be made to cover all aspects of plant tissue culture, as the subject is much broader than those areas considered in this symposium. Areas of research that will only be mentioned briefly are: secondary product formation, biotransformation of xenobiotics and genetic engineering at the molecular level (that is, the use of restriction enzymes for isolating and cloning genetic material).

This introduction will only briefly touch on some of the research conducted at the USDA Metabolism and Radiation Research Laboratory, and will describe some of the results of experiments to regenerate the perennial weed leafy spurge (Euphorbia esula). Most of the discussion will describe ways in which tissue cultures can be used, and to set the stage for the following talks in the symposium. Other speakers will describe specific aspects of plant tissue culture used in their laboratories to help solve problems.

The following are pertinent references that may be helpful to beginners in becoming familiar with plant tissue culture techniques and areas of research (present and future):

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   Vol. 2 Sharp, W.R., Evans, D.A., Ammirato, P.V. and Yamada, Y., eds, (1984) Crop species.
   Vol. 3 Ammirato, P.V., Evans, D.A., Sharp, W.R. and Yamada, Y., eds, (1985) Crop Species.
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(7) TISSUE CULTURE AS A TOOL IN PLANT PHYSIOLOGICAL RESEARCH

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Attempts to isolate plant cells were first reported eighty-five years ago by Haberlandt (1902). Limited success was finally achieved by Molliard, Kotte and Robbins in the 1920's. Today plant tissue culture has become a generic term which includes the culture of diverse plant cells, tissues and organs. It is no longer a major task to establish cell or callus cultures from most plants. It is also fairly easy to develop fully functional organs from their excised primordia in many plant species. Whereas we have learned to manipulate organized development, tissue culture has resulted in some major horticultural applications. Most recently, plant scientists have made progress in applications of techniques in recombinant DNA, protoplast manipulation, genetic and protein engineering, monoclonal antibody production and microbiological engineering, to mention a few.

As yet, the most extensive use of plant tissue culture is in research. It allows us to explore growth phenomena with minimal interference by correlative factors and provides new approaches to physiologic and genetic problems heretofore difficult if not impossible to resolve. Some of the areas contributed to most significantly have been experimental morphogenesis, genetics and plant breeding research, disease etiology, rapid clonal propagation, production of disease free stock and production of antibodies, pharmaceuticals and related substances.

In our laboratory, plant tissue cultures have been utilized to study the effects of water stress on nitrate assimilation, the role of phytochromes in crown bud development in leafy spurge, the regulation of organogenesis in spurge cell suspension cultures and the regeneration of dihaploid plants from ovule cultures.

Water stress affects many physiologic processes which directly or indirectly affect nitrate assimilation by plants. The use of cell suspension cultures permits the imposition of regulated water stress on plant cells by the addition of a metabolically inert, non-toxic osmoticum to the culture medium. This eliminates the many indirect effects of stress mediated through modification of other physiologic processes thus permitting the evaluation of the impact of stress directly on nitrate uptake, reduction and assimilation.

Leafy spurge (Euphorbia esula L.) is a noxious perennial weed of the upper U.S. and Canada. It propagates extensively from root and crown buds rendering non-cultivated lands unproductive if not controlled. Cell and organ cultures have enabled us to study the significance of various environmental factors in the regulation of root and shoot bud development and the possible role of the phytochrome system in controlling the growth and cold hardening of crown buds.

Lastly, tissue culture has been used to develop dihaploid plants from ovule cultures of sugarbeets, which in turn are used by geneticists in their breeding programs.

Plant tissue culture has evolved quite rapidly and has already provided us with many benefits. It has gained prominance amongst many research groups and commercial users. However, the revolutionary methods of growth manipulation and genetic modification, using cultured cells and protoplasts, may only be the beginning of a new era in plant science.

(8) ANTHER CULTURE OF WHEAT AND TRITICALE

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The development of cereal lines for increased yields, stress tolerance, or improved seed quality can be limited by the production of homnozygous plants. One research technique that has potential for use in the introduction of new lines with uniform traits is tissue culture. Anther culture (androgenesis) can result in the production of haploid plants, homozygous diploid (dihaploids), and variant lines. Dihaploid plants are derived from microspores contained in the anther sac after formation of anther derived callus. Shoot initiation and root formation occurs from the callus. Chromosome doubling can occur spontaneously or can be induced by chemical treatment. At present, the yield of callus formation derived from microspores is low (3-4%). We report in these studies improved environmental and nutritional culture conditions to increase the production of anther derived callus from Triticum aestivum L. cv. Kitt and Triticale cv. Coorong.

Anthers were removed asceptically from plants when the microspores were between the tetrad and mid-uninucleate stage of development. Vernalization duration, auxin concentration, carbohydrate source and concentration, pH of the nutrient medium, and lactalbumin hydrolysate concentration were examined. Photoperiod, effect of light source, growth source of donor material, and the combination of "optimum" parameters were also examined for each cultivar. The relative area, correlation between relative area and fresh weight, and the growth rate of callus was measured. The relationship of anther orientation to the medium and the constitution of the anther wall was investigated. Greatest productivity of anther derived callus was observed in a medium that consisted of basal salts (1); 2,4-D, 15 mg/l; sucrose, 3.0%; lactalbumin, wheat 0g/l and Triticale 1g/l; pH, wheat 5.7 and Triticale 6.1; photoperiod 16h; temperature 22C; relative humidity 80%. Vernalization (4C) pretreatments of the inflorescence were: wheat 72h and Triticale 48h. Wheat responded best to blue light and Triticale responded best to red light (Table 1).

Table 1. Effect of wavelength of light on anther callus production of Triticum aestivum L. cv. Kitt and Triticale cv. Coorong. Light source was cool white flourescent (CWF) with filters passing the indicated wavelength (Filters obtained from Carolina Biological Supply, Burlington, NC).

Wavelength Maxima[1] (nm)	Anther Callus Production		
	Kitt (Percent)	Coorong (Percent)	Mean (Percent)
0	11.6 ± 3.9	34.7 ± 7.7	23.2 AB[2]
450	29.2 ± 8.4	38.9 ± 7.9	34.0 A
650	26.9 ± 3.3	39.1 ± 5.6	32.3 A
750	24.6 ± 2.1	31.0 ± 5.9	27.8 A
CWF	15.7 ± 4.7	10.4 ± 5.6	13.0 B
Mean	21.8[3]	30.8[3]	

Values are averages of 4-5 replicates ± standard error of the mean.

The number of anthers plated per treatment ranged from 233-420.

[1] Wavelength of light source determined significantly different ($p \leq 0.05$) by General Linear Models.

[2] Means with the same letter are not significantly different ($p \leq 0.05$). Determined by Student-Newman Keuls multiple range test.

[3] Species of tissue determined significantly different ($p \leq 0.05$) by General Linear Models.

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(9) DIHAPLOID PLANT PRODUCTION FROM OVULE CULTURES OF SUGARBEET

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Dihaploid plants are obtained by doubling the chromosome numbers of haploid plants. In sugarbeet, the 9 chromosomes in the haploid genome are doubled to give 18 in the dehaploid genome.

There are many uses for dihaploid plants. Homozygous plants are obtained very quickly by doubling the chromosome numbers of haploids. Dihaploids produced from ovules or anthers of hybrids allow for selection of lines with the best characteristics of the hybrids. In genetic engineering studies, dihaploid plants are used preferably in foreign gene insertion research.

Haploid sugarbeet cultures grown from ovules were used to produce dihaploid sugarbeet plants. The ovules were isolated from surface sterilized inflorescences of suitable diploid plants that hadn't begun to shed pollen. Isolated ovules were cultured on appropriate media under 16 or 18 h. days at 22-25 C for approximately a month at which time growth was visible. Generally, organized growth of a single plant per ovule emerged at the micropylar end of the ovule.

Organized tissue was transferred to vials of suitable media for further growth and development. Chloroplast counts were made on the guard cells of the leaves when they were well developed. Bossoutrot and Hosemans (1) as well as other research workers have found a good correlation between chloroplast number per guard cell and chromosome number. Colchicine was added to the media to induce chromosome doubling of the haploids. Generally, the cultures that survived the colchicine treatment had their chloroplast numbers increased from 4 to 6-10. The plantlets that grew after treatment were usually bigger with broader leaves than those without colchicine treatment.

The plantlets were allowed to develop on various suitable media. Rooting was induced by addition of naphthaleneacetic acid to the solid or liquid media. On transfer to sterile soil in the greenhouse, the weak haploid plants were difficult to grow in contrast to the dehaploid ones that become readily established.

The haploid plants were generally distinguished by small, narrow, abundant leaves. Chromosome counts were made on newlydeveloped leaves to verify dihaploidy. Gel electrophoresis of leaf enzyme extracts also helped to distinguish dihaploids.

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(10) IN VITRO SCREENING OF PONDEROSA PINE FOR RESISTANCE TO WESTERN GALL RUST

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Western gall rust (Endocronartium harknessii) is a forest pathogen which can severely damage many native and exotic pine species. Damage varies from the loss of lateral branches and terminal leader to the death of the entire plant. In North Dakota, ponderosa (Pinus ponderosa) and Scotch (Pinus sylvestris) pines are hosts of western gall rust. The long reproductive cycle of the host, the genetic variability in the pathogen, and the difficulty in controlling environmental parameters makes traditional screening methods for resistance in the host impractical. Therefore, an in vitro screening system is being developed.

Five main goals have to be met for the successful adoption of an in vitro screening system. They are (1) host families which represent resistant and susceptible genotypes have to be selected; (2) culturing parameters for the host callus, regenerated shoots and excised embryos have to be defined; (3) genetic variability found within the pathogen has to be described; (4) parameters for in vitro inoculation and host/pathogen co-cultivation have to be described; and (5) in vitro responses to known field performance and tested greenhouse performance have to be correlated. Progress is underway for the first of our goals. The fifth goal requires completion of the first four goals.

Goal 1 - Four resistant and four susceptible seed sources of ponderosa pine have been identified from within a 17-year-old provenance study, and will be used to create 64 full-sib families from within a tester mating scheme. These full-sib families will be used during the development of the in vitro screening system.

Goal 2 - Five mineral salt formulas were tested initially for suitability to culture ponderosa pine. LePoivre's (Aitken-Christie (1)) medium was selected for callus culture; Gresshoff and Doy's (2) medium was selected for a shoot production medium. Eight different ratios of 6-Benzylamino purine (BAP) and Naphthaleneacetic acid (NAA) were also tested. 1.0 mg/L NAA and 0.01 mg/L BAP were selected for callus production, and 15 mg/L BAP and 0.1 mg/L NAA were selected for shoot initiation. Complete plantlets have been produced.

Goal 3 - Starch gel electrophoresis has been used to examine 35 enzymes within individual gall collections of western gall rust. Twenty-one enzymes express activity, with 10 enzymes displaying variability among isolates. It appears that several isolates will have to be used during the screening process.

Goal 4 - Artificial inoculation of 9-month-old ponderosa pine seedlings were successful. Gall formation was evident three months after inoculations. In vitro inoculations of pine callus were unsuccessful. Contaminanats appeared on two of the 20 cultures; the remaining cultures eventually died with no signs of infection. Callus cultures have been established from cambium tissue found within galls of infected seedlings. Calus from healthy tissue has grown at a faster rate than callus from infected tissue. Histological tests are being used to verify pathogen mycelium within the gall-derived callus.

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(11) POTATO TISSUE CULTURE - TOOL FOR STUDYING THE MECHANISM OF STARCH SYNTHESIS

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Callus tissue (Solanum tuberosum L. cv. Norchip) was utilized to help clarify the physiological role(s) of pyrophosphorylase enzymes in regulating starch deposition in potato cells. The enzyme ADPglucose pyrophosphorylase (ATP:α-glucose-1-P adenylyltransferase, E.C. 2.7.7.27) is the major rate-limiting step in the biosynthesis of α-glucans in bacteria and plants (1). This enzyme catalyzes the first step in the synthesis of starch (i.e., ATP + glucose-1-P ADPglucose + PPi) (Fig. 1, reaction 4). The product ADPglucose is the primary glucosyl donor for soluble and particulate starch synthases in potato tubers (Fig. 1, reaction 5).

Starch granule development occurs in plastid structures (amyloplasts) during potato tuber growth. These granules are surrounded by a double walled plastid membrane that serves as a viable partition between the starch granule and the cytoplasm of the cell. Recent data suggests that amyloplasts from nonphotosynthetic tissues may be similar to leaf chloroplasts in the transfer of phosphorylated intermediates across their plastid membranes. The tentative metabolic flow scheme for starch-sugar interconversion in potato cells is shown in Figure 1. Reactions 3 and 4 represent the triose P-Pi transport system and the ADPglucose pyrophosphorylase reaction, respectively. Similar to the ADPglucose pyrophosphorylase isolated from plant leaf chloroplasts, the enzyme purified from potato tuber is allosterically activated by 3-P-glycerate (3PGA) and inhibited by inorganic phosphate (Pi) (2). This regulation mechanism appeared to represent an efficient way of linking starch synthesis to assimilate transport (3).

De-differentiated callus tissue generated from parenchyma cells of potato tissue retains thepotential to form starch, but at a concentration far below that observed in the mother tuber (4). Supplementation of media with excess carbohydrate, coconut milk, and amino acids generally resuled in an increase in solids content, but it was difficult to discern the influence of the individual media constituents on the starch synthesizing mechanism. Activities of enzymes related to starch synthesis in potato callus cultures have been studied (5), but assays of pyrophosphorylase enzymes were not included.

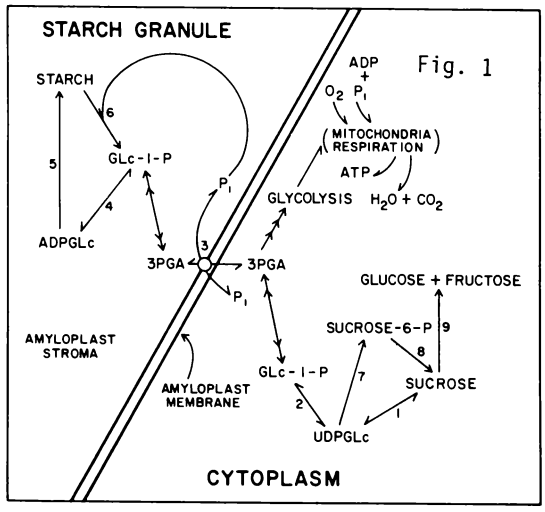

Fig. 1

The basal media used in this study was minimal in nutrients while still allowing growth anddivision to occur. Only salts, auxin and sucrose were required. Initial studies were conducted with agar cultured cells. A micro-injection technique was employed that permitted the supplementation of certain metabolites (i.e., ATP, Pi, ADpglucose, 3PGA, KCl) singly or in combination (at physiological concentrations) into the callus mass. After a defined culture period, their effect on starch synthesis was determined. Sucrose synthase (reaction 1) and pyrophosphorylase enzyme activites (reaction 2 and 4) were assayed and their activity levels were compared to levels noted in the mother tubers.

A deficiency of ADPglucose pyrophosphorylase activity was found in the low starch callus tissue. Results supported that coarse (enzyme level) and fine (concentration of key substrates and effectors) metabolic controls may cooperatively limit starch synthesis in potato callus tissue. Addition of 2.0 mM 3PGA to the cells gave the greatest stimulation of starch formation. This is consistent with the view that triose-P is the form in which carbon is transported into the amyloplast.

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(12) PROPERTIES OF POTATO TUBER CELL CULTURE RESPIRATION

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The market quality of potatoes is influenced largely by the ability to control wound healing (suberization) and starch degradation (sweeting) attributed to the oxidation of membrane lipids with subsequent changes in respiratory pathways i.e. electron transport via the cytochrome pathway (cyanide/azide sensitive) and alternative oxidase pathway (cyanide/azide resistant but sensitive to hydroxamates).

Respiration studies of fresh tuber slices are complicated by an immediate 5-fold rise in oxygen uptake (respiration) followed by another 3 to 5-fold rise in respiration upon aging (1). Whole tuber respiration is cyanide resistant but freshly cut tuber slices are cyanide sensitive and use lipid as respiratory substrate. Upon aging the slices become cyanide resistant and revert to carbohydrate for respiratory substrate. Freshly harvested potatoes have a high respiration rate and utilize a relatively large proportion of lipid for respiratory substrate until suberization is complete. Carbohydrate then becomes the substrate and respiration rates continue to decline until sprouting occurs. However, the proportion of respiration via the cytochromes verses alternative oxidase appears to change as the potatoes become older and market quality declines. Tuber cell cultures provide a means to analyze the relationship(s) between respiratory pathways and specific changes in lipid metabolism without the interference of a large wound response.

Although the physiological function(s) of the alternative oxidase pathway in tubers remains unclear, this respiration is present in callus-forming potato tuber disks (i.e. nonsubcultured cells proliferating on the explant). The production of ATP per glucose by the alternative oxidase pathway is one third that of the cytochromes (12 vs 36). Despite this inefficiency, alternative oxidase can comprise well over half of the total respiration in callus-forming potato tuber discs (2).

We have subcultured tuber callus cells (cv. Norchip) which display normal lag, log, stationary and death phases (3). Like the mother tuber, these callus cells possessed significant lipolytic acyl hydrolase activity, but another lipid metabolizing enzyme linked to senescence and alternative oxidase was anomalously absent. This variation in lipid metabolism is currently under investigation. Respiratory characteristics have been partially described for this line of cells in suspension cultures.

Respiratory responses to specific concentrations of cyanide (0.02 to 20.0 mM) varied during the growth cycle and at higher concentrations, cyanide stimulated existing oxygen uptake. Consequently, sodium azide was generally used to determine/inhibit cytochrome respiration because it did not stimulate oxygen uptake at supraoptimal concentrations. Total respiration, including that of the cytochromes (azide sensitive), rapidly increased upon addition of new media to the cells and then remained reasonably constant during cell culture growth. However, the addition of azide and salicylhydroxamic acid (SHAM) did not demonstrate the presence of classical SHAM sensitive respiration (alternative oxidase); instead Sham stimulated respiration in these growing cultures. At the end of the cell culture growth cycle the basal respiration decreased to nearly zero. Surprisingly, addition of 20 mM cyanide to these older cells stimulated oxygen uptake, but this respiration was SHAM sensitive.

We are continuing research to determine if these anomalies in SHAM sensitive respiration are related to repeated susculturing, media constituents or changes in metabolism of membrane lipids that are purported to regulate alternative oxidase activity.

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SYMPOSIUM

on

ELECTRICAL ENGINEERING: RESEARCH AND EDUCATION

presiding: David A. Rogers
Department of Electrical and Electronics Engineering
North Dakota State University
Fargo, ND

Banmali Rawat
Department of Electrical Engineering
University of North Dakota
Grand Forks, ND

46. Computer-Aided Laboratory Measurements in Electronics
Donald A. Smith*
Department of Electrical and Electronics Engineering
North Dakota State University
Fargo, ND

47. Software for Linear Systems Study and Design
Douglas B. Miron*
Electrical Engineering Department
South Dakota State University
Brookings, SD

48. A Rough Surface Model for Radar Backscattering
Guang-Wen Pan*
Department of Electrical Engineering
South Dakota State University
Brookings, SD

49. Planar Piece Matching Using Curvature Functions
Floyd M. Patterson*
Department of Electrical and Electronics Engineering
North Dakota State University
Fargo, ND 58105

Thomas A. Nelson
Magnetic Peripherals
Oklahoma City, OK

50. Creativity and Critical Thinking Linked with Graduate Research in Electrical Engineering
G. R. Babu* and B. Rawat
Department of Electrical Engineering
University of North Dakota
Grand Forks, ND

51. The Relationship Between VCO Disturbance and Reference Spurs in Charge-Pump PLL's
Eric Rudie*
E. F. Johnson Company
Waseca, MN

Daniel Krause
Department of Electrical and Electronics Engineering
North Dakota State University
Fargo, ND

52. A Study of Biomedical Effects Using Electromagnet Field Concepts
B. Rawat*, G. R. Babu, and G. Kumar
Department of Electrical Engineering
University of North Dakota
Grand Forks, ND

53. Determinant Evaluation Through Enumeration of Loops
V. V. Bapeswara Rao*
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(46) COMPUTER-AIDED LABORATORY MEASUREMENTS IN ELECTRONICS

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The power of personal computers and their implementation in engineering applications have made them attractive to industry as inexpensive, versitile controllers for test and measurement instruments. The focus of this work is to encourage familiarization and experimentation with computers in the control of test and measurement instruments in the Electrical and Electronics Engineering Department at North Dakota State University. The combination of a personal computer (PC) with some Hewlett Packard PC controlled instrumentation provides measurement, analysis, and control of experimental systems to a degree comparable to expensive specialized dedicated systems but at a much lower cost.

The PC instrumentation package was investigated for use in a senior level communication electronics laboratory. The instrumentation was utilized in existing experiments performed in the laboratory. Much of the measurement and analysis normally performed in the experiments was accomplished with much less time and effort, thus allowing a more complete and detailed experimental investigation. The project allowed an assessment of this approach to laboratory teaching and allowed students to experience modern measurement techniques such as they are likely to encounter in industry.

Included in the PC instrumentation package are digital multimeter, function generator, universal counter, and digitizing oscilloscope modules. These modules are all very useful in this laboratory and allow the screen of the personal computer to display a digital multimeter, a counter, or a digitizing oscilloscope. Thus the instrumentation package allows direct measurements provided by these instrument functions. The instrumentation package also allows the use of programming to provide more specialized measurements than those provided by the conventional instrumentation. Programming the personal computer in the BASIC language allows the user to expand the measurement capabilities of the instrumentation package to a wide range of specialized experimental investigations.

The experiments covered in this senior level communication electronics laboratory include tuned amplifiers, phase-shift oscillators, tuned circuit oscillators, amplitude modulation, AM detection, frequency modulation, FM demodulation, and frequency mixing. In the tuned amplifier experiment a program was provided to the students that would display the frequency response of the amplifier and determine the center frequency, the upper and lower half power frequencies and the value of Q of the amplifier. In the two oscillator experiments the oscillator outputs were displayed on the PC screen using the digitizing oscilloscope function, the amplitudes of the output signals were measured using the digital multimeter function, and the frequencies of the output signals were measured using the counter function. In addition a BASIC program was provided to the students to allow them to determine a range of information on the harmonic distortion present in the output signals. In the amplitude modulation experiment the output signal was displayed on the digitizing oscilloscope and programming was used to determine percent modulation. In the AM detection experiment quality of the detected signal along with the useful detection range may be determined. In the remainder of the experiments the students were encouraged to use their own applications of the instrumentation package and to demonstrate their results to the rest of the class.

The students reacted favorably to the computer-aided laboratory measurements. They welcomed the opportunity to make measurements using this instrumentation package. A current drawback to this approach is that only one such measurement station is available in the laboratory. Each laboratory group must therefore wait in turn to make the measurements. This limits the number of measurements that can be made using the PC instrumentation package. It would be desirable to have such an instrumentation package available at each laboratory position. Available funding does not permit such implementation at this time.

The investigation of the use of the PC instrumentation package in the senior level communication electronics laboratory was highly successful. It allowed more ease and success of measurements and tests than normally permitted in laboratory experiments. Considerable time and effort was saved in making the measurements. The measurement station is considered to be a significant step in laboratory teaching and of great benefit to the students as they begin their jobs in industry. The success of the project thus far is very encouraging and prompts the desire for additional development.

(47) SOFTWARE FOR LINEAR SYSTEMS STUDY AND DESIGN

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This is the story of an educator's development of a software package for class use. During Spring, 1985, we bought a PC version of the APL language. It is very compact, yielding much shorter programs and application development times than languages such as FORTRAN or PASCAL. Graphic display of variables is, in my view, essential to engineering work. I first wrote plotting functions to display data with automatic scaling, axis and grid generation, and labeling.

At that time, I was teaching the Linear Control Systems course so I began writing functions for that context. Complex quantities are represented in APL by adding another dimension to hold the imaginary part. Thus, a comples scalar has two elements, a complex vector has two rows, and a complex matrix has two tables. This allows complex arithmetic to be done with array arithmetic. Each of the basic operations are written in one line of code, including complex matrix inverse. Since APL is an interpreter, it is important to avoid loops to minimize execution time. APL provides an index generator so that a variable which is a funtion of index can be generated as a vector whose elements are the sequence values. In this way time is saved at the expense of storage space. For frequency response calculations, it turned out to be faster to form the transfer function polynomials and split them into even and odd powers of frequency, which splits them into real and imaginary parts, do the real arithmetic, and only do the complex division at the end. The more obvious alternative is to form a vector of the factors of the numerator, convert them to polar form, multiply across the magnitudes and sum across the angles, and do the same for the denominator. x/A[;1] and +/A[;2] are the product and sum over the elements of the rows of A. This leads to shorter code, but it is slower because the rectangular-to-polar conversion is slow. Such alternatives tested for speed in the development of many of the functions in this package.

The feeling of user-program dialogue was the second principle objective in writing this software. This means that the program should give a response in less that 30 seconds. I did not write a function to do root-locus plots for a long time. For all the other functions, the complete response is calculated before the plot is given. Since I could not find a factoring routine fast enough, I used the sketching rules and the phase criterion to do a step-by-step presentation of the locus. The off-axis branches are followed by stepping in radius and searching in angle for the next point meeting the phase criterion. The result of each step is displayed, so that something new appears every few seconds, though the entire plot might take several minutes. Doing the work in the frequency domain allows system time delay to be taken into account.

Each of the simulation packages I've read about requires the user to learn a new language. These are often described as "natural". Well, the examples I've seen aren't any closer to natural than BASIC. They are different enough so that one has to learn them just like any other programming system. To avoid this, I've written this package to be accessed through menus, most of which have a preamble so that the user knows what is about to happen. Familiarity with the field allows one to use the package without documentation or guidance. I think this is the essence of user-friendliness, followed closely by easy error avoidance and recovery. I strongly feel that learning a new language just to use a particular software package is a waste of time. I would much rather learn a general-purpose language which can be used to solve problems in a wide range of fields. I have used APL in rf network response, oscillator design, scattering integral evaluation, and even written a random exam generator. All of these things were done in short stretches of time, the sort a "full-time instructor" can make. I certainly would not ask a student or a practicing engineer with a variety of areas of responsiblility to make a large effort to learn a language that only serves one area. Even having to learn new key definitions is enough to put me off a software package. I need convincing that itis going to be worth my time.

This paper connot represent the live presentation given using the package on a personal computer. The conclusion I would like to leave with the reader is that it is possible with a microcomputer and APL to write programs to solve problems and display results with as much pleasure as working with paper and pencil on the sketched model and model equations.

(48) A ROUGH SURFACE MODEL FOR RADAR BACKSCATTERING

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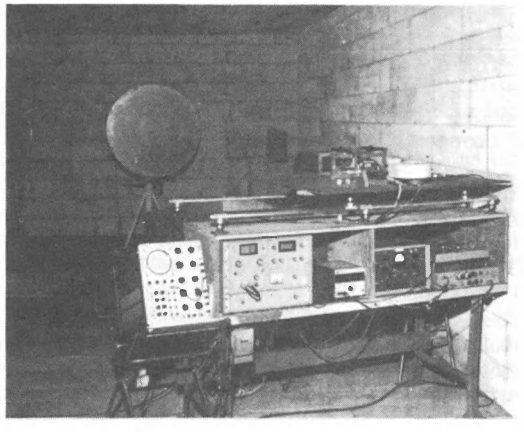
The standard integral equation for the surface current is solved iteratively to obtain an estimate of the surface current on a perfectly conducting randomly rough surface. A sufficient condition on the validity of this estimate has been found to be $k\sigma^2/\ell \ll 1$, where k, σ and ℓ are the wave number, rms surface height and surface correlation length, respectively. The far zone scattered fields and the backscattering coefficients for vertical, horizontal and cross polarizations are then computed using this current estimate. The polarized backscattering coefficients are explicit functions of the surface parameters and reduce to the Kirchhoff solution in the high frequency region and to the first order perturbation solution in the low frequency region. The cross polarized scattering coefficient reduces to the second order perturbation result in the low requency region and to zero in the high frequency limit. A comparison is made with scattering measurements taken under laboratory conditions on a random surface with $k\sigma$ equal to 0.44 and $k\ell$ equal to 3.25. It is found that a better agreement is obtained with the current model than the first order perturbation model in predicting polarized scattering. It is also shown that the separation between VV and HH polarization decreases gradually with frequency and approaches zero in the high frequency limit.



The 25 GHz Backscattering Radar: Foreground left to right-- Oscilloscope, Receiver, DVM, Klystron Power Supply, Processor; (Bench-Top) Microwave System; Background center--Target Holder with Mounted Mirror; Background, left--Shield.

(49) PLANAR PIECE MATCHING USING CURVATURE FUNCTIONS

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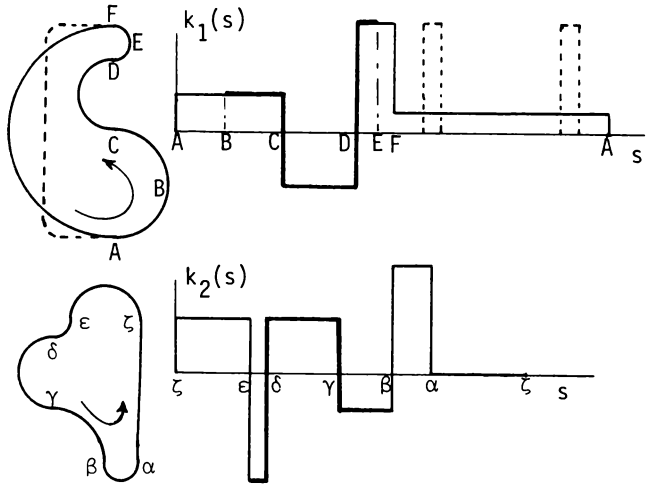
Curvature functions in parametric form relate path "turning" characteristics in space with distance along the path as a useful parameter. An object projected onto a plane gives an image with the image edge capable of unique representation, in both shape and size, by a suitable signed curvature function. Slight variations in edge shape are dramatically revealed in the associated curvature function and this allows for a pattern recognition tool. Requirements of the curvature functions which correctly predict whether edges of two objects can "fit" together is presented.

The curvature of a continuous planar plot is sometimes presented as the inverse of the radius of the circle which approximates the plot at a particular point (1). These curvatures expressed as a function of the position on the plot describe a curvature function for the plot. The value of the curvature function is zero where the plot is a straight line and assumes large values at those plot locations where tight corners exist. A common expression for the curvature function of an x-y plot is given in parametric form as

$$k(s) = \frac{\left|x'(s)\, y''(s) - y'(s)\, x''(s)\right|}{\left([x'(s)]^2 + [y'(s)]^2\right)^{3/2}} .$$

The distance along the plot path is represented by s and the primes are the derivative order with respect to s.

Curvature functions used in this research have plus or minus values prefixed to them, a plus value if traversing the image boundary in the counterclockwise direction results in a turn toward the object interior (convex) and a minus value if the turn is to the object exterior (2). The figure at right illustrates these characteristics. Impulse functions can be used to represent abrupt corners if the signed curvature function is considered a density function. The dashed lines of the upper portion of the figure refer to an alternate choice of countour shape from F to A.



Two planar pieces fit together over a contour path interval if the two pieces touch one another without overlap everywhere within this interval. Thus, segment BCDE of the upper object and segment $\beta\gamma\delta\varepsilon$ of the lower object fit together with B-β, C-γ, D-δ and E-ε each common touching points. Characteristics of the two curvature functions which indicate this fitting over the interval of interest are i) one is the negative of the other, and ii) the s-axis is reversed on one with respect to the other. The enhanced portion of the curvature function of the figure illustrates this as $k_1(s) \equiv -k_2(s_B + s_\beta - s)$ for the interval $s = s_B$ to $s = s_E$. Proper fitting of two pieces is also accurately predicted if a planar piece is "flipped on its back" as this results in an s-axis reversal of its curvature function. The necessary requirement then appears as $k_1(s) \equiv -k_3(\text{const} + s)$ for the appropriate interval. It has also been found that computer software is simplified when automated matching is sought from the curvature function rather than directly from the image edge.

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(50) CREATIVITY AND CRITICAL THINKING LINKED WITH GRADUATE RESEARCH IN ELECTRICAL ENGINEERING

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In the contemporary world, different areas of scientific knowledge are being drawn together in new and exciting combinations, due in large part to the fundamental success of the ideas of Electrical Engineers in particular, Faraday, Ampere, Gauss, Orestead, and Maxwell and their ideas in Mathematics, Physics and Technology, Natural Philosophy or Physical Science has been taught in two ways. One method is through the forces of mathematical equations and the other is through experimentation. Even though both these methods independently achieve the task of subdividing nature to human use, neither of them can fully accomplish the still greater taste of strengthening their reason and developing new powers of thought. The pure mathematician endeavors to transfer the actual effort of thought from the natural phenomenon to the symbols of equation and the pure experimentalist is apt to spend so much of this mental energy on matters of detail and calculation leaving hardly any time for higher forms of thought. Both the methods seem to acquire a vain familiarity with the facts of nature rather than awakening those powers of thought by the capabilities of the fresh revelation of nature.

Physical research is continually revealing to us new features of natural processes and we are compelled to new forms of thought appropriate to them (1). Human mind is not like a heated body continually settling down to an ultimate state of quiet uniformity; it is rather like a true shooting art branch which adapt themselves to the new aspects of the sky towards which they climb and roots which contest themselves among the strange state of the earth into which they go. These who breathe only the spirit of an age and know only the characteristics of contemporary thought, it is impossible to predict the general of the science of the future and anticipate the discoveries will make.

Having been exposed to the basic fundamentals of Science and Engineering principles through the language of mathematics and also having acquired the minimum analytical and experimental skills in the classroom and laboratories at the bachelor's level, a graduate student should keep an open mind while engaging himself in the research activity. He must cultivate new techniques such as (2):

(i) new Mathesis.
(ii) accepting both successes and failures in experimentation so that new ideas evolve.
(iii) use combinational methods of mathematical, physical and metaphysical reasoning to observations.
(iv) acquire the dynamics of novel styles in research collaboration and decision making.
(v) concentrate on both breadth and depth of learning.
(vi) and finally a good mastery over the subject matter of particular field of study in its completeness as a single scientific entity.

Studies of history of modern Science and Engineering with biographies of important discoveries will give a good push into the thinking of the graduates.

In the evolution of the subject certain entities, properties and processes which were derogatory at one time have proved to be extremely useful at later time-and hence proving that there is nothing which is not useful in nature but it all depends upon the time of observation and observers' reference plane.

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(51) THE RELATIONSHIP BETWEEN VCO DISTURBANCE AND REFERENCE SPURS IN CHARGE-PUMP PLL'S

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A high degree of spectral purity is essential for frequency synthesizers used in communication systems since the presence of phase noise and reference spurs can seriously degrade performance. In an angle modulated system, for example, any phase noise $\Delta\phi(t)$ directly adds to the desired signal to degrade the signal to noise ratio. Transmitted spurs and phase noise can interfere with other signals on adjacent channels, and receiver performance also suffers with a noisy local oscillator.

Since all VCO's tend to be microphonic to some extent, VCO vibration and drifting is a major source of phase noise in PLL frequency synthesizers. Therefore, a common approach to analyze the problem is to apply a disturbance signal, D(s), to the often used linear PLL model just before the VCO. D(s) may be in the form of random noise and/or periodic disturbances. If we approximate a second order charge-pump PLL with the model shown in figure 1, the resulting transfer function between D(s) and $\Omega_o(s)$ is given as

$$H_d(s) = \frac{K_v s^2}{s^2 + \left[\frac{K_v K_\phi R}{N}\right] s + \left[\frac{K_v K_\phi}{NC}\right]}$$

This is in the form of a second order high-pass filter. Therefore, the loop will track out low frequency disturbances provided the natural frequency of the loop, ω_n, is large enough and for this reason, ω_n is usually made as large as possible (large ω_n also reduces lock time).

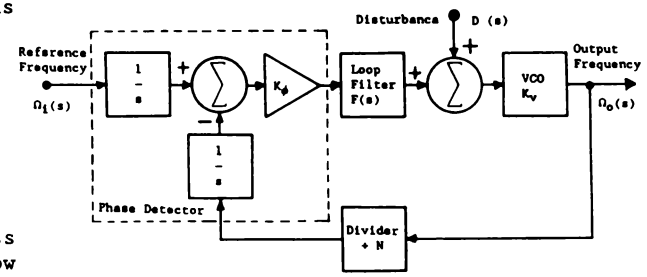

FIGURE 1: CONTINUOUS TIME APPROXIMATION MODEL

The form of the steering line voltage must be considered when the VCO is being driven by a charge-pump under dynamic conditions. The current pulses created by the charge pump will modulate the VCO and produce reference spurs not predicted by the continuous time approximation model. Figure 2 shows this effect when D(s) is a linearly decreasing ramp. The system responds with a linearly increasing ramp generated by discrete pulses. The power contained in the current pulses, and therefore the strength of the reference spurs, is proportional to the slope of the disturbance, D(s). A typical spectrum resulting from a ramp disturbance is shown in figure 3.

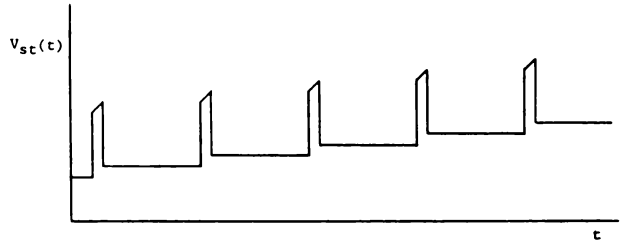

FIGURE 2: CHARGE-PUMP RAMP OUTPUT

All deterministic disturbance signals (i.e. vibrating a microphonic VCO) have a slope which may be approximated by a ramp over a suitable time interval. The resulting reference spur modulation may then be expected. Usually we are most concerned with the worst-case spur level which occurs when the derivative of the disturbance is at a global maximum or minimum. One problem experienced in observing this was that the spectrum analyzer scan speed is limited, and therefore spurs produced by only low frequency disturbances are easily visible in lab.

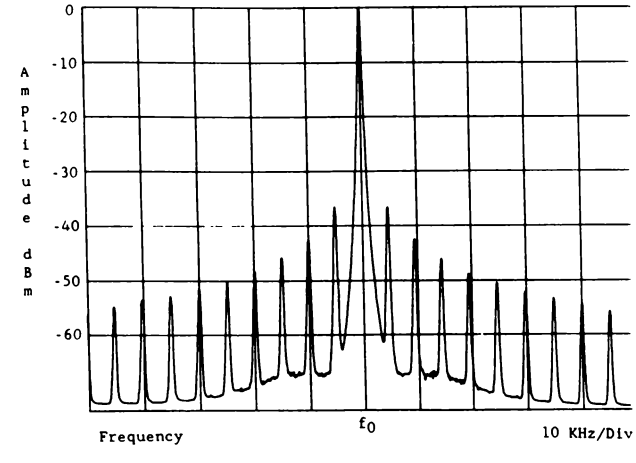

FIGURE 3: VCO SPECTRUM WHEN DRIVEN BY CHARGE-PUMP RAMP

(52) A STUDY OF BIOMEDICAL EFFECTS USING ELECTROMAGNETIC FIELD CONCEPTS

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Radio and microwaves have been extensively used in many areas of human endeavor. In some of the applications, human beings are exposed to microwaves of low to moderate intensities for various time periods. The reactions of dielectric medium with the wavefield and how the wave gets affected by the medium in respect of reflection, scattering and diffraction have been studied. The dielectric properties of the biological substances depend on the type of the substances, which are basically related to the water content, temperature and the frequency of the signal showing a characteristic dependence with three relaxation regions, i.e., electronic, molecular and orientational polarizations or relaxations. The constitutive properties of the medium such as the complex permeability, permittivity, conductivity and its interaction with electromagnetic wave fields could be studied well using the fundamental Maxwell's equations which govern electromagnetic fields in free space and media and also solving the generalized constitutive relations.

The individual cells that constitute the tissue perform very specific functions so that different types of cells have different structures. On the molecular level the tissue is composed of a myriad of very complex molecules, one of the simplest of which is water molecules (1). All these elements i.e., cells, organelles and biomolecules have charged components that experience a force when exposed to EM fields. Biological responses are due to the EM fields within the body rather than external fields. The electrical properties of the living systems and its geometry determine the amount of radiation reflected, transmitted and absorbed. The response of the several elements varies with the frequency of the fields and the resulting change is the observed dispersion in the macroscopic dielectric permittivity of the tissues (2).

In general the exposure field is characterized by the frequency, intensity, polarization and type of wave, i.e., plane wave, fringe field, near field of an antenna. The amount of quantity that is essential in determining interactions of non-ionizing radiation with biological bodies is called SAR (Specific Absorption Rate) (1).

Interaction mechanism of RF and microwaves with biosystems are of two kinds, thermal and non-thermal. In thermal, the absorbed EM energy is converted into heat which in turn elicits biological responses. The conversion mechanism is of various types, like rotation of polar molecules, space charge polarization, and ionic conduction. Thermal interactions are well understood and utilized to a fuller extent in such medical applications as diathermy and hyperthermia in cancer treatment and thawing (2).

The data obtained from the non-thermal interactions have been controversial and incomplete but there is good evidence that amplitude modulated microwave signals of low level have shown effects on brain tissues, eyes, nervous system, neural and behavioral responses (2). There is another sophisticated and important application known as NMR imaging, which has been used in microwave radiometry for breast cancer detection and monitoring of lung edema and respirations (2).

Much work remains to be done in the modelling of the brain system, electrical signals from the brain, its transmission and feedback mechanism. With induced external EM field forces, how the above operations get affected is a big question mark.

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(53) DETERMINANT EVALUATION THROUGH ENUMERATION OF LOOPS

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INTRODUCTION: In the analysis of networks and systems, it is often necessary to evaluate the determinant of a square matrix A of order n. It can be evaluated as a sum of products of edge weights of loop sets of an associated graph G. The paper illustrates the method of evaluation.

ASSOCIATED GRAPH G: It will be convenient to describe the construction of G with respect to an example. Let the given matrix A be

$$A = \begin{bmatrix} 1 & 2 & 1 \\ -1 & 3 & 1 \\ 2 & 0 & -1 \end{bmatrix}$$

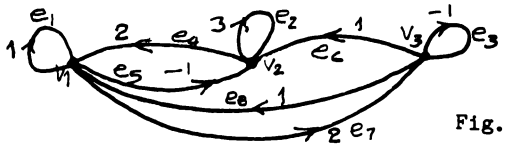

Fig. 1

Each row of A corresponds to a vertex of G. The weight of the self loop at vertex i is equal to a_{ii}. The weight of the edge oriented away from vertex i and towards vertex j is a_{ij}. The edges are numbered $e_1, e_2, e_3, \ldots, e_m$. The vertices are numbered $v_1, v_2, v_3, \ldots, v_n$. For the example under consideration, m=8 and n=3. The graph associated with the given matrix A is shown in Fig. 1.

The matrix A is factored as P_a Y P_b where P_a and P_b are of order n x m and Y is a diagonal matrix of order m. Further the entry $a(i,j)$ of P_a is 1 if edge e_j is oriented towards vertex v_i. Similarly, the entry (i,j) of P_b is 1 if the edge e_j is oriented away from vertex v_i. The diagonal entry y_{kk} is the weight of edge e_k. All other entries are zeros. For the example,

$$P_a = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

$$P_b = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \end{bmatrix}$$

$$Y_d = \{1, 3, -1, 2, -1, 1, 2, 1\}.$$

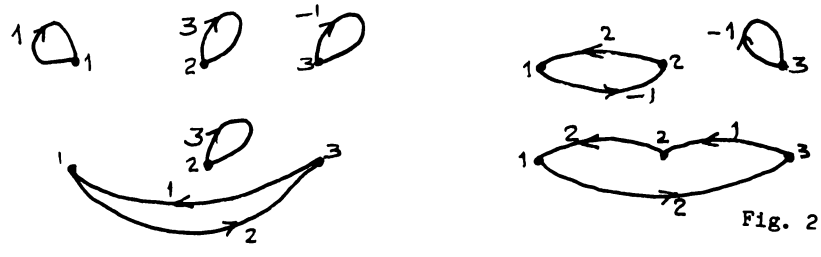

Fig. 2

It follows from Binet-Cauchy's theorem that determinant A is the sum of products of the corresponding nonsingular majors of P_a and YP_b (see Ref. 1). Consider a subgraph G_s of G, formed by a set of nontouching loops in which each vertex is included in one loop or the other. Let k be the number of loops in G_s. Let

$$T_s = (-1)^k \{\text{Product of edge weights of edges in } G_s\}.$$

It then follows that Det. $A = (-1)^n \sum T_s$, where the summation extends over all possible loop sets. The four loop sets for the example graph are shown in Fig. 2. Hence, det. $A = (-1)^3 \{ (-1)^3(-3) + (-1)^2(2) + (-1)^2(6) + (-1)^1(4) \} = -7$.

ENUMERATION OF THE LOOP SETS: The edge sets can be determined following the procedure described in Reference 2. The following tables are formed for the example under consideration.

TABLE 1

Vertex	Edges oriented towards it
1	1,4,8
2	2,5,6
3	3,7

TABLE 2

Vertex	Edges oriented away from it
1	1,5,7
2	2,4
3	3,6,8

We select one edge from each row of Table 1. The edges constitute a set of loops of interest if no two of them are in the same row of Table 2. We then determine the number of loops by evaluating the rank of the submatrix of the incidence matrix corresponding to the selected edges. For example, if the rank is n-2, there would be two loops.

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SYMPOSIUM

on

ECOLOGY OF A PRAIRIE WETLAND COMPLEX IN THE COTEAU DU MISSOURI

Presiding: George A. Swanson
Northern Prairie Wildlife Research Center
Jamestown, ND

54. An Introduction to the Cottonwood Lake Area
George A. Swanson*
Northern Prairie Wildlife Research Center
Jamestown, ND

55. Climatic Characteristics of the Cottonwood Lake Area, North Dakota
D. O. Rosenberry*
Water Resources Division
U. S. Geological Survey
Denver, CO

56. Hydrology of the Cottonwood Lake Area Stutsman County, North Dakota
Thomas C. Winter*
Water Resources Division
U. S. Geological Survey
Denver, CO

57. Use of Ion Ratios as Indicators of Processes Affecting Chemical Characteristics of Selected Wetlands in the Cottonwood Lake Area, North Dakota, 1979-86
James W. LaBaugh*
Water Resources Division
U. S. Geological Survey
Denver, CO

58. Vegetation Changes in Wetlands of the Cottonwood Lake Area
George A. Swanson*
Northern Prairie Wildlife Research Center
Jamestown, ND

59. The Aquatic Coleoptera of Cottonwood Lake Wetlands
B. A. Hanson* and G. A. Swanson
Northern Prairie Wildlife Research Center
Jamestown, ND

60. Seasonal Abundance of Larval and Adult Chironomids (Diptera:Chironomidae) in Four Prairie Wetlands
Richard D. Nelson*
Biology Department
University of Mary
Bismarck, ND

Malcolm G. Butler
Zoology Department
North Dakota State University
Fargo, ND

61. Tiger Salamanders (Ambystoma Tigrinum) in North Dakota Prairie Lakes
J. J. Peterka*
Zoology Department
North Dakota State University
Fargo, ND

(54) AN INTRODUCTION TO THE COTTONWOOD LAKE AREA

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The Cottonwood Lake Study Area is located in Stutsman County near the eastern edge of the Missouri Coteau in east-central North Dakota (Fig. 1). The hydrologic setting and the hydrology and chemistry of selected wetlands in this area have been described (1, 2).

The area contains eight seasonally flooded and ten semipermanently flooded (3) basins situated in a topographic setting that slopes from a southeastern high to a northwestern low with local relief of about 30 m (2). The wetlands are nonintegrated as far as surface water is concerned and most of the semipermanently flooded basins do not overflow. Exceptions are T2, P3, P4, and P8 which overflow during periods of high runoff into adjacent closed wetlands that are lower in elevation (Fig. 2). Wetlands T2, P8, and P9 are connected by surface-water channels that contain water during periods of high runoff (1, 2).

Semipermanent wetlands on the study area are dominated by hardstem bulrush (Scirpus acutus) and cattail (Typha spp.) and are classified as slightly brackish (3). The wetland that is the local hydrologic sump for the area functions as a ground-water discharge area and is dominated by alkali bulrush (S. maritimus), hardstem bulrush, and sago pondweed (Potamogeton pectinatus) and is classified as brackish (3). The seasonally flooded wetlands that function as ground-water recharge areas are dominated by slough sedge (Carex atherodes) and marsh smartweed (Polygonum coccineum). Those that receive ground-water discharge are dominated by whitetop (Scolochloa festucacea).

Work on the study area was initiated in 1967. Wetland conditions were documented using ground and aerial photographs and ground transects. The U.S. Geological Survey and the U.S. Fish and Wildlife Service initiated a cooperative study on the area in 1978 to define the hydrology of the wetlands, the role of hydrology in determining wetland chemistry, and the combined influence of hydrology and chemistry on the plant and animal communities. A study of phytoplankton and zooplankton populations of selected wetlands was initiated during the spring of 1984. A seed bank study was initiated in the summer of 1985.

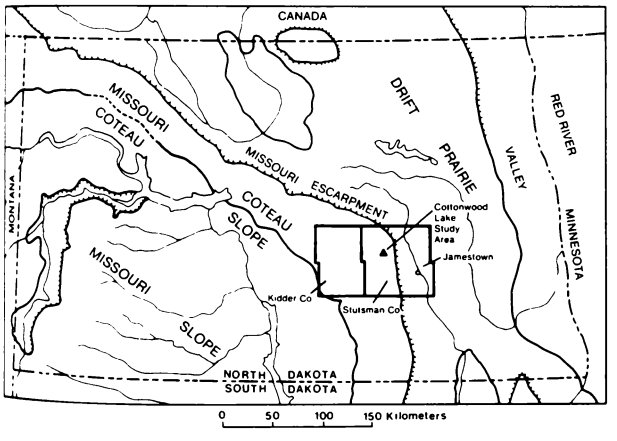

Fig. 1. Location of the Cottonwood Lake Study Area.

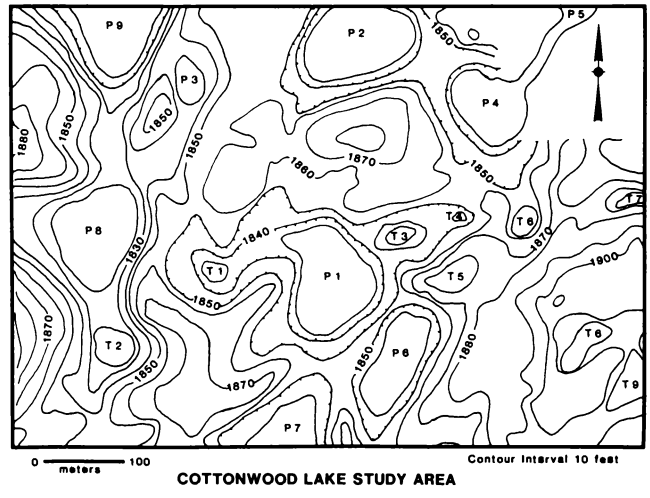

Fig. 2. Location of wetland basins in the Cottonwood Lake Study Area.

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(55) CLIMATIC CHARACTERISTICS OF THE COTTONWOOD LAKE AREA, NORTH DAKOTA

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Wetlands in the Cottonwood Lake area, Stutsman County, North Dakota, have been instrumented for long-term hydrologic studies to facilitate better understanding of the interaction between wetlands and their contiguous ground-water system. The study site is located on a regional topographic high within the Missouri Coteau. Long-term climatic records indicate annual evaporation is approximately twice the annual precipitation.

Regional analysis of National Weather Service precipitation data resulted in errors as great as 40 percent when predicted values were compared to actual daily precipitation measured at the site. The nearest available pan data for determining evaporation are collected 50 kilometers from the site. Because of this distance, and the uncertainty in estimating evaporation using pan data, climatic data are being collected in the Cottonwood Lake area in order to more accurately determine precipitation and evaporation at the site.

Wetland P1 has been instrumented to allow evaporation to be calculated using the energy-budget method, which generally is considered to be the most accurate method. Other methods of measuring evaporation, including the mass-transfer method, commonly use a coefficient that needs to be calibrated against an independent measurement of evaporation. Therefore, the initial phase of this study has concentrated on collecting those data needed in the energy-budget equation, which will be used to provide the standard of comparison to calibrate other less expensive and less labor-intensive methods.

The energy-budget method requires measurement of all the energy entering or leaving a wetland, as well as the change in energy stored in the wetland. Data are collected on a raft centered in wetland P1, and on land near the wetland. Sensors measure air temperature and vapor pressure at 2 meters above the wetland surface, wind speed at 2 and 3 meters above the water surface, incoming shortwave solar radiation, and atmospheric longwave radiation. A digital data logger scans the sensors each minute and calculates hourly and daily averages and totals. Thermal surveys are made bi-weekly to measure the change in heat stored in the wetland. Because the wetland is shallow, a probe containing thermistors has been inserted 1 meter into the sediment at the raft station to measure changes in heat stored in the wetland sediment.

Climatic data have been analyzed for 1982 through 1984. During that period, mean annual precipitation measured at the site was 1 percent less than the long-term mean annual precipitation of 445 millimeters. Water and sediment temperatures in wetland P1 are variable, both on a daily and an annual basis. Daily average bottom-water temperature fluctuates to nearly the same extent as does the surface-water temperature, which usually is greater than the daily average air temperature. The Cottonwood Lake wetlands have thermal characteristics that differ markedly from those of deeper lakes in other environments. The wide range of thermal conditions within the wetland could be a factor in wetland chemical processes and could have an effect on the diversity and distribution of benthic fauna.

(56) HYDROLOGY OF THE COTTONWOOD LAKE AREA STUTSMAN COUNTY, NORTH DAKOTA

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The topographic diversity of the Cottonwood Lake area makes it an attractive site to study a variety of hydrologic processes. The presence of micro and macro depressions on the land surface can be used to study surface runoff processes characteristic of the hummocky topography and low-permeability till soils of the Missouri Coteau. For example, the role of depressional storage, a major question related to the flood-control function of wetlands in the till prairie, can be studied here at a variety of scales. The importance of depression-focused ground-water recharge in relation to the overall pattern of recharge to local and regional ground-water flow systems can also be studied at a variety of scales. To facilitate such studies a 1-foot contour interval topographic map has recently been completed of the study area which will be used to identify specific sites for instrumentation.

The need for detailed studies of runoff and ground-water recharge has been identified by results from present work in the area. For example, the common assumption that the configuration of the water table is a subdued replica of the configuration of the land surface is not justified at all localities, even within this 240-acre area. Water-table lows occur beneath some land-surface highs, and in these areas the wetlands are areas of ground-water recharge. In other areas water-table highs occur beneath land-surface highs, and in these areas wetlands are areas of ground-water discharge. Some wetlands are surrounded by a combination of these two water-table configurations, and in some cases the seepage direction reverses seasonally, but not in a consistent manner.

Because of the complexity of the interaction of ground water and wetlands in the Cottonwood Lake area, it is clear that thorough understanding of the interaction of ground water and wetlands requires additional study and instrumentation of the complete watersheds of individual wetlands. Instrumentation of only one or two sides of a wetland watershed can lead to misinterpretation of hydrologic processes and the function of wetlands in the hydrologic system.

(57) USE OF ION RATIOS AS INDICATORS OF PROCESSES AFFECTING CHEMICAL CHARACTERISTICS OF SELECTED WETLANDS IN THE COTTONWOOD LAKE AREA, NORTH DAKOTA, 1979-86

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Average annual evaporation at the Cottonwood Lake area, North Dakota is greater than average annual precipitation by approximately 50 centimeters. Most of the wetlands in the study area have no surface water inlets or outlets. Thus, the water balance of these wetlands commonly is a function of evaporation, precipitation, and interaction with ground water.

Chemical characteristics have been determined for water in selected wetlands and contiguous ground water in the study area. Within the local ground water flow system, the identity of the most abundant anion and cation changed from bicarbonate and calcium in areas of recharge to sulfate and calcium some distance along the flow path to sulfate and magnesium in areas of ground water discharge. Along longer flow paths sodium ion can replace magnesium as the most abundant cation.

Among the wetlands, the identity of the most abundant anion and cation varied from bicarbonate and potassium, or occassionally calcium, in a seasonal wetland that recharged ground water, wetland T8, to sulfate and calcium in seasonal wetland T3, which receives ground water discharge on one side and recharges ground water on the other, to sulfate and magnesium in wetland P1 and sulfate and sodium in wetland P11, semipermanent wetlands receiving discharge from ground water flowing along different length flow paths, to bicarbonate and magnesium in semipermanent wetland P8, which receives ground water discharge and also had an intermittent surface water outlet. Wetlands differ from one another in their chemical characteristics based on their location in the ground water flow system.

Chloride was the least abundant anion in water within the wetlands in the study area. At the concentrations present in the wetlands, chloride could be assumed to be a conservative substance. Therefore, individual major ions were compared to chloride to provide an independent indication of processes affecting the temporal variation in chemical characteristics of the wetlands.

Declines in calcium relative to chloride occurred in wetlands P1, P8, and P11. Water in these wetlands were saturated with respect to calcium carbonate minerals, so that the change in calcium relative to chloride indicated a loss of calcium by chemical precipitation. Also in wetlands P1, P8, and P11, the ratio of alkalinity to chloride declined coincident with the decline in the ratio of calcium to chloride, a result consistent with loss due to chemical precipitation of calcium carbonate minerals.

In wetlands T8, T3, and P1 some ratios increased between loss of ice cover and dryness for the seasonal wetlands and ice formation for the semipermanent wetland. In wetlands T8 and T3 seasonal increases in most ion ratios were initially due to dissolution of minerals in the sediments. Sulfate/chloride ratios in wetland P1 increased to values similar to ratios in adjacent wells, indicating supply of sulfate from ground water was occurring.

Chemical characteristics in water of wetland P8 had the least seasonal and annual variation. In this wetland ratios of most major ions to chloride were relatively constant, except for bicarbonate. These data indicated the supply and loss of most major ions in water of the wetland must be approximately equal when the wetland is ice free.

The only wetland in which nearly all major ions had the same temporal change relative to chloride was wetland P11. Ion ratios were relatively constant over a season even though specific conductance would increase by as much as 8000 µS/cm in the same period. Thus, changes in water volume in response to seasonal and annual differences in evaporation and precipitation controlled changes in concentration of most major ions in wetland P11.

Use of ion ratios relative to chloride, where chloride can be assumed to be a conservative substance, provided a means by which individual major ions could be evaluated to determine if previously unidentified inputs or losses existed for those ions in a particular wetland. This may be useful in studies of the chemical characteristics of prairie wetlands for which interaction with ground water has not been defined.

(58) VEGETATION CHANGES IN WETLANDS OF THE COTTONWOOD LAKE AREA

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A wetland complex located in the eastern edge of the Missouri Coteau in Stutsman County, North Dakota (1), that contained eight seasonally and ten semipermanently flooded basins (2), was observed over a 19-year period (1967-1986). Changes in emergent vegetation were documented using ground and low level aerial photography and randomly selected ground transects that contained 0.25 m^2 stations (3). A cooperative study was initiated by the U.S. Geological Survey and the U.S. Fish and Wildlife Service on this area during the summer of 1978 to define the influence of hydrology and chemistry on plant and invertebrate communities. This paper describes changes in emergent vegetation associated with major changes in water level and specific conductivity.

By combining information derived from this study with previous descriptions of wetlands in the Cottonwood Lake Area (2, 4) it is possible to describe changes that have occurred over a 25-year period (1961-1986). During this period semipermanent wetlands have cycled between extremes in water level from highs that eliminated emergent vegetation to drawdowns that exposed mud flats and reestablished emergent vegetation. Vegetation zones stabilized when annual fluctuations in water level did not exceed the tolerance of emergent vegetation or did not expose mud flats during the growing season. Rapid changes occurred when an increase in water level persisted long enough to drown out emergent vegetation or when drawdown exposed mud flats during the growing season.

Semipermanent basins that contained identical hydrologic functions and, as a result, similar salt concentrations, responded to climatic trends to produce zones of emergent vegetation that were similar in structure and species composition. Basins that discharged surface water and had high turnover rates tended to be stable and low in dissolved salts. Basins closed to surface outflow tended to be more dynamic in both water level changes and salt concentrations as they responded to climatic trends. Seeds of salt tolerant species (2) such as wild barley (Hordeum jubatum), alkali bulrush (Scirpus maritimus), and whitetop (Scolochloa festucacea) germinated during drawdown in wetland P1. In 1977 specific conductance of water in this closed basin was 8,000 microsiemens per cm just prior to drawdown. After wetland P1 reflooded in 1978, whitetop, a shallow-marsh species (1) that germinated in 1977, dominated the basin until 1980 when it drowned out and a central open water zone was reestablished. Cattail (Typha spp.), on the other hand, germinated in 1974 on the exposed mud flat of wetland P4, a flow-through system lower in salt content, and have dominated this basin for the last 11 years.

The wetland complex investigated contained wetlands that varied in hydroperiod and salinity and, subsequently, produced a variety of plant and invertebrate communities over the 19-year period (3, 5). Wetland communities were controlled by: (1) annual fluctuations in water level that established and maintained different wetland zones, (2) long-term trends in climatic conditions that cycled semipermanent lakes between extremes of flooding and drawdown, and (3) surface and ground-water flow systems that interacted with basin topographic setting and geologic conditions to influence salt concentrations. As salt concentrations increased, salt tolerant species dominated and altered the wetland zones.

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(59) THE AQUATIC COLEOPTERA OF COTTONWOOD LAKE WETLANDS

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The Cottonwood Lake study area is the site of an intensive study of hydrology (1), the impact of hydrology on wetland chemistry (2), and the combined influence of hydrology and chemistry on plant and invertebrate communities of prairie wetlands. The purpose of this portion of the invertebrate analysis was to identify the aquatic Coleoptera of the two dominant wetland classes on the study area and compare them with an extensive study on the aquatic Coleoptera of North Dakota (3).

Two seasonally flooded wetlands (T-3 and T-8) and two semipermanently flooded wetlands (P-1 and P-8) were selected for invertebrate collections. Wetland T-8 is at the highest elevation (580 m asl) in the southeast section of the study area, and P-8 is at the lowest elevation (560 m asl) in the northwest section of the study area. Wetlands T-3 and P-1 are located centrally in the area, within 15 m of each other, at 563 m asl and 562 m asl, respectively.

On each wetland six transects were established to obtain samples of water, vegetation, and invertebrates. The first transect was selected randomly at 158 degrees from magnetic north, and the remaining five were established at 60 degree intervals, clockwise around the wetlands. These transects were designated A through F, and invertebrates were collected on transect A and D in 1979 and 1980. One activity trap (4) was set on each transect for 24 hr., and the specimens were then flushed into a sample container with 80% alcohol.

In seasonally flooded wetlands, traps were set centrally on the transect, in the shallow marsh zone. Collections began in seasonally flooded wetlands with spring snow melt (mid-April to early May), and continued until they dried in late June or early July. As water receded in seasonally flooded wetlands a single trap was used in the center of the wetland. Although indicative vegetative species identified the shallow marsh zone of P-1 and P-8 flooding did not occur in 1979 or 1980, and traps were set in the deep marsh zone. Collecting began in semipermanently flooded wetlands when ice melted in April and continued until they were iced over in November.

Fifty-seven species of Coleoptera were identified from 2594 individuals collected. Wetlands from which collections were made totaled 7.43 ha and contained 53% of the Dytiscidae, 43% of the Haliplidae, 38% of the Hydrophilidae, and 22% of the Gyrinidae species previously identified in North Dakota. Collections from seasonally flooded wetlands produced 1637 Coleoptera, or 40.9 individuals per unit effort (one trap for 24 hours). Semipermanently flooded wetlands produced 937 Coleoptera, or 7.7 per unit effort.

Forty-seven species of aquatic Coleoptera were collected from seasonally flooded wetlands, and 38 species from semipermanently flooded wetlands. Eighteen species were collected only from seasonally flooded wetlands. Conversely, 11 species were collected from semipermanently flooded but not seasonally flooded wetlands.

The Dytiscidae outnumbered all other aquatic Coleoptera, and 38 species were identified from 1975 individuals collected. Although Dytiscidae were abundant on all wetlands, occurrence or density of individual species varied according to wetland class. One hundred seventy-two Agabus antennatus were collected from semipermanently flooded wetlands, and one from a seasonally flooded wetland. Eighty-eight Hydroporous criniticoxis were collected from seasonally flooded wetlands, and two from semipermanently flooded wetlands.

New species records for North Dakota included Agabus ajax, Agabus bifarius, Agabus falli, Hydroporous criniticoxis, Hygrotus picatus, Laccornis conoideus, and Berosus hatchi.

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(60) SEASONAL ABUNDANCE OF LARVAL AND ADULT CHIRONOMIDS (DIPTERA:CHIRONOMIDAE) IN FOUR PRAIRIE WETLANDS

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Aquatic insects play an important role in waterfowl production in North Dakota's prairie pothole region. Studies on the feeding ecology of ducks has shown that the family Chironomidae is a major component in the diet of breeding hens and juveniles (1). Larval chironomids (Diptera:Chironimidae) are an important protein source for nesting hens (2) and emerging adult chironomids provide a vital food source for ducklings (3).

To determine the seasonal abundance of larval and adult chironomids four ponds were sampled during the ice free periods in 1983 and 1984. Two ponds (P1 and P8) were semi-permanent and two (T8 and T9) were seasonal wetlands. All four wetlands were located in the Cottonwood Lake Waterfowl Production Area.

Larvae were sampled using a metal coring device (4), preserved in formalin and identified to species. Six sampling sites were used in each of the four ponds with two cores taken at each site. Larval densities (mean number per square meter ± standard error) were calculated for each sample date for each pond. Highest densities occurred in P1 and P8 in both 1983 and 1984.

In P1 highest densities occurred in April 1983 (6354 ± 2205), October 1983 (120,845 ± 16661), April 1984 (9363 ± 1002) and September 1984 (12,371 ± 2279). Pond P8 had highest densities in May 1983 (78,358 ± 5104), November 1983 (176,019 ± 20473), May 1984 (3741 ± 574) and October 1984 (10,968 ± 561). In both ponds densities dropped to near zero during the period of mid-July to mid-September.

Ponds T8 and T9 had larval densities below those of P1 and P8 during both years of the study. Pond P8 had maximum densities in May 1983 (1285 ± 301), and June 1984 (2550 ± 246). Pond T9 had greatest densities in May 1983 (3485 ± 226) and May 1984 (3443 ± 357). Larval numbers declined in T8 and T9 after mid-May and both ponds were devoid of larvae after mid-July.

Adult chironomids began emerging in mid-May in all four ponds. In P1 and P8 emergence continued until early July but emergence ended by mid-June in T8 and T9. Adults were captured with conical emergence traps constructed from polycarbonate sheets. Each trap was designed to sample an area of 0.10 square meters (m^2). Adults were preserved in alcohol and identified to species. Emergence was expressed as mean number per square meter ± standard error.

Pond P1 had greatest emergence in May 1983 (1076 ± 174) and June 1984 (4520 ± 560). A limited number of adults emerged in September 1983 (93 ± 16) and September 1984 (6 ± 3). Pond P8 had a similar pattern of emergence of adult chironomids. Highest densities occurred in May 1983 (1676 ± 169) and June 1984 (19,713 ± 3543) with a limited emergence in September 1983 (46 ± 12). No adults were captured during the fall of 1984.

Emergence in ponds T8 and T9 was limited to a short period in May during 1983 and 1984. Densities of emerging adults were low in both ponds compared to P1 and P8. The highest density occurred in T8 on May 17, 1984 (103 ± 33). All other sampling dates for both ponds showed densities less than 100 adults/m^2.

The results of this study show that semi-permanent and seasonal wetlands produce large quantities of protein rich food for waterfowl. The abundance of larval and adult chironomids is high during critical times for nesting hens and juveniles.

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(61) TIGER SALAMANDERS (*Ambystoma tigrinum*) IN NORTH DAKOTA PRAIRIE LAKES

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The Coteau du Missouri, an extensive moraine extending from northwestern to southeastern North Dakota, is part of the prairie pothole region extending from northwestern Iowa to northwestern Alberta. It contains numerous wetlands and shallow (<3 m maximum depth) potholes or prairie lakes. Tiger salamanders (*Ambystoma tigrinum*) are often abundant in prairie lakes in North Dakota (1,2,3) and in Manitoba (4,5).

The high densities of large salamanders are overlooked in many wetland studies. Because salamanders are an important component of energy flow in wetlands, we present data on their biology, biomass and production, the elaboration of new tissue including that lost through mortality.

In three prairie lakes studied in in Stutsman County, in 1981-82, larval salamander densities reached highs of 5000 ha^{-1}, maximum biomass (wet weight) was 780 kg ha^{-1}, and maximum annual production was 565 kg ha^{-1}. The maximum annual production of 565 kg/ha for the 1981 cohort in Lake II, is probably close to the maximum possible for production of aquatic vertebrates in prairie lakes in our region. Lawler (1974) reported a maximum natural yield of 313 kg ha^{-1} for four stocked rainbow trout in a Manitoba prairie lake; based on their annual mortality estimates of 50%, the maximum annual production would be nearly 350 kg ha^{-1}.

Within a given lake, overwinter survival of larvae may vary markedly from year to year. In 1981 over-winter survival of larvae was excellent in Lake II; in the spring, densities of neotenics (larvae that overwintered) were 800-1000 ha^{-1}. In contrast, no neotenics were found in Lake II in 1982, and none were found in Lake I in either 1981 or 1982. In May 1981, neotenics were large (mean weight of 150 g), and their biomass of 150 kg ha^{-1} was nearly as large as the maximum biomass of 160 kg ha^{-1} in late July of larvae from the year's cohort. This was in contrast to 1982 in Lake II and to both 1981 and 1982 in Lake I when there was an extremely low biomass in the spring, comprised of many small larvae.

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SYMPOSIUM

on

TEACHING EVOLUTION

presiding: Robert Tolbert
Department of Biology
Moorhead State University
Moorhead, MN

94. Evolution, Public Education and Religious Fundamentalism
L. Rodney Sheffer*
Jefferson High School
Bloomington, MN

95. Scientific Issues Related to the Second Law and Radiometric Dating
Judith A. Strong*
Dean of Social and Natural Sciences
and Professor of Chemistry
Moorhead State University
Moorhead, MN

96. Newest Discoveries and Ideas in Human Evolution
Lynne A. Schepartz*
Department of Anthropology
Moorhead State University
Moorhead, MN 56560

97. Constitutional and Political Aspects of the Balanced Treatment Law
Lawrence W. Byrnes*
Dean of Educational and Regional Services
Moorhead State University
Moorhead, MN

Panel Discussion on Teaching Evolution

The major principles of biological evolution have been well established and accepted by the scientific community for over 125 years. It is often quoted, "Nothing in biology makes sense except in the light of evolution" (1). Although most main-stream religions have no difficulty accepting evolution, certain religious fundamentalists espousing creationism are attacking the theory of evolution (2). As a result, science teaching suffers when teachers, school boards, parents or legislators choose to either include creationism or omit evolution from the science curriculum as a means of avoiding controversy. The inability to distinguish between science and religion is an indicator of educational impoverishment (3). Therefore, despite the fact that scientific acceptance of the theory of evolution as an explanation for the nature of the living world, including humans, is stronger today than ever, the teaching of evolution is in need of attention and support. This symposium will provide four perspectives on the issues followed by audience and panel discussion.

1. Dobzhansky, T. (1983) in Evolution versus Creationism: The Public Education Controversy (Zetterberg, J.P., ed.) pp. 18-28. Oryx Press, Phoenix.
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(94) EVOLUTION, PUBLIC EDUCATION AND RELIGIOUS FUNDAMENTALISM

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The teaching of evolution in biology classes in public schools has been under criticism and attack by religious fundamentalists. The fundamentalists have demanded that their literal interpretation of their Bible be presented on an equal time basis along with the scientific explanation for the evolution of the world and its biota.

Evolution in many biology classes has been avoided or diluted to the point that it has not been a contributing part or unifying theme for millions of students. This is true for a variety or reasons.

Here is an appropriate format and rationale for the teacher to help the student understand that science and religion are different but parallel approaches to understanding the universe and their lives without perceiving them as a polarized dichotomy.

(95) SCIENTIFIC ISSUES RELATED TO THERMODYNAMICS AND RADIOMETRIC DATING

Judith A. Strong*
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Moorhead State University, Moorhead, MN 56560

A summary of the laws of thermodynamics will be presented, with special emphasis on the interpretation of entropy and the second law. Examples of spontaneous processes and their interpretations and mis-interpretations (1) based upon the second law will be discussed. A brief presentation of the kinetic basis of radiometric dating will also be made with emphasis upon criticisms cited (2) of such methods in creationist literature.

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(96) NEWEST DISCOVERIES AND IDEAS IN HUMAN EVOLUTION

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Moorhead, Minnesota 56560

Human evolution is itself an evolving field, where new fossil discoveries continually augment our data base and new ways of analyzing these fossils expand our body of information regarding the human lifeway of the past. The major events of human evolution are well understood due to an extensive array of fossil finds and archaeological discoveries ranging from the earliest Australopithecines of Africa; the more widespread populations of *Homo erectus* from Africa, Asia and Europe; archaic *Homo sapiens* and Neandertals of Africa, Asia and Europe; and remains of most recent *Homo sapiens sapiens* from Australia to the Americas. These fossil and archaeological data along with biochemical and genetic data from living populations illustrate the ways humans adapt culturally and biologically to changing environmental conditions. As a result, we have a dynamic framework for understanding human evolution that continues to generate questions about human diet and economy in the past, the development of modern human diversity and the role of humans as a biological species.

(97) CONSTITUTIONAL AND POLITICAL ASPECTS OF THE BALANCED TREATMENT LAW

Lawrence W. Byrnes*
Dean of Educational and Regional Services, Moorhead State Univ.
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In 1963, the Supreme Court of the United States ruled that Bible reading in public schools was unconstitutional as a violation of the Establishment Clause of the First Amendment. However, the Court muddied the waters by including in the majority opinion the notion that one's education was not complete without a study of comparative religion, the history of religion and its relationship to the advancement of civilization. It noted that the study of the Bible or of religion, "when presented objectively as part of a secular program of education, may not be effected consistently with the First Amendment."

An analysis of these statements uncovers a number of questions that must be addressed before assuming the task of developing a curriculum for "teaching about religion." For example,

1. What do people mean when they use the term religion?
2. What meanings are attached to the notion of education?
3. What is an objective presentation?
4. What is a secular program?

In this same case, it was determined that violations of the Establishment Clause could be determined by the following test:

> What are the purpose and the primary effect of the enactment? If either is the advancement or inhibition of religion, then the enactment exceeds the scope of legislative power as circumscribed by the Constitution. That is to say that to withstand the structures of the Establishment Clause there must be a secular legislative purpose and a primary effect that neither advances nor inhibits religion.

Of key importance in this ruling was the distinction made between the Free Exercise and Establishment Clauses. Since the purpose of the Free Exercise Clause is to prohibit civil authority from invading religious liberty, it is necessary to show the coercive effect of legislation as it inhibits the practice of religion. However, an Establishment Clause violation need not be predicated on coercion.

The Balanced Treatment proposal requesting that creation and evolution be treated as scientific theories and offered equal status in the science curriculum offers the opportunity to examine many crucial issues.

SYMPOSIUM

on

ESTABLISHMENT AND MAINTENANCE OF NATIVE GRASS SEEDINGS

Presiding: Charles Lura
Department of Life Sciences
North Dakota State University-Bottineau
Bottineau, ND

98. Effects of Seed Origin on Warm Season Native Grass Establishment
Wendell W. Olson*
U. S. Fish and Wildlife Service
Fergus Falls, MN

99. Performance of Native Warm Season Grasses in North Dakota, South Dakota, and Minnesota
D. A. Tober*, R. J. Haas, and M. J. Knudson
USDA Soil Conservation Service, Plant Materials Center
Bismarck, ND

100. Planted Grasslands for Wildlife Habitat in the Prairie Pothole Region
Harold F. Duebbert*
Northern Prairie Wildlife Research Center
Jamestown, ND

101. Maintenance of Planted Grass Stands for Wildlife
Kenneth F. Higgins*
U. S. Fish and Wildlife Service
South Dakota Cooperative Fish and Wildlife Research Unit
Brookings, SD

102. Weed Control for Native Grass Establishment
Calvin G. Messersmith* and Rodney G. Lym
Agronomy Department
North Dakota State University
Fargo, ND

103. Influence of Prairie Vegetation in Soil Development
J. L. Richardson*
Department of Soil Science
North Dakota State University
Fargo, ND

C. L. Lura
Department of Life Sciences
North Dakota State University-Bottineau
Bottineau, ND

W. T. Barker
Department of Animal and Range Sciences
North Dakota State University
Fargo, ND

(98) EFFECTS OF SEED ORIGIN ON WARM SEASON NATIVE GRASS ESTABLISHMENT

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Since the 1930's various cultivars of warm season native grasses have been developed for conservation and forage uses. Most varieties were selected or developed by the U.S. Soil Conservation Service (SCS), but many were developed by various state universities. The SCS has long recommended that warm season grass varieties not be moved more than 300 miles north or 200 miles south of its origin. Varieties moved beyond the 200 mile southward limit have low forage production and are susceptible to disease. Varieties moved beyond the 300 miles northward movement usually will not form seed and are prone to winter injury (1).

McMillan (2) and others determined that warm season grass ecotypes from more northern and western areas flowered earlier than those from more southern and eastern areas and that this response was genetically related to photoperiod. McMillan's data established a time-distance relationship on a north-south basis for reaching first anthesis. For big bluestem (Andropogon gerardi vitm.) and switchgrass (Panicum virgatum L.), the time-distance relationship was found to be a one day difference in reaching first anthesis for every 12-14 miles. For Indiangrass, (Sorghastrum nutans (L.) Nash.) the time-distance relationship was found to be one day for every 9 miles.

In 1983 phenology of various cultivars of warm season native grasses was studied by this author (3) in a uniform garden. The garden was established by the SCS in Fergus Falls, Minnesota. The results were similar to what McMillan obtained and have far reaching implications for seeding establishment.

For big bluestem, there was approximately 50 days difference in phenology in the south-north origin extremes. The east-central Kansas origin variety Kaw was generally 10-15 days later than the southeastern Nebraska origin variety Pawnee, 18 days later than the eastern Nebraska origin variety Champ, 21 days later than the southeastern South Dakota origin variety SD-43, 25-30 days later than the South Dakota origin variety SD-27 (Bonilla), and 50 days later than the North Dakota origin variety NDG-4. Kaw, Pawnee and Champ formed no seed at the Fergus Falls garden.

For Indiangrass, there was approximately 75 days difference in south-north extremes. The Kansas-Oklahoma origin variety Osage and the southern Illinois variety MI-5734 (Rumsey) showed no significant differences among themselves. Osage and Rumsey were generally 10 days later than the southeastern Nebraska origin variety Otoe, 40 days later than the north-central Nebraska origin variety Holt and 75 days later than the North Dakota origin variety ND-444. Osage, Rumsey, Otoe and Holt produced no seed at the Fergus Falls garden.

For switchgrass, there was approximately 50 days difference in south-north extremes. There was generally no significant difference between the southern Illinois origin variety Cave-in-Rock, the north-central Oklahoma variety Blackwell, and the southeastern Nebraska origin Pathfinder. Cave-in-Rock, Blackwell and Pathfinder were approximately 10 days later than the southeastern Nebraska origin variety Summer, 20 days later than the north-central Nebraska origin variety NB-28 and the southeastern South Dakota varieties SD-149 (Forestburg) and SDSU-32 (Sunburst), and 50 days later than the south-central origin variety NDG-965-98. Cave-in-Rock and Blackwell did not form seed at Fergus Falls. Pathfinder did so on only one replication of three.

Because of the extreme intraspecific variation in warm season native grass with regard to phenology, variety choice should assume as great an importance as species choice. Varieties that are in earlier phenological stages at the time of complete freezing may be limited by environmental pressures such as fall wildlife, grazing or even haying. Phenological order of species should probably be given greater consideration than it presently is. In a native tall grass prairie, the phenological order by species is switchgrass-big bluestem-Indiangrass. It is possible to reverse this order by using varieties recommended for a given area. The effects of interspecific competition in this circumstance is an unknown.

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(99) PERFORMANCE OF NATIVE WARM SEASON GRASSES IN NORTH DAKOTA, SOUTH DAKOTA, AND MINNESOTA

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Increased use of the native warm season prairie grasses for pasture planting, range seeding, erosion control, and wildlife habitat has created the need for information on plant performance and area of adaptation. Spring and fall temperatures in the northern plains are ideal for cool season species, but during the summer months, warm season grasses have increased growth and higher forage quality. The USDA Soil Conservation Service, Plant Materials Center at Bismarck, North Dakota has six field evaluation plantings in ND, SD, and MN. Plant performance being evaluated includes stand ratings, density, plant height, weed contamination, phenology and annual forage production. The seeding was done from 1982 through 1986. The experimental design is a randomized complete block, with three replications for data collection. The six evaluation sites are in north central ND (McHenry Co.), west central MN (Otter Tail Co.), southeastern MN (Olmsted Co.), central SD (Sully and Stanley Counties), and southeastern SD (Charles Mix Co.). Several state and federal agencies are also cooperating in this effort.

Entries tested included all commercially available varieties and selections of seven species in advanced stages of testing for use in the central and northern plains. The entries were big bluestem (Andropogon gerardii Vitman), sand bluestem (Andropogon gerardii var. paucipilus (Nash) Fern), indiangrass (Sorghastrum nutans (L.) Nash), switchgrass (Panicum virgatum L.), prairie sandreed (Calamovilfa longifolia (Hook.) Scribn.), little bluestem (Schizachyrium scoparium (Michx.) Nash), and sideoats grama (Bouteloua curtipendula (Michx.) Torr.).

Seed origin ranged from North Dakota to Oklahoma. Plant stands during year of establishment were rated good to excellent at all six sites. The effect of seed source on performance and survival was apparent. On the North Dakota site, winter injury was documented for many varieties originating from central Nebraska and southward. No injury was noted on the switchgrass varieties, regardless of origin. When winter injury did not occur, southern varieties generally had higher forage production. Northern varieties moved more than 200 miles southward generally perform poorly. Forage production was significantly less than local or more southern varieties. Plant phenology varied among varieties and among sites.

The evaluation is ongoing. Data will be collected at each site for a minimum of six years. Preliminary results will be presented.

Entries Evaluated and Origin

big bluestem	
NDG-4	central ND
Bonilla(SD-27)	east central SD
SD-43	southeast SD
Champ	western IA, eastern NE
Pawnee	southeast NE
Kaw	east central KS
Rountree	west central IA
sand bluestem	
Goldstrike	west central NE
Garden	west central NE
indiangrass	
ND-444	southeast ND, northeast SD
Holt	northeast NE
Oto	NE, KS
Osage	central KS, OK
Rumsey	southern IL
prairie sandreed	
ND-95	southwest ND
Goshen	southeast WY
switchgrass	
NDG-965-98	central ND
Forestburg(SD-149)	east central SD
Sunburst	southeast SD
Neb-28	north central NE
Summer	east central NE
Pathfinder	NE, KS
Trailblazer	NE, KS
Cave-in-Rock	south IL
Blackwell	north central OK
little bluestem	
Camper	south east NE
Blaze	south east NE
Aldous	east central KS
Cimmaron	KS, CO, NM, OK
sideoats grama	
Killdeer	west ND
Pierre	central SD
Butte	north central NE
Trailway	north central NE

(100) PLANTED GRASSLANDS FOR WILDLIFE HABITAT IN THE PRAIRIE POTHOLE REGION

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The dominant role of man in determining land use patterns has resulted in the widespread occurrence of altered ecosystems. In wildlife management, it is often desirable to establish and maintain stands of perennial grasses on sites that were previously cultivated. The need for sound management of planted grasslands on areas dedicated to maintenance of wildlife populations is important because of the high rate of destruction and degradation of native grasslands. This paper contains state-of-the-art guidelines for establishing planted grasslands for wildlife habitat within the glaciated prairie region in the north-central United States. The purpose of the guidelines is to help managers establish and maintain good stands of planted grasslands for dabbling duck nesting and use by other prairie wildlife (1).

Several options are available for selecting a type of grassland to be established. Three major grassland types are available for planting on cultivated lands in the prairie pothole region. The grassland types are: (1) introduced cool-season grasses and legumes; (2) tall, warm-season native grasses; and (3) mixed-grass prairie native grasses. Major vegetative species for (1) are tall wheatgrass (Agropyron elongatum), intermediate wheatgrass (A. intermedium), alfalfa (Medicago sativa), and sweetclover (Melilotus spp.); for (2) are big bluestem (Andropogon gerardi), indiangrass (Sorghastrum nutans), and switchgrass (Panicum virgatum); for (3) are green needlegrass (Stipa viridula), little bluestem (Andropogon scoparius), western wheatgrass (Agropyron smithii), and sideoats grama (Bouteloua curtipendula). Each mixture has a place but no single one can be applied in every situation.

The important factors that affect success of establishment of planted grasslands include adaptability of site, site preparation, seedbed preparation, seed source, planting equipment and method, and rate and date of seeding. Before planting grasses it is imperative to bring previously existing vegetation under control. In our region, quackgrass (Agropyron repens) is especially troublesome. The general methods used to accomplish control of competitive plants are by use of chemical herbicides or mechanical tillage. Planting of grasses with a special grass drill is highly recommended (2). After planting it is important that seeds remain in close contact with soil having an adequate moisture supply. This is why it is essential to have a very firm seedbed to facilitate moisture conservation and early root development (3). Once the grass seedlings have emerged it is necessary to control annual weeds that will have become established from the reservoir of viable seeds existing in cultivated soils. Usually about 6 to 8 weeks after planting the grasses will have attained enough growth that 2,4-D can be applied at a rate of 1 quart per acre. Reducing this weed competition is an essential element in successfully establishing a planted grassland (4). Establishing a good planted grassland requires a great amount of dedication and expense. However, if a healthy stand of grass is established initially its future management will be easier. A management goal for planted grasslands intended to provide optimum habitat for prairie wildlife should be to establish a vigorous stand of vegetation with the tallest, most dense cover that is possible under prevailing soil and climatic conditions (5).

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(101) MAINTENANCE OF PLANTED GRASS STANDS FOR WILDLIFE

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Cool-season exotics and native grass cover plantings are only two among several possible types of replacement plant communities adaptable as wildlife habitat in the Northern Great Plains. These are wildlife cover crops that can be grown on lands having annual precipitation of 30-61 cm and for soils of capability class IV or better.

Compared to other cover types such as woodlands and wetlands, grass plantings are economical and easy to establish, which makes them desirable for use in extensive public land programs or for wildlife management programs on private lands where the production:cost ratio is often narrow and the range of establishment methods is broad.

The main decision periods for maintenance of grass stands are during stand establishment (first three years) and after the sixth growing season. Decision guidelines for qualitative maintenance of grass plantings for these periods should occur in the following order. Prepare the soil and plant the grass seed mixture according to procedures presented earlier described in this symposium by H. F. Duebbert. Inspect each stand for success of establishment and for noxious weed invasion during the first, second, and third growing seasons. If desirable grass species appear to dominate stands of cover during the second and third growing seasons and noxious weeds are not an apparent problem, quality grass stands have been established. If desirable species are rarely apparent in the second and third growing seasons and weed species are dominant, these stands should be eliminated and soil preparations and establishment procedures should be started over. This latter decision can be made in the second growing season, if growing conditions have been favorable and the amount and distribution of annual precipitation have been average or above during the previous year or two. If desirable grass species dominate the stands during the second and third growing seasons, yet stands also have an apparent heavy noxious weed infestation, managers have the options of controlling the weeds with herbicides, temporarily subduing the weeds with mechanical equipment which may enable desirable species to dominate in the future, or eliminating the stand by cultivation. The choice of these options should be based on the quantity and dispersion of noxious weed species within stands and on the degree of difficulty and cost for controlling or subduing the target weed species.

Grass stands that have been successfully established on good sites can be expected to provide substantial structure for at least the first six growing seasons, and to retain desirable species composition for at least the first ten growing seasons; probably longer for most stands. Except for regulated noxious weed control, there should be no management treatments of grass stands during the first six growing seasons. Periodic checks for stand performance and invasion by regulated noxious weeds should be made on stands seven or more years old.

A stand apparently reaches maximum growth during only one of the first ten years. This growth seems to occur during either the third, fourth, or fifth growing season, but the specific year is too variable to predict. Stands also tend to degenerate in height and density after the year of maximum growth. The degeneration does not always occur in a predictable pattern.

Beginning as soon as the seventh growing season, some seeded grasslands that are composed of introduced cool-season grasses and legumes or native grasses degenerate to a condition commonly described as "sod-bound". The condition is related to nitrogen deficiency, and stands must be periodically rejuvenated to maintain their optimum vigor. Methods used to rejuvenate and maintain seeded grasslands can be natural (fire), chemical, or mechanical. If fire or grazing is used, cool-season native species should be treated in the period between late March and mid-May or from 15 August to 15 September, warm-season natives between 15 May and 15 June, and introduced cool-season grasses and legumes should be treated soon after snowmelt, usually between 15 March and 15 May.

Chemical treatments of less than 100 pounds of N per acre have increased plant height for one or two years, whereas application of 250 to 600 pounds of N enhanced grass height for three to six years.

Mechanical scarification from either early spring or late summer tillage treatments showed similar effects. Tillage treatments should completely disturb the soil and roots to a depth of about four to six inches (1-1.5 dm). Light discing or harrowing should follow spiking, chiseling, or shallow (four inches) plowing in order to smooth the surface of the field. Residual vegetation should be removed by haying, grazing, or burning just before the mechanical treatment to remove excessive plant materials that would hamper tillage operations.

Grassland plantings that are managed to provide suitable wildlife habitat in the prairie pothole region should not be subjected to annual grazing or haying in order to avoid reduction of residual vegetation, an essential component of nesting habitat. In the Northern Great Plains, maintenance of seeded grasslands requires periodic rejuvenation at intervals of three to four years. Periodic rotation of cover management should be devised to capitalize on the direct relationship between young or vigorous condition of vegetation and higher wildlife production. This type of management should be considered a never-ending activity if cover of suitable quality is to be maintained for long periods of time.

(102) WEED CONTROL FOR NATIVE GRASS ESTABLISHMENT

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Weed control for native grass establishment can be conducted either prior to planting, during seedbed preparation and planting, or postemergence in the young grass stand. Weed control on native grassland generally is limited to physical or chemical methods. Few biological control methods are available, and when available, either are not adequate to control the broad spectrum of weeds in a new planting or are too slow to provide acceptable weed control during the establishment phase. Many grass seedlings require optimum growing conditions to become well established, so many cultural weed control methods such as delayed planting or using rapidly establishing crop varieties are not practical.

Preplanting. Perennial weeds can be controlled prior to seedbed preparation, including the growing season prior to grass seeding. For example, sagebrush (Artemisia spp.) and buckbrush (Symphoricarpos spp.) can be controlled with 2,4-D [(2,4-dichlorophenoxy)acetic acid] applied in the year prior to grass planting. Dicamba (3,6-dichloro-2-methoxybenzoic acid) and picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) can be used to control broadleaf perennial weeds that are not controlled by 2,4-D. Two precautions are important; a) these auxin-type herbicides can change the chemical composition of some poisonous plants so animals consume the plants that normally are not palatable, and b) some herbicides can have a soil residual that will injure the grass seedlings, so the rate of application and time interval between application and planting must be monitored.

Tillage and glyphosate [N-(phosphonomethyl)glycine] can be used prior to planting for both weed control and seedbed preparation. Glyphosate is a nonselective herbicide, although it is more effective for grass than broadleaf weed control. It can be applied either in the fall or in spring when the perennial grasses to be controlled have at least 20 cm of growth. Tillage can start approximately 7 days after glyphosate application.

At planting. Clean seedbed preparation is the best cultural weed control alternative at planting. Herbicides are not available for a mixed seeding of grasses, but atrazine [6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] is labeled preplant or preemergence for pure stands of big bluestem (Andropogon gerardii) and switchgrass (Panicum virgatum).

Postemergence. Two herbicides, bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) and 2,4-D, are labeled for broadleaf weed control in seedling grass stands. Bromoxynil may be applied any time after grass emergence, whereas 2,4-D may be applied after the grass seedlings have 3 or more leaves.

Mowing can be effective for control of many upright broadleaf weeds, but it is ineffective against prostrate broadleaf and grass weeds where the axillary buds are below cutting height.

After the grass seedlings become well established, i.e. generally well tillered, then herbicides such as 2,4-D, bromoxynil, dicamba, and picloram, can be applied for broadleaf weed control. If annual grass weeds, such as Bromus spp., are a problem after the new seeding becomes established, atrazine can be applied in the fall before the ground freezes.

Label precautions concerning both grazing and harvest intervals after treatment and herbicide soil residues must be followed when planning and carrying out a weed control program for native grass establishment.

(103) INFLUENCE OF PRAIRIE VEGETATION IN SOIL DEVELOPMENT

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The black soils of the northern prairie are well known for their natural fertility and their excellent physical condition. The nature and condition of the grass roots is the single most important factor in creating the thick organic-rich A-horizon of these soils. The names by which they are called reflect the A-horizon. The Russians call these "Chernozems" which literally translates black soil; the Canadians call them "Orthic Black soils"; and the U.S. classification calls them Mollisols from the Latin root "mollic" meaning soft.

Prairie grasses have a large amount of their biomass below ground (1). These grass roots die and are decomposed to the stable forms of organic matter in place. Thus, soil organic matter accumulates. The annual leaf fall of deciduous trees in comparison fall on the soil and only a little gets incorporated into the soil; therefore these soils have thin A-horizons (2).

We measured 178 tons/acre organic matter on average in nine range soils at Streeter, ND (3). The annual above ground organic matter for the range plants growing on the soil averaged 0.85 tons/ha for 1981 to 1983 which are considered to be exceptionally good years for production. The ratio of stored organic matter to annually produced above ground organic matter is about 106 to one. Considering that grass roots may be double the above ground annual production, it would take at least 33 years of total preservation to store this amount of organic matter. The organic material produced by grasses obviously is very easily preserved compared to woody species.

Landscape position has been observed to be the primary factor that controls plant production and the organic matter development in soils of North Dakota (3, 4, 5). Other factors that were observed to be important on range soils were salinization and available water capacity of the soil (3). The latter factor is largely a function of the soil texture and usually, soil organic matter is as well (6). In Figure 1, the soil organic matter was related to estimated available water and is the X-axis. The annual production on the Y-axis is directly related to the observed organic matter in the soil in seven of the nine soils studied. The Arvilla soil was sandy with very little available water capacity and low organic matter but it was located in a site that received water from above. The Lallie was saline, produced little growth annually but was able to preserve the organic matter well.

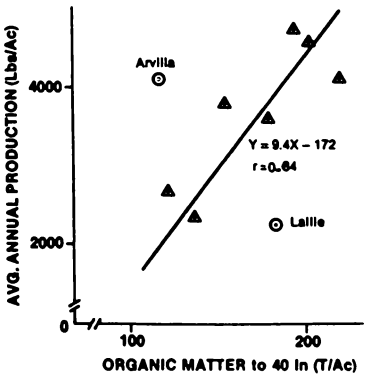

Fig. 1. Comparison of organic matter to annual production for the Central Grasslands Research Station (modified after [3]).

Other important considerations on the relationship of grasses to soils include the products produced by the grasses and the large amount of calcium usually found in the restricted rainfall areas of prairies. The products produced by the grasses that are converted to stable organic matter are lignin and proteins. Carbohydrates tend to disappear rapidly because of the solubility and ease of oxidation. The lignin material in particular is considered to be the basic building block of soil organic matter (7). Lignin is abundant in grass roots. The biodecomposition of organic matter produces a negative charge which enables calcium to be adsorbed. The calcium aids in soil organic matter stability by resisting microbial removal, oxidation, and leaching (7).

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(13) BODY COMPOSITION OF DOMINANT SOMATOTYPE GROUPS

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The developers of the concept of somatotype attempted to identify the morphological characteristics which differentiate body structure. These morphological characteristics, which were empirically identified, served as standards to determine the somatotype rating. Arm length, foot size, hand size, shape of the body, chest, waist, thigh circumference, and a number of other anthropometric measurements were either rated or measured to estimate the somatotype.

Because somatotyping preceded the technology for measuring body fat and lean mass, these components of body composition could only be included descriptively in the somatotype rating. Sheldon (1) described the endomorph as having a low specific gravity and the mesomorph as having large bones and prominent muscles. These descriptions were the first associations between body composition and somatotype.

Parnell's (2) anthropometric somatotyping used skinfold thicknesses to estimate endomorphy and used bone and muscle measurements to estimate mesomorphy. This approach suggested a relationship between fat and endomorphy and betweeen lean weight and mesomorphy. However, this relationship was only implied, and neither Sheldon nor Parnell pursued it. Therefore, the role of fat and fat free weight in somatotype ratings remains unclear. To test the hypothesis that fat weight (FW) and fat free weight (FFW) are associated with somatotype dominance, we assessed body composition in 375 healthy adults (217 males and 158 females) aged 18-73 years. Somatotypes were determined by the Heath-Carter method (3) using anthropometric measurements of skinfold thicknesses, femur and humerus widths, calf and biceps circumferences, standing height, and body weight. A computer sort identified three groups according to somatotype dominance: endomorphs (78 females and 34 males), mesomorphs (33 females and 143 males), and ectomorphs (47 females and 40 males). No significant gender differences were found among dominant ectomorphs, but significant ($p < 0.05$) gender differences were found among dominant mesomorphs and endomorphs. The mean body weight and standing height assessed by dominant somatotype indicated that the endomorphs were heaviest, the ectomorphs were tallest; the mesomorphs were heavier than the ectomorphs, lighter than the endomorphs and shorter than either the endomorphs or ectomorphs.

Body composition was estimated by the hydrodensitometic method of Akers and Buskirk (4); results were analyzed for influence of gender and somatotype dominance. Fat free weight was not significantly different among female endomorphs, mesomorphs or ectomorphs, 48.6 ± 6.8 (mean ± SD), 48.3 ± 5.3 and 45.6 ± 6.4 kg, respectively. Fat weight was less ($p < 0.05$) for female ectomorphs (11.1 ± 2.4 kg) than endomorphs (21.5 ± 8.5 kg) or mesomorphs (16.0 ± 5.3 kg). Fat free weight was greater ($p < 0.05$) for male mesomorphs (71.1 ± 10.0 kg) than endomorphs (67.6 ± 10.2 kg) and ectomorphs (62.9 ± 10.3 kg). Fat weight for males was significantly ($p < 0.05$) different for endomorphs (23.5 ± 10.0 kg), mesomorphs (14.6 ± 8.1 kg) and ectomorphs (8.2 ± 3.5 kg).

In conclusion, in this large sample of subjects, somatotypes were significantly different, and body composition variables, body weight and standing height, varied significantly according to somatotype dominance. The findings provide the first evidence of a strong relationship between body structure or somatotype and body composition.

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(14) EXPLORATION OF SOLAR RADIATION EFFECTS ON PATIENTS WITH MULTIPLE SCLEROSIS ADMITTED TO HOSPITALS IN NORTH DAKOTA

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Multiple sclerosis (MS) frequency has been shown to be higher in eastern than western North Dakota (1). Differences in disease distribution between these regions may be climate-related (2). Whether solar radiation as a climatic factor affects the individual with multiple sclerosis as manifested by hospital admission is not known. Therefore, the purpose of this study was to examine solar radiation for its possible effects on the number of patients diagnosed with multiple sclerosis admitted to North Dakota hospitals during a three year period (January 1, 1978 through December 31, 1980).

Patient data were obtained through survey of all acute care hospital medical record departments throughout the state. Information included: (a) day, month, and year of each multiple sclerosis patient hospital admission; (b) diagnosis as entered on the patient's record (including diagnoses other than multiple sclerosis); and (c) date multiple sclerosis was first diagnosed. Out of 872 admissions, 232 individuals who had been admitted for treatment of conditions other than multiple sclerosis were identified. Subsequent exclusion of these individuals resulted in data for 641 admissions related to multiple sclerosis and its complications.

Solar radiation data for Bismarck (the most centrally located monitoring point with available data in the state) was obtained from the National Oceanic and Atmospheric administration (NOAA). The computer edited data are presented in kilojoules for global, direct and diffuse solar radiation. Global radiation can be defined as the incoming solar radiation at the outer limits of the atmosphere (Q_s), the planetary albedo (a), and outgoing long-wave radiation from earth to space (I), and can be computed via the following equation:

$$R = Q_s(1-a) - I$$

where: R is the radiation balance (surplus or deficit), and (1-a) is the percentage of total insolation which is absorbed by the earth and atmosphere (3). Direct radiation comprises the degree of sunshine, natural light, clear skies and absence of rain, and is inversely related to diffuse radiation which occurs in proportion to increased cloud cover, rain and high humidity conditions.

Data for hospital admissions and solar radiation converted to thousandths kilojoules were plotted via the Lotus 1-2-3 program using a smoothing technique for five monthly increments in the three-year period:

$$\frac{\text{Jan-May}}{5}; \frac{\text{Feb-June}}{5}; \frac{\text{Mar-July}}{5}; \text{ and so forth.}$$

The resultant graph (Figure 1) reveals that the pattern of hospital admissions follows a similar pattern to diffuse but not to direct or global solar radiation. This relationship will be investigated further using optical data in an effort to elaborate on the findings of this study. It appears that aspects of the solar spectrum may affect the body and body functions that determine the effects of thermoregulation and photochemical responses in some patients with multiple sclerosis.

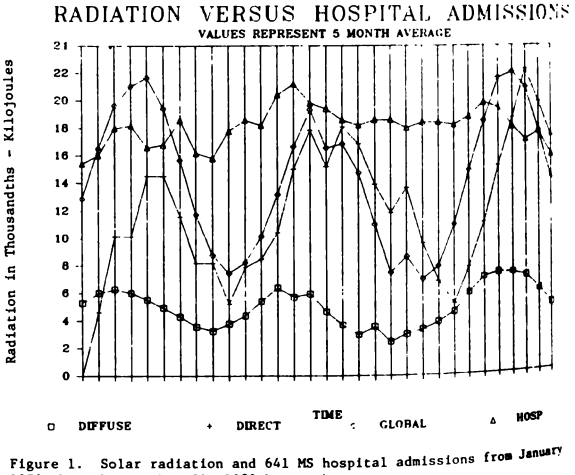

Figure 1. Solar radiation and 641 MS hospital admissions from January 1978 through December 31, 1980 by month.

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(15) MECHANISM OF STERILIZATION IN VITAMIN E DEFICIENT MALE RATS

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Deficiency of dietary alpha tocopherol (vitamin E) has been known to cause sterility in rodents since 1927 (1). This work was confirmed for the male rat several years later by another laboratory (2) and continuing work on vitamin E has been reviewed in 1980 and 1982. No further investigations have been reported, however, on sterilization of the deficient male rat. Poor understanding of the mechanisms involved in this event is made more vexing by the fact that sterilization of the deficient female is not homologous with that of the male, being apparently directed at the embryo, rather than the gonad.

In 1985 we reported to this forum on the impaired fertility of our male Long-Evans rats maintained on a synthetic diet containing <1ppm alpha tocopherol. Since that presentation we have accumulated data on the testes of 19 deficient animals and on 10 control animals which had been raised on the same purified diet to which had been added 120ppm of the vitamin. We have continued our morphological studies in more depth and we believe that we can now trace some of the events in testicular degeneration in vitamin E-deficiency and form some hypotheses regarding the mechanisms involved.

Twenty male Long-Evans rats were placed on synthetic diets from weaning. The vitamin E-deficient diet contailed <1pp alpha tocopheral and the control diet, indentical in all other respects, contained 128ppm. Commencing at about 100 days of age the animals were mated to normal mature proestrus females. Of the deficient animals 142 confirmed inseminations produced only 38 normal litters, a success rate of 27%. Eight control males on the vitamin E-replete diet produced 48 litters from 53 inseminations, a success rate of 90%. Tissue from testis and epididymis from deficient and control animals was fixed in Carnoy solution for light microscopic study after staining with the PAS-hematoxylin method. Other samples were fixed in Karnofsky's solution for electron microscopic study. By tracing the gradual degeneration of testicular tissue from animals at different stages of deficiency we found that the ultimate product of the destructive process is an acellular hyalinized basal lamina of the seminiferous tubule, a true sterilization. The process involves first the disappearance of mature sperm, then spermatids, and then spermatocytes. As in other forms of tubular destruction the spermatogonia are the last of the germ cells to go, followed eventually by the Sertoli sustentacular cells, leaving no cells of any kind within the tubule. The progression of these events does not occur synchronously in all parts of the tubule. Various stages can be found in a single testis but in long-term deficiency all tubules are destroyed. In some animals a marked proliferation of Leidig cells provide a picture similar to that found in human Klinefelter's syndrome.

The first changes we have seen in the testes of our deficient animals is an increase in the level of luminal sloughing of germinal epithelium. The next stage is the appearance of large vacuoles in the Sertoli cells. From this point the germinal epithelium thins and soon is limited to a thin layer of spermatocytes, spermatogonia, and Sertoli cells. The next stage is a fusion of 'cytes into a unique structure which has been described as a "multinuclear cell". This structure, when studied by electron microscopy appears not to be a cell at all but, rather, a bag of nuclei of degenerating 'cytes. This "bag" can be seen to increase in size by the inclusion of more nuclei from the smaller fusions by breakdown of their abutting membranes until it reaches a size containing 20 or so nuclei. At all times this "nuclear bag" remains membrane bound and wholly contained within the cytoplasm of the Sertoli cell. Its fate, as seen by both light and electron microscopy is disintegration after which its fragments become dispersed into the Sertoli cytoplasm. None of these events were encountered in our control animals which had been maintained on the vitamin E-replete diet.

In considering these observations we are reminded that the Sertoli cell is a phagocyte. One of its functions in normal testis is to salvage residual bodies from 'tid formation and malformed sperm. The Sertoli cell, by nature of its maintenance of the "blood-testis barrier" also prevents germ cells from escaping the tubules to extra-tubular tissue where their haploid nuclear structure becomes antigenic. We believe that the biological role of the sequestration of germ cell nuclear material into accumulations for enzyme degradation is the prevention of nuclear protein of germ cells from escaping the tubule of the injured testis and thus inducing a sterilizing auto-immune reaction. This activity of the Sertoli cell can be induced by vitamin E deficiency as well as by other insults to testicular tissue. The site of damage caused by the deficiency is probably cells of the germ line and the Sertoli cell activity is a reaction to the presence of damaged germ cells. The damage done to the testes by vitamin E deficiency destroys fertility and is not reversible by vitamin replacement.

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(16) DIETARY BORON AFFECTS CALCIUM, PHOSPHORUS AND MAGNESIUM METABOLISM OF POST-MENOPAUSAL WOMEN FED LOW OR ADEQUATE MAGNESIUM

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Recent studies in animals, some described elsewhere in this volume, have shown that boron affects major mineral metabolism, and the response to high dietary aluminum and low dietary magnesium. Accordingly, a study was done with 13 post-menopausal women between ages 48 and 82 housed in a metabolic unit. They were fed a diet made from conventional foods, containing 14% protein, 47% CHO and 39% fat and supplying about (per day) 600 mg calcium, 870 mg phosphorus, 116 mg magnesium, and 0.25 mg boron. All women participated in the first four dietary periods of 24 days: 1) basal diet only, 2) + 1000 mg aluminum/day, 3) + 200 mg magnesium/day, 4) + 1000 mg aluminum + 200 mg magnesium/day. After completing this phase of the study, 12 women participated in two additional dietary periods in which the basal diet was supplemented with 3 mg boron/day. Six women were fed: 1) the boron basal diet only, and 2) + 1000 mg aluminum/day. The other six women were fed: 1) + 200 mg magnesium, and 2) + 200 magnesium + 1000 mg aluminum. Thus, six women were fed low (0.25 mg/day) or normal (3.75 mg/day) amounts of boron with a low magnesium (116 mg/day) diet; another six women were fed the same levels of boron with an adequate magnesium (316 mg/day) diet. Selected findings from these dietary treatments are shown in the table.

Table 1. Effect of Boron, Aluminum and Their Interaction on Ca, P, and Mg Variables

Dietary Treatment, mg/day		Urinary Excretion, g/24 hrs			Plasma Concentration, mg/dl		
B	Al	Ca	P	Mg	Ca	P	Mg
		Post-Menopausal Women Fed a Mg-Low Diet					
0.25	0	0.117	0.67	0.069	9.9	4.0	2.12
0.25	1000	0.124	0.69	0.071	10.1	4.1	2.14
3.25	0	0.065	0.54	0.050	9.6	3.8	2.06
3.25	1000	0.073	0.59	0.047	9.7	3.7	2.07
		Analysis of Variance - P Values					
Boron		0.0004	0.003	0.0004	0.02	0.002	0.002
Aluminum		NS	0.07	NS	NS	NS	NS
B x Al		NS	NS	NS	NS	NS	NS
		Post-Menopausal Women Fed a Mg-Adequate Diet					
0.25	0	0.132	0.65	0.111	9.9	4.1	2.18
0.25	1000	0.128	0.73	0.097	9.9	4.1	2.23
3.25	0	0.104	0.67	0.083	9.7	4.2	2.11
3.25	1000	0.113	0.64	0.089	9.6	3.9	2.11
		Analysis of Variance - P Values					
Boron		0.001	NS	0.004	0.03	NS	0.06
Aluminum		NS	NS	NS	NS	NS	NS
B x Al		NS	NS	NS	NS	NS	NS

The data show that, regardless of dietary magnesium, boron supplementation depressed the plasma calcium concentration and the urinary excretion of calcium and magnesium; however, the depression seemed more marked when dietary magnesium was low. Boron supplementation also depressed plasma phosphorus and magnesium concentrations, and the urinary excretion of phosphorus in women fed the magnesium-low diet; these variables were not significantly affected ($P > 0.05$) by dietary boron in women fed adequate magnesium. Neither high dietary aluminum nor an interaction between boron and aluminum affected the variables presented. The findings indicate that boron affects major mineral metabolism in humans.

(17) EFFECT OF BORON, CALCIUM, AND MAGNESIUM AND THEIR INTERACTION ON THE MINERAL CONTENT OF KIDNEY AND LIVER FROM MARGINALLY METHIONINE DEFICIENT RATS

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Recent findings from our laboratory have supported the hypothesis that B has an essential function in the rat that affects Ca, P, and Mg metabolism (1). Other findings showed that the interaction between B and Mg, and the response to B deprivation, were more marked and consistent when rats were fed a marginal methionine deficient diet containing luxuriant arginine (1). Therefore we decided to ascertain the mineral composition of livers and kidneys from rats fed marginal-methionine, arginine-luxuriant diets containing variable dietary B, Ca, and Mg. Some selected findings are presented in Table 1.

Male weanling Sprague-Dawley rats were assigned to groups of six in a fully crossed, three way 2x2x2 design. They were fed a casein based diet that was not supplemented with methionine and contained luxuriant arginine (supplemental 10 g/kg diet) (1). The dietary treatments were B at 0 and 3 µg/g, Mg at 100 and 400 µg/g and Ca at 2.5 and 5.0 mg/g. Environmental conditions have been described (1). The rats were fed their respective diets for seven weeks, fasted overnight, weighed, anesthetized and decapitated. The liver and kidney were removed, blotted dry, weighed and frozen for later analysis. The samples were prepared by our usual methods for elemental analysis using a Perkin Elmer ICP/6500 system (2,3).

Table 1. Effect in Rats of Dietary Boron, Calcium and Magnesium and Their Interaction on Mineral Content of Liver and Kidney

Treatment µg/g diet			Liver (dry) µg element/g				Kidney (dry) µg element/g			
B	Mg	Ca	Ca	Mg	P	Cu	Ca	Mg	P	Cu
0	100	5000	142	1039	12619	16.4	2333	1240	18952	40.5
0	400	5000	107	699	9350	10.0	261	1012	12487	20.4
3	100	5000	160	1119	14248	16.6	2329	1273	18698	33.4
3	400	5000	101	672	9242	10.4	263	1057	12803	21.1
0	100	2500	124	975	11843	15.3	3800	1091	16632	21.5
0	400	2500	113	788	10828	10.7	247	987	12287	18.5
3	100	2500	130	1003	12144	14.9	2465	1040	16021	22.3
3	400	2500	126	840	11372	10.6	245	1033	12401	19.4
Analysis of Variance - P Values										
B			0.03	0.02	0.003	NS	NS	NS	NS	NS
Ca			NS	NS	NS	NS	NS	0.0007	0.008	0.0001
B x Ca			NS	NS	NS	NS	NS	NS	NS	NS
Mg			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
B x Mg			NS	NS	0.05	NS	NS	NS	NS	NS
Ca x Mg			0.0001	0.0001	0.0001	0.07	NS	0.007	0.04	0.0001
B x Ca x Mg			0.04	0.03	0.01	NS	NS	NS	NS	NS
Error Mean Square			150	2732	494529	3.0	1602135	12944	4245636	25.5

Boron deprivation depressed liver Ca, Mg and P, but did not affect liver Cu or kidney minerals. Magnesium deprivation elevated Ca, Mg, P, and Cu in both liver and kidney; the elevations were, except for kidney Ca, less marked in Ca-deprived rats. Calcium deprivation depressed Mg, P and Cu in the kidney, but not in the liver. The most unexpected findings were that Mg deprivation elevated the Mg concentration in liver and kidney, and that Ca deprivation elevated the Ca concentrations in liver of Mg-adequate rats; the latter effect being most marked when boron was supplemented to the diet. These unusual changes were not seen in methionine-adequate rats (unpublished data). The results show that dietary B, Ca and Mg and their interaction markedly affect the elemental composition of the liver and, to a lesser extent, of the kidney of the rat.

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(18) INTERACTIONS AMONG DIETARY BORON, MAGNESIUM, AND CHOLECALCIFEROL IN THE CHICK

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We have shown previously that dietary boron significantly improves the grossly deformed tibial epiphysial plate (TEP) of chicks fed inadequate cholecalciferol (vitamin D_3); also, that interactions among dietary boron, magnesium and vitamin D_3 affect several physiological indices. This study was done to confirm and extend those findings.

In a fully crossed, 2x2x2 factorially arranged experiment, day-old cockerel chicks (17 per group) were fed a ground corn-casein-corn oil based diet (1) containing 0 to 0.04 mg/kg boron supplemented with boron at 0 or 3 mg/kg; magnesium at 300 or 500 mg/kg; and vitamin D_3 at 125 or 625 IU/kg. Environmental conditions have been described (2). The chicks were fed their respective diets for four weeks, weighed and decapitated. Selected indices listed in the table were determined by our usual methods (2,3).

Table 1. Effects in Chicks of Dietary Boron, Magnesium and Cholecalciferol and Their Interactions on Selected Indices

Treatment				Blood Plasma			
B	Mg	Vitamin D_3	Body Weight	Uric Acid	Glucose	Albumin	Boron
mg/g	mg/g	IU/g	g	mg/DL	mg/DL	g/DL	ng/ml
0	300	125	560	6.24	327	2.42	40
3	300	125	512	7.78	418	2.24	93
0	500	125	592	6.83	463	2.36	32
3	500	125	635	5.64	329	2.29	160
0	300	625	835	6.33	327	2.31	34
3	300	625	771	7.07	315	2.25	125
0	500	625	825	7.43	337	2.36	33
3	500	625	761	6.08	317	2.13	150
			Analysis of Variance - P Values				
B			NS	NS	NS	0.0006	0.0001
Mg			NS	NS	NS	NS	0.0002
Mg x B			NS	0.0003	0.0001	NS	0.0001
Vitamin D_3			0.0001	NS	0.0001	NS	NS
Mg x Vitamin D_3			NS	NS	NS	NS	NS
B x Vitamin D_3			NS	NS	NS	NS	NS
B x Mg x Vitamin D_3			NS	NS	0.0002	NS	0.02

After four weeks, vitamin D_3 deficiency depressed growth and altered the structure of the proximal TEP. Boron deprivation depressed, or elevated, plasma concentrations of uric acid in chicks fed inadequate, or adequate, magnesium respectively. Calcified areas of the TEP (CTEP) contained the highest boron concentrations. The CTEP boron concentration correlated ($R^2 = 0.798$; $p < 0.018$) with the distance between the calcified extracellular matrix and marrow sprouts (CEM-MS). Dietary boron did not affect the CTEP boron concentrations but did decrease the CEM-MS by 62% in vitamin D_3 deficient, magnesium adequate chicks. The findings suggest that physiological levels of dietary boron affect a wide range of physiological indices including bone structure and metabolism.

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(19) THE INFLUENCE OF ZINC DEFICIENCY AND BACILLUS CALMETTE-GUERIN CELL WALL INJECTION ON THE PROLIFERATION OF CONCANAVALIN-A STIMULATED LYMPHOID CELLS

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The increased ability of Zn deprived rat spleen lymphoid cells (SLC) to respond to concanavalin-A (Con-A) was shown to be the consequence of reduced food intake during Zn deficiency (1). Other studies using protein-energy deficient animals showed increased SLC response to the mitogen phytohemagglutinin (2). The injection of Bacillus Calmette-Guerin cell wall (BCGcw) into animals consuming normal diets reduced the T-cell mitogen response of SLC (3). This depressed response was attributed to a BCGcw induced suppressor cell population within the spleen. The present study was done to determine the effects of BCGcw injection on the proliferation of spleen lymphoid cells from zinc deficient and food restricted rats.

Weanling male Long Evans rats were fed for 21 days ad libitum either zinc-adequate (20 µg/g) or zinc-deficient (2 µg/g) diets. A third group was pair-fed (PF) the zinc-adequate diet (ZA) using the average daily intake of the zinc deficient (ZD) animals. At two weeks, equal numbers of rats from each dietary group were injected in both forelimb footpads with a suspension of BCGcw in incomplete Freund's adjuvant (125 µg/0.05ml/footpad). Control rats (10/group) were injected with 0.05 ml/footpad of Hank's balanced salt solution in incomplete Freund's adjuvant (IFA). Seven days later all animals were anesthesized, bled, and tissues removed. Spleen lymphoid cells were isolated by centrifugation using Ficoll-sodium metrizoate density gradient, incubated with multiple concentrations of Con-A, and pulsed with tritiated thymidine (^{3}H-Thy). Plastic adherent cells (PAC) were separated from the density gradient SLC by incubating the SLC (suspended in RPMI-1640 devoid of serum) on plastic tissue culture dishes for 90 min. at 37°C in 5% CO_2. Nonadherent spleen lymphoid cells (NASLC) were collected by gently swirling the dishes and pipetting off all cells in suspension.

Table 1. Influence of ZD and BCGcw on the maximum in vitro response of SLC to Con-A (Mean ± SE)[1]

Treatment	Log 10 Counts Difference DPM ^{3}H-Thymidine		
	ZA	ZD	PF
IFA	5.08 + 0.07^{a,*}	5.37 ± 0.08^{b,*}	5.49 ± 0.02^{b,*}
BCGcw	4.01 ± 0.13^{c,d}	3.38 ± 0.32^{c}	4.30 ± 0.12^{d}

Table 2. Influence of plastic adherent cells on the maximum in vitro response to Con-A of ZA-SLC from BCGcw injected rats (Mean ± SE)[1]

Index	Treatment	Cell Type	
		SLC	NASLC
^{3}H-thymidine (Log 10 DPM)	IFA	5.10 ± 0.08*	4.83 ± 0.05*
	BCGcws	4.06 ± 0.11	5.05 ± 0.09

[1]Values in each row marked with a similar superscript letter are not significantly different ($p > 0.05$); analysis of variance (ANOVA), followed by Scheffe contrast. IFA values marked with an asterisk are significantly different ($p < 0.05$) than BCGcw values; Student t-test.

The in vitro response to Con-A was greater with SLC from ZD-IFA and PF-IFA than ZA-IFA rats (Table 1). When compared with IFA treatment, BCGcw effectively depressed the proliferation of SLC from rats in all three dietary groups. Removal of PAC from ZA-BCG SLC restored the Con-A response of the NASLC to the control IFA level (Table 2). BCGcw suppressed splenic Con-A activity in all three dietary groups. This suppressive ability is associated with the PAC.

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(20) THE AVAILABILITY OF ZINC FROM FOODS FED TO THE RAT

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The nutritional value of a food depends not only on the concentration of nutrients in the food, but also on the availability of those nutrients for absorption and metabolism. Zinc availability from foods varies substantially. Proposed reasons have included the presence of enhancers such as protein or certain amino acids, and inhibitors such as phytic acid or competing minerals (1). The purpose of this investigation was to determine in rats the zinc availability from a variety of foods, and to identify chemical properties or constituents which could be used to predict availability.

Foods (except soybean flour) were prepared as for human consumption, then lyophilized and sieved. Phytic acid, Cu, Ca, Fe, Mg, P and Zn contents were assayed. Protein and amino acid contents of foods were obtained from USDA food composition tables. An *in vitro* model was used to determine whether zinc solubility or its association with low molecular weight compounds after enzymatic digestion could be used to predict zinc availability.

Male Long-Evans rats consuming diets containing 12 mg Zn/kg were fed a single test meal containing: 1.5 g sucrose, 0.45 g corn starch, 0.15 g corn oil, 1 µCi carrier-free $^{65}ZnCl_2$, and 1.5 µmol Zn in the form of $ZnCl_2$ or a food. Activity of ^{65}Zn was monitored by whole body counting immediately after the meal and intermittently for 3 weeks. Corrected retention of ^{65}Zn was determined by extrapolating to zero time the linear portion of a plot of ln % activity versus time. Corrected retention and availability relative to $ZnCl_2$ are given in the table below.

Table 1. Retention and Relative Availability of Zinc from Various Food Sources

Zinc Source	Corrected Retention (%)	Relative Availability
Pork	81.7 ± 7.2 a*	121
Chicken	81.3 ± 6.0 a	121
Peanut butter	78.8 ± 7.6 ab	117
Egg	77.7 ± 16.9 abc	115
Milk	74.9 ± 5.5 abcd	111
Corn	70.0 ± 5.3 abcde	104
$ZnCl_2$	67.3 ± 4.7 abcde	(100)
Leavened flat bread	65.2 ± 13.6 abcde	97
Cheese	60.7 ± 9.4 bcde	90
Unleavened flat bread	59.7 ± 6.9 cde	89
Oysters	58.8 ± 7.9 de	87
Leavened loaf bread	57.2 ± 6.4 de	85
Rice	56.4 ± 9.0 e	84
Beef	55.9 ± 11.9 e	83
Soybean flour	52.5 ± 5.3 e	78
Navy bean	52.7 ± 8.6 e	78

*Mean + S.D. The same letter indicates no difference by Tukey's contrasts, $p < 0.05$.

When expressed relative to zinc concentration in the food, several amino acids and protein were significant predictors of zinc availability (R^2 from 0.39 to 0.57, $p < 0.01$). The relative amounts of phytate and minerals were of limited value as predictors. Neither *in vitro* zinc solubility nor the degree to which zinc was associated with low molecular weight substances was a useful predictor of *in vivo* availability.

Together with previous experiments (2), these data indicate that zinc availability from food may be either enhanced or reduced from that expected if it were present as a zinc salt. The data do not support the general concept that zinc is more available from foods of animal rather than plant origin. Even within categories of similar foods, such as meats or legumes, zinc availability varies widely. Characteristics of food protein should be further evaluated for usefulness in predicting zinc availability.

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(21) 54-MN ABSORPTION AND EXCRETION IN RATS FED STARCH OR SUCROSE

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A 2 x 2 factorially arranged experiment was done to study the effect of sucrose or starch on absorption and excretion of 54-Mn in growing male rats. Animals were fed diets containing 65% sucrose or starch and 1 mg or 5 mg added Mn/kg. After 5 days, 6 rats from each diet group were gavaged with 2 µCi of 54-Mn and 5 µg Mn in 0.2 ml of 0.9% NaCl. An additional 6 rats from each dietary treatment were injected with 0.5 µCi of 54-Mn in 0.1 ml of 5 mM glycine-0.9% NaCl into the left thigh to determine the rate of 54-Mn excretion. A second experiment was done that used a 2 x 3 factorial arrangement and was similar to the first experiment except that an additional diet containing 50 mg Mn/kg was used and the rats were fed 54-Mn in test meals instead of by gavage. The test meal was 4 g of either sucrose or starch diet and contained 20 µg Mn plus 2 µCi 54-Mn. Using a whole body counter equipped with a ND 62 multi-channel analyzer, 54-Mn retention of each rat was measured 1.5 hour after the administration of 54-Mn and at 2-day intervals for the next 20 days. Percent apparent absorption (AA) of 54-Mn was calculated by extrapolating the linear portion of a plot of ln % retention vs time to zero time. Percent retention (R) of intramuscularly administered 54-Mn was similarly calculated. True absorption (TA) was obtained by dividing AA by R (1). Excretion rate (ln % R/d) of 54-Mn was the slope of the linear portion of a plot of ln % injected retention vs time. All data were subjected to analysis of variance. An interaction between carbohydrate and Mn affected absorption and excretion rate of 54-Mn in experiment 1 (Table 1). The effect of sucrose on excretion rate was evident only in rats consuming 5 mg Mn/kg diet. A similar enhancing effect of sucrose on the excretion rate was found in experiment 2 (Table 1). Sucrose-fed rats also absorbed significantly more 54-Mn from the test meal than starch-fed rats (Table 1). The marked effect of sucrose was not seen when the 54-Mn was administered by gavage. Thus both dietary sucrose and 54-Mn apparently must be present in the gut before sucrose exerts an effect on 54-Mn absorption. When compred to starch, dietary sucrose seems to enhance absorption and accelerate excretion of 54-Mn. These findings suggest that dietary factors affect Mn absorption. Further study of the bioavailability of Mn in different foods would be useful.

Table 1. True absorption and excretion rate[1]

Experiment 1

Diets		TA[2] (%)	Excretion rate[2] (ln % R/d)
Starch	1 mg Mn/kg	36.3[a3]	- 0.023[b3]
Sucrose	1 mg Mn/kg	30.7[a]	- 0.022[b]
Starch	5 mg Mn/kg	19.6[b]	- 0.027[b]
Sucrose	5 mg Mn/kg	21.9[b]	- 0.036[a]
Root MSE		3.8	0.003

ANOVA	p values	
Carbohydrate	NS	0.003
Mn	0.0001	0.0001
Carbohydrate x Mn	0.02	0.0007

Experiment 2

Diets			Pooled		Pooled
Starch	- Mn	2.8		- 0.016	
Sucrose	- Mn	6.1	4.4[a3]	- 0.017	- 0.017[c3]
Starch	5 mg Mn/kg	2.7		- 0.026	
Sucrose	5 mg Mn/kg	6.7	4.7[a]	- 0.029	- 0.027[b]
Starch	50 mg Mn/kg	1.7		- 0.056	
Sucrose	50 mg Mn/kg	3.6	2.6[b]	- 0.060	- 0.058[a]
Root MSE		1.6		0.003	

ANOVA	p values	
Carbohydrate	0.0001	0.01
Mn	0.006	0.0001
Carbohydrate x Mn	NS	NS

[1]Mean value of 6 rats. [2]See the text. [3]Values not followed by the same letter in each column are significantly different ($p < 0.05$).

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(22) EFFECTS OF DIETARY TAURINE AND ARSENIC ON PLASMA AND LIVER MINERAL CONTENT IN THE SPONTANEOUSLY HYPERTENSIVE RAT

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We have found that arsenic deprivation depressed plasma taurine levels (unpublished). Nara et al. (1) found a decreased content of taurine in serum and liver of spontaneously hypertensive rats (SHR). Thus, we designed a 2x2 factorially arranged experiment to ascertain the effects of taurine on arsenic deprivation in SHR. Male weanling SHR were assigned to groups of six and were fed a 70% ground corn, 16% casein based diet (containing 12 ng As/g) supplemented with $Na_2HAsO_4 \cdot 7H_2O$ at 0 or 1 µg arsenic/g and taurine at 0 or 10 mg taurine/g. Environmental conditions have been described (2). The rats were fed their respective diets for 62 days, fasted for 16 hours, weighed and decapitated subsequent to ether anesthesia and cardiac exsanguination with a heparin coated needle and syringe. The liver was removed and weighed. Plasma proteins were precipitated with 30% trichloroacetic acid prior to mineral analysis. Liver was digested with HNO_3-H_2O_2. Mineral content of plasma and liver was determined using standard atomic absorption methodology. Selected findings are summarized in Table 1.

Table 1. Effects of Taurine, Arsenic and Their Interaction on Plasma and Liver Mineral Content in the SHR

Treatment		Plasma		Liver (dry wt)				
As	Tau	Cu	Zn	Ca	Cu	Mn	P	Zn
µg/g	mg/g	µg/ml	µg/ml	µg/g	µg/g	µg/g	µg/g	µg/g
0	0	1.17	1.62	117.2	22.7	10.28	10575	94.9
1	0	1.07	1.54	103.3	17.1	8.94	10161	87.9
0	10	1.12	1.58	107.1	16.8	8.61	10639	96.1
1	10	1.18	1.49	100.3	18.1	8.30	10187	87.8
		Analysis of Variance - P Values						
As		NS	0.01	0.02	NS	0.03	0.02	0.04
Tau		NS	NS	NS	NS	0.004	NS	NS
As x Tau		0.003	NS	NS	0.04	NS	NS	NS
Error Mean Square		0.003	0.005	82.1	13.3	0.61	152520	61.0

An interaction between taurine and arsenic significantly affected plasma and liver copper. Arsenic supplementation decreased the copper concentration in plasma and liver of rats fed no supplemental taurine, but not in rats fed 10 mg taurine/g diet. Plasma zinc and liver calcium, manganese, phosphorus, and zinc concentrations were elevated by arsenic deprivation regardless of dietary taurine. Rats fed 10 mg taurine/g diet exhibited lower liver manganese concentrations than rats fed no supplemental taurine.

The results indicate that arsenic affects the mineral content of several tissues, and that dietary taurine, a metabolite of methionine, can influence the effect of arsenic. The findings support previous studies which indicate that arsenic deprivation affects methionine metabolism (3,4).

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(23) AN EVALUATION OF THE CONDITION OF TWELVE COMMON WINDBREAK SPECIES IN NORTH DAKOTA

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The health of tree and shrub species was determined in nine North Dakota counties in 1979-81. The counties selected were representative of all areas and major soil types in the state. Condition ratings were made for each species at each site, and factors that might influence condition ratings were recorded. Ratings were an adaptation of a system developed by Read (1), where condition was scored as 1 (excellent), 2 (good), 3 (fair), or 4 (poor). The 503 sites examined included 60 Prairie States Forestry Project (PSFP) field windbreaks (planted 1935-42), 249 field windbreaks planted 1943-1979 (designated FS/SCS for Forest Service/Soil Conservation Service plantings), 116 farmstead windbreaks, 10 tree claims, 6 wildlife or recreation plantings, 5 feedlot protection windbreaks, 18 other types of plantings and 40 stands of native woodland.

The 12 woody species most commonly encountered during the survey are listed in Table 1A, along with the statewide mean condition rating and range of condition ratings for that species. Average condition rating of those species by type of site and by county are given in Table 1B and 1C, respectively. In determining the statewide mean condition given in Table 1A, all counties were given equal weight. The range of condition for each species are the means for counties and types of site. This is the initial report of results of this survey.

Significant variation was found among statewide mean conditions of the species (Table 1A). Picea pungens and Caragana arborescens had the best average rating. Acer negundo, Prunus virginiana and P. americana had the worst average rating. Range of condition means for each species by counties is an indication of how much species performance varied. Caragana arborescens and Prunus virginiana had a small range, indicating similar performance statewide. Populus deltoides had the largest range. Its performance was greatly affected by the county where it was planted. Likewise, range across types of sites indicates how much species performance varied by site. Caragana arborescens and Fraxinus pennsylvanica had small ranges, so would be most likely to perform equally well in all sites. Eleagnus angustifolia, Prunus virginiana, and Picea pungens, had the largest range, indicating their performance in different types of site would be most likely to differ from their statewide average.

No significant differences were found in performance of these species by type of site or by county. This is partially due to a large variation in performances in each county and type of site caused by interactions with each other and with other factors, e.g. species, age of site, and individual site factors. In each county and type of site, there were some species which were best and some which were worst, but different species were best or worst for the different sites. For example, in farmstead and PSFF windbreaks, Picea pungens was the best, while Caragana arborescens was among the best in FS/SCS windbreaks and wildlife plantings. Also, Picea pungens was among the best species in McIntosh, McKenzie, Ramsey, Ransom, and Stutsman counties, while Eleagnus angustifolia was among the best species in McIntosh county and among the worst species in Burke and Traill counties.

Table 1. Condition of trees and shrubs common in North Dakota.

A. Statewide condition[1] by species

Species	Mean[2]	Range Counties	Range Sites
Picea pungens	2.1	1.4-3.0	1.5-4.0
Caragana arborescens	2.1	1.8-2.5	1.8-2.5
Ulmus americana	2.3	1.8-3.0	1.7-2.7
Fraxinus pennsylvanica	2.4	1.9-3.4	2.0-2.8
Juniperus virginiana	2.5	1.8-3.5	2.0-3.0
Pinus ponderosa	2.5	1.8-3.0	2.0-4.0
Populus deltoides	2.6	1.0-3.7	1.8-4.0
Eleagnus angustifolia	2.6	1.9-3.3	1.0-4.0
Ulmus pumila	2.8	2.3-3.3	2.3-3.4
Prunus americana	3.0	2.0-3.8	2.0-4.0
Prunus virginiana	3.0	2.5-3.2	1.0-4.0
Acer negundo	3.1	2.5-3.9	2.5-4.0

B. Condition[1] by type of site

Site type	Mean[3]
Feedlot	2.24
Native Stands	2.28
Other plantings	2.50
Field Windbreaks	
PSFP	2.62
Farmstead	2.84
Field Windbreaks	
FS/SCS	2.90
Tree Claim	2.90
Wildlife	3.24

C. Condition[1] by county

County	Mean[3]
Oliver	2.47
Ramsey	2.48
Burke	2.50
McKenzie	2.50
McIntosh	2.53
Traill	2.58
Bowman	2.65
Ransom	2.71
Stutsman	2.76

1. Condition: 1=excellent, 2=good, 3=fair, 4=poor. 2. FLSD (0.05) = 0.47.
3. Differences not significant at 0.05 level.

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The assistance of Lee Pederson and Thomas Garhoffer in this survey are gratefully acknowledged.

(24) POPULATION BIOLOGY AND MODELS OF THE MALLARD

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The mallard duck (Anas platyrhynchos) is now less common than it was a few years ago. Recent estimates of numbers in the primary North American range are about 5 million, less than half of the values of 30 years ago. Despite some skepticism about the reliability of those estimates, due to a sampling fraction of less than 1% and an unbalanced survey design, the downward trend seems real (1).

Numerous reasons for the mallard decline have been proposed, including drought on the breeding grounds, intensification of agricultural land use, increased numbers of predators or changes in their species composition, diseases and contaminants, excessive hunting, and deterioration of migrational or wintering habitat. For each suggested reason, there is an equally plausible argument for its inadequacy. For example, drought on the breeding grounds does not explain the persistence of the mallard decline when rains returned (1), and hunting has not been shown to affect most populations of mallards (2). Worse yet, the plethora of contributing factors makes it too easy to conclude that all of them, acting in concert, contribute to the decline, and thereby plead impotence to address them.

Modeling has been suggested as a means of resolving such uncertainty. With a model, investigators can consolidate information about a population, test certain hypotheses, and determine critical shortcomings of the data. For the past 15 years, the Northern Prairie Wildlife Research Center has been developing and using a model of mallard productivity (3), which accounts for the population dynamics on the prairie breeding grounds. Included in the model are variables relating to time of arrival in the spring, physical condition of females, their daily survival, initiation of nests, selection of nest sites, clutch sizes, hatch rates of clutches, and survival of ducklings until fledging. A sensitivity analysis of the model indicated that reproduction was most strongly influenced by hatch rates of clutches, condition of females, and duckling survival rate. Recent modifications of the model permit variable wetland conditions, catastrophic weather phenomena, and migrational homing by mallards (4).

The model, along with several data bases that support its application, has been used to address a variety of management issues (5), including mitigation for water development projects, regional and continental management strategies for the mallard, and planning for a proposed new wildlife refuge.

Based on the success of the productivity model, a decision was made to develop a model encompassing the full annual cycle of events affecting mallard population dynamics. In addition to the breeding season, components included in this model are fall migration, hunting, wintering, and spring migration. Some critical concerns must be addressed in this more comprehensive modeling effort (6). For example, whether hunting at current levels influences annual survival is not known (2), but obviously determines how a model is to be constructed. Also, although diseases and contaminants kill or impair large numbers of waterfowl (7), the extent to which they affect the population dynamics is uncertain. Further, any heterogeneity among individuals in a population can cause misleading conclusions from population analysis (8). The model requires population biologists to face these questions head-on.

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(25) MICROSPORIDEA ON NINESPINE STICKLEBACKS

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During July, August and September, 1974, A.J. Derksen, Manitoba Department of Renewable resources and Transportation Services, collected many Ninespine sticklebacks infected with numerous conspicuous external cysts. The sticklebacks were netted in the Saskatchewan River below the Grand Rapids Dam, in Lake Winnipeg near the Saskatchewan River mouth, and in Lake Winnipeg approximately nine miles (15 kilometers) north of the Saskatchewan River mouth (Eating Point Area). Microsporidea have been found on certain fishes in eastern Canada (1). Up to 1970, apparently no Microsporidea had been identified on Ninespine sticklebacks in Canada (2). In 1976, however, Glugea anomala was reported on this host species in Quebec (3).

Each infected stickleback was stored in 10% formalin, with cysts intact. Later, several fish were removed, cysts punctured and smears prepared from cyst contents. Some smears were air dried and stained with Ehrlich's acid alum hematoxylin. Other smears were kept moist on albumen treated slides, then stained with Ehrlich's hematoxylin. Several smears were evaluated for the presence of iodinophillic vacuoles.

Metric comparisons with recognized species were made, using no less than 15 measurements of each structural dimension of cysts and spores (Figure 1). Of 18 sticklebacks submitted, 17 displayed cysts on the exterior of the body. The white, rounded cysts ranged from 0.1mm to 4mm in diameter, with an average of 0.8mm for 119 cysts. A maximum of 40 cysts were observed on an individual fish, while the average was seven cysts per fish. Cyst location was diverse; almost all body regions were used. Some preference was noted for sites on or immediately next to the eye, gill cover and fins, where 39% of all observed cysts were found. An additional 13% were found along the lateral line. One of 17 infected fish exhibited an abnormal protrusion of the eyeball (exophthalmos).

A comparison of taxonomic features shows the sporozoan belongs to the class Microsporidea, and produces comparatively small spores with polar filaments. The presence of a presumed single polar filament on each spore aligns it with the suborder Monocnidina (4). Of nine related genera, Nosema can be eliminated by the absence of diplokarya in the spore (5), Perezia by the hypertrophy of the host cell, and five other genera by the internal spore structures (including vacuole, nucleus and sporoplasm) (6). Distinction between the remaining two genera, Glugea and Plistophora, depends on sporont development into two or more than two spores. This form may prove to be new to science.

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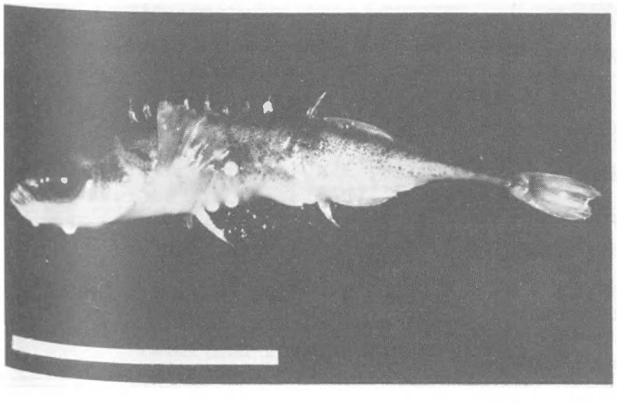

Figure 1. Lateral view of Ninespine stickleback showing microsporidian cysts on body and fins. Bar equals 50 mm.

(27) PARASITOSIS IN RELATION TO AGE OF FISH HOST

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The older an animal is, the longer it has had to contact and become infected with parasites. Because of this in some host-parasite systems the intensity (number of individual parasites or parasite burden) and incidence (number or percent of host population infected) change and may increase with age. Advancing age of fish may be associated with change in structure, diet and social behavior and probability of infection. During the course of fish parasite surveys (1975-77) involving the thorough examination of 800 fish an opportunity became available to study the relation of host age to parasitosis. The relationship of host age to number of parasite species and parasite burden was elucidated using multiple regression analyses of nine fish species in study area S (upper Missouri, James and Sheyenne rivers and Wild Rice River; lotic habitats in two major drainages) and 12 host species in study area F (lower James and Sheyenne rivers and lakes Arrowwood, Jim, Mud and Ashtabula and Jamestown Reservoir; lotic and lentic habitats in two major drainages). Hosts were aged using scales and spines.

The number of parasite species recovered is significantly correlated with host age in six fish species (marked with an asterisk in Table 1) in study areas F and S. Absence of significant correlation coefficient between age and number of species for Esox lucius differs sharply with results obtained by Dogiel (1). He found the number of parasite species to more than double (3.4 to 9.4) between 0^+ and 5-11 years of age. Age of host is positively and significantly correlated with number of individual parasites present in four species in study are S (Table 1). Whereas in the Carpsucker, Carpiodes carpio, (Table 1) there is a significant negative correlation between age and number of parasites. Apparently in this host the worm burden decreases with increasing age.

In six of 14 fish species included in the study (Table 1) age is significantly related positively to number of individual parasites and/or number of parasite species recovered. Dogiel (1) explains such differences in parasite fauna as due mainly to change of diet and migration within a lake. Holmes (2) points out that parasite populations in the definitive host can be affected by the intraspecific factors of density dependent immunity and intraspecific competition and the interspecific determinants of cross immunity, interspecific competition and environmental modification within a host (infrapopulation level). At the suprapopulation level parasites in the definitive host are affected by host population size and selective mortality of heavily infected individuals (2). These factors and others affect the populations under study but one has been separated out (age) and demonstrated to have significant positive relation with number of parasites or number of species in six host species in the study areas.

TABLE 1

CORRELATION OF HOST AGE WITH PARASITOSIS

	Correlation Coefficient			
Host	Number of Species Study area F	Number of Species Study area S	Number of Parasites Study area F	Number of Parasites Study area S
Carpiodes carpio		0.186		-0.374*
Catostomus commersoni	-0.109	0.613*	-0.095	0.315
Cyprinus carpio	-0.235	-0.152	0.009	0.295
Esox lucius	-0.204	-0.274	-0.218	0.052
Hiodon alosoides	-0.260	0.459*	0.242	0.214
Ictalurus melas	0.236*	0.268	-0.027	0.336*
Ictiobus cyprinellus	0.529		0.374	
Lepomis macrochirus	0.172	0.428*	0.148	0.738*
Moxostoma macrolepidotum	-0.387		0.107	
Noturus gyrinus	0.309		-0.026	
Perca flavescens	0.240*	0.198	0.093	0.551*
Morone chrysops	0.410		0.248	
Notropis cornutus		0.349*		0.765*
Stizostedion vitreum	-0.240		0.050	

* $p < 0.05$

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(28) FLEAS (SIPHONAPTERA) OF SMALL MAMMALS FROM THE SOUTHERN END OF THE RED RIVER VALLEY

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The flea fauna and its distribution in the Upper Midwest are incompletely known. In Minnesota, 47 species have been reported (1, 2), mostly from three regions: 1) the area adjacent to the Twin Cities, 2) the Arrowhead region north of Lake Superior, and 3) Itasca State Park. In North Dakota, 52 species or subspecies of fleas are known (3). Again, extensive collecting has occurred in only three regions: 1) the counties south and west of the Missouri River, 2) the north-central area encompassing Minot, and 3) Grand Forks County. Except for the last location, little is known about the flea fauna of the Red River Valley (Fig. 1). The purpose of this study was to determine what fleas occur on small mammals in the southern end of the Red River Valley.

This project was incidental to an extensive comparison of small mammal populations from an agricultural area of the upper Red River Valley. Excluding August, mammals were snap-trapped each month from 18 May through 12 November 1976. Twelve sites were sampled, 5 each in Cass Co., and Richland Co., North Dakota, and 2 in Clay Co., Minnesota (Fig. 1). Each collection bag was checked and all animals were brushed to remove ectoparasites. All specimens were stored in 70% ethanol. Fleas were bleached in 10% KOH, dehydrated, cleared and mounted on slides by standard methods.

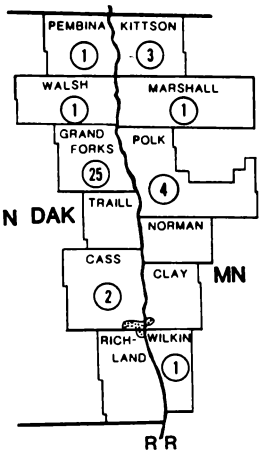

Figure 1. Species of fleas reported from counties bordering the Red River. Stippled area encompasses sites trapped, this study.

A total of 875 mammals representing 16 species were captured during 14,236 trap nights. From these, 358 fleas were recovered which are presented in Table 1 along with the infested hosts. Also included are 3 specimens of Nosopsyllus fasciatus, the northern rat flea. These were taken in 1941 from rats in Fargo, but never reported. Voucher specimens have been deposited in the University of North Dakota Parasite Collection.

The majority of fleas collected were Orchopeas leucopus (43.6%) & Monopsyllus wagneri (38.8%). They were very common on deer mice, and occasionally on ecologic associates. Of the 10 species reported herein, only Epitedia wenmanni wenmanni constitutes a new record for the Red River Valley. All 10 are known from both Minnesota and North Dakota, and all have mid- or transcontinental distributions. The most extreme is N. fasciatus, its worldwide distribution on rats and mice having been facilitated by ship and rail traffic (4). Despite the absence of new flea/host associations or major range extensions, this study provides information about the flea fauna of an area previously unstudied.

Table 1. Fleas found on small mammals from the southern end of the Red River Valley

HOSTS \ PARASITES	Corrodopsylla c. curvata	Ctenophthalmus p. pseudagyrtes	Epitedia w. wenmanni	Megabothris asio megacolpus	Megabothris quirini	Monopsyllus wagneri	Nosopsyllus fasciatus	Opisocrostis bruneri	Orchopeas caedens	Orchopeas leucopus
Sorex cinereus	—	—	3	—	3	3	—	—	—	—
Blarina brevicauda	1,2	3	—	—	—	—	—	—	—	—
Spermophilus richardsonii	—	—	—	—	—	—	—	1	—	—
Spermophilus 13-lineatus	—	—	—	—	—	—	—	1	—	—
Glaucomys sabrinus	—	—	—	—	—	—	—	—	1	—
Peromyscus maniculatus	2	3	—	1,3	1,2,3	1,2,3	—	1	—	1,2,3
Peromyscus sp.	—	—	—	—	—	—	—	—	—	2
Clethrionomys gapperi	—	—	3	—	1,2,3	1,2	—	—	—	1
Microtus pennsylvanicus	—	—	2	—	—	2	—	—	—	—
Rattus norvegicus	—	—	—	—	—	—	1*	—	—	—
Zapus hudsonius	—	—	—	—	1	1,2	—	—	—	2

1 = Cass Co., ND; 2 = Richland Co., ND; 3 = Clay Co., MN
*Not obtained in this study, but present in UND Collections

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(81) GEOARCHAEOLOGICAL INVESTIGATION OF THE DAHNKE SITE: RED RIVER VALLEY, NORTH DAKOTA

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The Dahnke site is a multi-component archaeological site located approximately 20 km north of Fargo, ND, near the confluence of the Red and Sheyenne Rivers. The surficial component is a scatter of artifacts that contained pottery diagnostic of Late Woodland cultures. Buried surface horizons in all soil profiles studied have been correlated with cultural remains dating to the Middle Woodland period.

The site is situated on a group of terraces associated with the Red River. The highest of these terraces is part of the Lake Agassiz lacustrine plain. The remaining two terraces are below the lake plain, but still as much as 9.7 m above the current mean stream elevation. The sediments are largely fluvial; however, some profiles have received surface additions from upslope. Soil and landform interpretations were conducted to aid the archaeologists in locating geomorphic surfaces which were stable in the past. Soil descriptions were made during the summers of 1985 and 1986 in the archaeological excavations using standard techniques. Lab analyses included organic carbon (OC), pH, HCO_3-extractable P and K, and DTPA-extractable metals[1]. Additionally, particle-size distribution by pipette[2] and calcium carbonate equivalent[3] (CCE) were determined.

Buried surface horizons (pedologic discontinuities) in all profiles studied (Fig. 1) were identified through an examination of OC, CCE, particle-size distribution, and soil morphology. The profile on the highest terrace (269.7 mASL) contained one discontinuity at a depth of 46 cm. The cultural layer identified in this soil occurred within this horizon. Cultural remains however, were insufficient to be diagnostic. The soil located on the second terrace (268.8 mASL) contained two buried surfaces at 42 and 60 cm. The lower of these was 14 C dated to 2200 $\pm$ 60 years B.P. (Beta-19046). Cultural remains were diagnostic of the Middle Woodland period. The profile on the lowest terrace (267.9 mASL) contained pedologic discontinuities at 80 and 110 cm. Both surfaces contained Middle Woodland artifacts. Charcoal recovered from these surface horizons yielded 14 C dates of 1860 $\pm$ 80 (Beta-19045) and 2030 $\pm$ 60 B.P. (Beta-17457) for the 80 and 110 cm depths, respectively. All dates are uncorrected radiometric years. The discontinuities in this profile are considered to be time stratigraphically continuous with those in the second soil due to the occurrence of similar diagnostic artifacts and similar 14 C dates. The lower elevation of the third soil examined, and the greater depth of sediment over the first buried surface in this profile are indicative of the instability of this landscape position.

The cultural horizons were expected to be enriched with respect to extractable P and K. However, bicarbonate extractable P and K levels were no different than non-cultural horizons. DTPA-extractable Mn, Cu, and Zn were analyzed but the results of these analyses were inconclusive.

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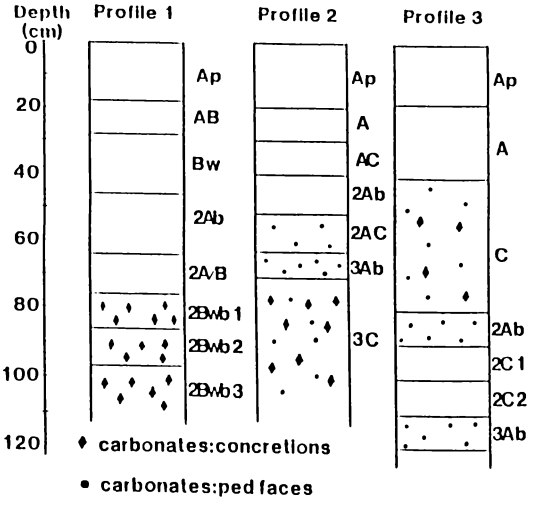

Figure 1. Soil profiles identified at the Dahnke site. Profiles 1, 2 and 3 correspond to terraces 1, 2 and 3, respectively.

(82) POSSIBLE NUTRITIONAL STRESS IN A PLAINS WOODLAND SKELETAL POPULATION

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Site 32RY100 is a Late Woodland mortuary located in eastern North Dakota just outside the city of Devils Lake in Ramsey County. The site has an uncorrected radiocarbon date of a.d. 810 ± 100 years. A total of 30 individuals were recovered from the mortuary; 16 adults, 13 juveniles and one late term fetus. A bimodal demographic profile was formed by these interments, with one mode during the first five years of life and the second during the third and fourth decades. All of the adults were sexed with a nearly even sex ratio of nine males and seven females.

Prehistoric Northeastern Plains skeletal populations can be characterized as having a low caries rate, high levels of enamel attrition, and few stress related skeletal pathologies (2,3). In this regard the individuals recovered from site 32RY100 are atypical. Although the permanent teeth recovered from site 32RY100 display excessive enamel attrition and interproximal wear, high caries and abscess rates were observed when compared with other spatially and temporally contiguous skeletal populations (Table 1). Enamel chipping was also present on one or more teeth in 46% of the permanent dentitions. In addition to these acquired dental defects three stress related skeletal pathologies were identified. The diaphyses of one juvenile (age 1.5 years) were antero-posteriorly bowed. This was accompanied by flaring of the metaphyses and suggests a diagnosis of rickets. The diaphyses of a second juvenile (age 2.0 years) were visibly porous near the metaphyses, taking on an almost sponge-like appearance, the apparent result of a severe metabolic stress. Last, sclerous tissue was found on the superior wall of the left and right orbits of a young adult (age 25-30 years). This is interpreted as a possible case of healed cribra orbitalia, a manifestation of iron deficiency anemia (1).

The excessive levels of enamel attrition and enamel chipping are typical of a coarse pre-horticultural diet (2). The high caries rate, however, indicates that processed carbohydrate food stuffs made a significant contribution to the overall diet. This, coupled with the observed skeletal pathologies leads to the speculation that site 32RY100 represents a population in a state of nutritional stress, possibly at a point of incipient horticulture. If this conclusion is correct then it is significant as site 32RY100 predates the earliest dated horticulture in North Dakota by more than 400 years.

Table 1. Caries/Abscess Incidence.

Site	N	# Affected Individuals	# Lesions	Frequency
32RY100	13	7/7*	21/28	54%/54%
32SN22	17	2/9	2/21	12%/53%
32GF1	12	2/5	6/38	17%/42%

* caries/abscess

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(83) SHARKS, RAYS AND RATFISHES FROM THE CANNONBALL FORMATION (PALEOCENE, DANIAN) OF THE DAKOTAS

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The Paleocene (Danian) Cannonball Formation, known positively only from western North Dakota and northwestern South Dakota, records the latest marine incursion into central North America. Of principally marine, poorly consolidated sandstone and mudstone, it contains a distinctive biota (1); of the conspicuous invertebrate macrofossils, molluscs--particularly bivalves and gastropods--predominate. Vertebrates are generally inconspicuous.

The cartilaginous fishes--sharks, rays and ratfishes--of the Cannonball are now known from 46 localities, most from western North Dakota. Our localities represent an addition of 34 to those of previously published studies (2, 3, 4). A new (1986) find along the Little Missouri River in northwestern Slope County extends the range of Cannonball sharks farther west than known previously, and represents the first occurrence of a shark from a Cannonball brackish tongue (upper). Most of the cartilaginous fish fossils have been recovered from the sandstone facies.

Based on our material of 850 shark teeth, and supplemented with data of previous workers, three genera are known to occur in the Cannonball: Odontaspis (Odontaspididae; sand sharks), Lamna (Lamnidae; mackerel sharks) and Notorynchus (Hexanchidae; cow sharks). Most of the teeth--usually collected as float--are of Odontaspis, followed by those of Lamna and Notorynchus. Notorynchus is here newly reported for the formation. Sufficient teeth of Odontaspis from one locality allow us to reconstruct a nearly complete artificial tooth set of anteriors, intermediates, laterals, posteriors and symphyseals.

Ray and ratfish fossils are less abundant than shark remains. Twenty-three crushing tooth plates of ?Myliobatis from five localities record the presence of eagle rays (Myliobatidae). Ratfishes (or chimaeras), of possibly the genera ?Ischyodus and ?Elasmodus, are evidenced by 11 fragments of tooth plates from seven localities. Ratfishes are here newly reported for the Cannonball.

Shark species similar to those in the Cannonball have been reported from presumably contemporaneous strata along the U. S. Atlantic and Gulf Coasts (3) and in northern Europe (5). The same species of Lamna and Odontaspis have been recovered from the Cannonball and contemporaneous Midwayan strata (3). This implies a cosmopolitanism of certain elements of Paleocene shark faunas.

The nearest, presumably marine, Paleocene cartilaginous fish fossils occur in the Shotgun Member of the Fort Union Formation in central Wyoming (6), about 250 miles to the southwest. The next closest occurrence is in the Clayton and Porters Creek Formations at the northern edge of the Mississippi Embayment (7), about 900 miles to the southeast. These occurrences suggest a southern source for the Cannonball but do not necessarily substantiate it.

The Cannonball sharks presumably fed largely on fishes and the ratfishes on fishes and invertebrates. The bottom-dwelling eagle rays likely used their tooth plates to crush hard-shelled molluscs and crustaceans. Lamna today is confined to warm temperate and boreal waters (8), and suggests a temperate Cannonball Sea as do certain molluscs (9). Following Applegate's (10) approach, the height of the largest anterior tooth suggests that Cannonball Odontaspis reached at least 2.5 m long.

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(84) THE CASE FOR YELLOWSTONE RIVER DIVERSIONS ACROSS THE DAKOTAS

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Evidence for abandoned Yellowstone River channels crossing southwest North Dakota and northwest South Dakota is present along the asymmetric drainage divide between the Little Missouri River and the southeast-flowing Knife, Heart, Cannonball, Grand and Moreau Rivers. This evidence suggests the northeast-flowing Yellowstone River was repeatedly diverted in eastern Montana to flow southeast across North Dakota. These diversions appear to have taken place near recognized glacial margins. Evidence is briefly described below:

Yellowstone River Alluvium: Numerous rounded pebbles and cobbles of a distinctive quartz latite porphyry, characteristic of Yellowstone River alluvium, can be found in the Knife, Heart, Cannonball, Grand and Moreau River valleys. The distinctive porphyry is present in lag gravels crossing the asymmetric divide between the Little Missouri River and the Knife, Heart, Cannonball, Grand and Moreau Rivers. The distinctive porphyry is also common in conglomeratic units which have been mapped as Oligocene White River Group at Chalky Buttes-White Butte in Slope County, at East and West Rainy Buttes in Slope County, and at the Little Badlands in Stark County (1). These (White River Group) deposits probably represent early Yellowstone River channels. Topographic inversion since the deposition of the sediments has produced the buttes we see today.

Northwest-Southeast Alignment of Drainage Network: A northwest-southeast alignment of many secondary streams and rivers can be observed on topographic maps of eastern Montana, northwest South Dakota and southwest North Dakota. Barbed tributaries enter the northeast-trending Yellowstone River Valley from both the northwest and the southeast. Barbed tributaries enter the north-trending Little Missouri Valley from the northwest. The north-flowing Little Missouri River turns in McKenzie and Dunn counties to flow southeast for a significant distance. A major asymmetric drainage divide separates the north-trending Little Missouri River from the southeast-flowing Knife, Heart, Cannonball, Grand and Moreau Rivers. Most tributaries of the Knife, Heart, Cannonball, Grand and Moreau Rivers also show a strong northwest-southeast orientation. The Little Missouri River appears to have captured the upper reaches of the Knife, Heart, Cannonball, Grand and Moreau Rivers which prior to capture probably extended to an area west of the present-day Yellowstone River Valley.

Northwest-Southeast Alignment of Buttes: A northwest-southeast alignment of buttes can be seen in southeastern Montana, northwestern South Dakota and southwestern North Dakota. The Long Pine Hills in Carter County, Montana and the West and East Short Pine Hills in Harding County, South Dakota show the same northwest-southeast orientation that can be seen in the regional drainage network. The north end of Slim Buttes in Harding County, South Dakota is oriented in a north-south direction while the south end is oriented in a northwest-southeast direction. The Chalky Buttes-White Butte complex in Slope County, North Dakota is oriented in a north-south direction with a spur at the southern end to the southeast. West and East Rainy Buttes show the same northwest-southeast orientation. These buttes probably represent sediments which had filled narrow valleys of early southeast-trending Yellowstone River channels which crossed the region. Erosion, inverting the topography, has produced the modern buttes composed of early Yellowstone River alluvium.

Rounded Boulders and Cobbles of Quartzite and Granite: Rounded boulders and cobbles of quartzite and granite can be found associated with conglomeratic units found at the base of sediments usually mapped as (Oligocene) White River Group at the Short Pine Hills, at Slim Buttes, at Chalky Buttes-White Butte, at the Rainy Buttes and at the Little Badlands. The largest boulders exceed 60 centimeters in diameter. These rounded boulders and cobbles indicate the presence of a major river at each locality.

Landslide Blocks Along Walls of Northwest-Southeast Orientated Valleys: Gill (2) and Toepelman (3) mapped landslide blocks developed along the southwest and northeast walls of what may have been a series of valleys trending in a northwest-southeast direction. These landslide blocks are present in the Short Pine Hills and Slim Buttes regions of Harding County, South Dakota. The landslide blocks include sediments usually mapped as (Oligocene) White River Group and are overlain by sediments usually mapped as (Miocene) Arikaree. Landslide blocks along one northwest-southeast oriented former valley in the Short Pine Hills suggest the valley was almost 200 meters deep and, at a point 70 meters above the floor, the valley was approximately 300 meters wide.

South-Southeast Oriented Cross Beds: Cross beds in the conglomeratic unit at the base of the White River Group sediments at Slim Buttes have been mapped by Malhotra and Teglund (4) and indicate the river which deposited the material came from the northwest. A similar study by Halley (5) in the Chalky Buttes-White Butte complex showed the river which deposited the conglomerate there flowed south-southeast.

Analogy with Modern Missouri-Yellowstone River System: The modern Missouri River has long been recognized to have formed as an ice-marginal river (6). An abandoned valley extending north from Williston, North Dakota has also long been recognized as an abandoned valley of the Yellowstone River which once flowed north. The Geologic Map of North Dakota (1) shows ice margins south of any recognized ice-marginal river channels. The northeast-flowing Yellowstone River must have been diverted by these ice margins and evidence for these diversions should exist.

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(85) ARSENIC AND SELENIUM IN IRRIGABLE SOILS OF EASTERN NORTH DAKOTA

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Soils in 18 potentially irrigable areas in eastern North Dakota were sampled during the fall of 1985 in cooperation with the U.S. Bureau of Reclamation to determine the content, distribution, and potential bioavailability of arsenic and selenium. Eighty soil samples representing 13 soil-classification series were obtained using an auger and were frozen until analysis. Samples were collected from representative soil horizons to about 2 feet below the water table. Total arsenic and selenium contents were determined using the method of Briggs and Crock (1). Subsequently, sequential extractions were performed to determine the content of arsenic and selenium in principal phases within soil samples as follows:

(A) Contents occurring in soluble salts or bound within the soil by weak ion-exchange associations were determined using the method of Sandoval and Power (2).

(B) Contents occurring as sorbed species or bound by moderate ion-exchange associations were determined by extraction of the residue with a mixture of 1 *M* sodium biphosphate and 1 *M* ammonium acetate.

(C) Contents associated with humic substances were determined by extraction of the residue with 1 *M* sodium pyrophosphate.

(D) Contents in carbonate minerals or bound by strong ion-exchange associations were determined by extraction of the residue with 1 *M* acetic acid.

(E) Contents in easily reducible phases, such as hydrous manganese oxides, were determined by extraction of the residue with 0.1 *M* hydroxyl-amine hydrochloride in 0.01 *M* nitric acid.

(F) Contents in sulfide minerals and residual organic matter were determined by extraction of the residue with a 3:2 volumetric mixture of 50% hydrogen peroxide and 0.025 *M* nitric acid at 80°C followed by a second extraction with 1 *M* ammonium acetate in 6% nitric acid.

(G) Contents in moderately reducible phases such as hydrous iron oxides were determined by extraction of the residue with 0.25 *M* hydroxyl-amine hydrochloride in 0.25 *M* hydrochloric acid.

Summary contents of arsenic and selenium are shown in table 1. Mean arsenic and selenium contents of 4.1 and 0.2 µg/g, respectively, are less than the worldwide means for glacial soils of 6.7 and 0.4 µg/g (3). Iron oxides were the dominant phase containing arsenic, although sulfide minerals and humic substances also contained substantial quantities. Manganese oxides, sulfide minerals, and humic substances were the dominant phases containing selenium. Clasts of Pierre Shale and lignite contained smaller contents of arsenic and selenium than encompassing glacial soils. Shale chips averaged 1.8 µg/g total arsenic and less than 0.1 µg/g total selenium. Lignite chips averaged 1.4 µg/g total arsenic and 0.1 µg/g total selenium.

Table 1
Contents of Arsenic and Selenium in µg/g

Element	Total	A	B	C	D	E	F	G
Arsenic								
Mean	4.1	0.04	0.140	0.36	0.22	0.29	0.99	1.71
Standard deviation	2.0	.02	.280	.68	.18	.23	1.03	1.63
Selenium								
Mean	0.2	0.02	0.003	0.04	0.006	0.06	0.05	0.03
Standard deviation	.2	.03	.002	.05	.004	.07	.07	.04

In general, arsenic contents in soil profiles were greatest immediately above the water table, where concentrations of iron oxides and sulfide minerals were common. Selenium contents in soil profiles were greatest near the land surface where organic substances and soluble salts were the dominant selenium-bearing phases or greatest immediately above the water table where manganese oxides, iron oxides, and sulfide minerals were the dominant selenium-bearing phases.

Estimates of bioavailability using an ammonium bicarbonate-DTPA leach (4) were within 5% of the sum of extractions (A) and (B). Bioavailable arsenic averaged 5.1% of total soil arsenic contents; and bioavailable selenium averaged 13.7% of total soil selenium contents. However, column leaches using oxygenated water to simulate irrigation conditions indicate that less than 4% of the arsenic and 10% of the selenium would be extracted by percolating irrigation waters.

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(86) SOIL CHARACTERISTICS OF THREE CALCAREOUS FENS IN NORTH DAKOTA AND MINNESOTA

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Calcareous fens are peatlands found in hydrologic settings in which saturated peat-forming conditions are maintained by ground water enriched with calcium and bicarbonate ions. Characteristically, calcareous fen soils are predominantly composed of partially decomposed calciphilic plant species (1), calcium-bicarbonate rich waters, and calcium carbonate precipitates in parts or all of the soil profile (2).

The purpose of this research was to select three geographically separate calcareous fens, sample and characterize representative peat soils from each fen, and identify important peat-forming processes. Through information contained in the McHenry County, North Dakota Soil Survey (3) and communication with USDA, Soil Conservation Service personnel in Minnesota (4), three peatlands were selected. Their locations are: 1) Denbigh Fen (Sec. 25, T155N, R77W, McHenry County, ND), 2) Kandiyohi Fen (Sec. 7, T122N, R34W, Kandiyohi County, MN), and 3) Gully Fen (Sec. 19, T150N, R39W, Polk County, MN). A selected transect was made across (perpendicular to slope) each fen so that elevation changes and vegetation differences were representative of the main body of the fens. Selected sites, along the transects, were sampled with a Macaulay peat sampler, soil profiles were described, and the surface vegetation identified. Peat samples, from one representative site from each fen, were analyzed by standard USDA soil characterization methods (Table 1).

The Denbigh Fen lies on a slightly elevated, flat floodplain of the Souris River with peat accumulation in a former river channel. In contrast, the Kandiyohi Fen formed in an ice-block depression in a large, sloping outwash plain. The Gully Fen lies at the base of a major shoreline of the former proglacial Lake Agassiz. In all fen settings, peat saturation is maintained by continual discharge of ground water from adjacent upland calcareous outwash soils. Although the peat soils are relatively high in ash content (Table 1), the fiber contents, $Na_4P_2O_7$ extract colors, and water contents are characteristic of only moderately decomposed peats. The most unusual characteristic is the high calcium carbonate accumulation at the surface of each profile, although carbonate occur throughout the profile. The pHs are also unusually high. All fen soils formed on top of lake sediments.

Table 1
Morphological, Physical, and Chemical Data for Peat Soils from Three Calcareous Fens

Site	Horizon	Depth (cm)	Field Color (Munsell)	Fiber Content Unrub (%)	Fiber Content Rub (%)	$Na_4P_2O_7$ Extract Color (Munsell)	pH (1:1) 0.01M H_2O	pH (1:1) 0.01M $CaCl_2$	Water Content (%)	Ash Content (550°C; % O.D.	Calcium Carbonate Equiv. (%)
Denbigh Fen	Oek	0-35	10 YR 4/2	40	28	10 YR 8/1	7.5	7.1	86.6	50.1	39.2
	Oek	35-55	10 YR 3/2	36	30	10 YR 8/1	7.4	7.2	90.1	19.4	1.9
	"	55-75	10 YR 3/2	46	36	10 YR 8/1	6.7	6.5	87.9	20.2	1.0
	"	75-95	10 YR 3/2	40	36	10 YR 8/1	7.5	7.1	87.7	20.3	4.0
	"	95-140	10 YR 3/2	40	26	10 YR 8/1	7.7	7.2	88.2	22.0	3.6
	Oe3	140-155	10 YR 3/2	28	24	10 YR 7/2	7.6	7.4	87.3	19.5	1.0
	Oe4	155-180	10 YR 3/2	44	36	10 YR 7/2	6.4	6.3	86.7	20.1	1.6
	"	185-195	10 YR 3/2	40	28	10 YR 8/2	6.7	6.6	86.3	21.0	1.1
Kandiyohi Fen	Lcap	0-18	5 Y 4/1	23	8	10 YR 6/1	8.1	7.6	56.8	72.7	48.9
	Lca1	18-39	2.5 Y 3/2	41	8	10 YR 7/2	8.0	7.4	66.8	60.1	47.3
	Oa1	39-58	10 Y 3/1	32	13	10 YR 5/4	8.2	7.5	57.7	45.1	30.2
	Oe	58-66	10 YR 3/2	57	24	10 YR 7/3	7.9	7.2	80.4	29.3	10.9
	Oi	66-134	7.5 YR 3/2	56	24	10 YR 8/2	7.0	7.3	82.3	18.9	4.0
	Oa2	134-144	10 YR 3/1	24	4	10 YR 7/3	7.2	6.6	83.6	15.2	2.6
	Lca2	144-580	5 Y 3/1	(silt loam)		10 YR 7/3	8.1	7.4	63.3	8 .2	61.2
Gully Fen	Lco1	0-21	2.5 Y 4/2	28	7	10 YR 8/1	7.9	7.6	67.8	78.5	61.1
	Oe	21-27	10 YR 3/3	60	24	10 YR 3/7	7.2	6.6	81.7	31.4	22.4
	Oa	67-82	10 YR 3/2	44	14	10 YR 3/2	7.7	7.5	77.6	43.8	2.1
Lco2	82-116		10 YR 5/2	(silt loam)		10 YR 8/1	8.0	7.6	57.9	82.3	73.3

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(87) ADDITIONAL FOSSIL VERTEBRATES FROM THE EARLY CRETACEOUS LAKOTA FORMATION IN THE BLACK HILLS, SOUTH DAKOTA

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Introduction:

Evidence of terrestrial vertebrates from lower Cretaceous rocks in the Black Hills is scanty. Only evidence of fish and dinosaurs have been documented; a somewhat surprising circumstance considering the great amount of petrified wood, dinosaur trackways, and numerous cycadeoids found in the formation. In 1924, Gregory (1) named a new fish, Lepidotes (?) lacotanus from the formation, and three type specimens of ornithischian dinosaurs have been described. P.R. Bjork, SD School of Mines (SDSM), and David Weishampel, John Hopkins University, will soon name a fourth new dinosaur from the formation. During class excursions to the Van der Voort Ranch, two additional specimens, another fish found by Darold Krein and a turtle found by Steve Fritz, were recovered from the fluvial sandstones.

Locality and Depositional Environment:

The Van der Voort locality (SDSM locality V871) lies on the eastern flank of the Black Hills, east of Piedmont, SD, and is in the Lakota Formation, the lowest unit within the Inyan Kara Group (2). At this locality the lithologies consist of alternating beds of yellow, white, and red calcareous quartz sandstone and gray siltstone and shale. The latter often contains abundant ostracods. The sandstones represent fluvial channels and point bar deposits, whereas the finer grained units represent deposits of flood plains or abandoned channel fills.

Vertebrate Fossils:

A second specimen which may be referred to Lepidotes (?) lacotanus was recently recovered from the Lakota Formation. Like the type specimen of L. (?) lacotanus, SDSM 2439, the new specimen, SDSM 13215, lacks the head. The preserved portion includes an imprint of the body, and a few rhombohedral ganoid scales are preserved near the tail. Not enough of the specimen remains for precise identification, but the occurrence south of the type locality of L. (?) lacotanus in the same stratigraphic unit and the similar scale structure suggest reference to the taxon. Fish from this site are usually associated with dinosaur tracks in an oxidized, mud-cracked, highly cross-bedded sandstone which lies high in the stratigraphic section. Deposition of this fish-bearing unit was attributed to a flood-born pulse of sandy sediment (3). The argillaceous sands gradually dessicated as the flood waters subsided, and the fish evidentally died of exposure and were later covered by additional sediments.

The turtle specimen, SDSM 13216, consists of a fragment of the plastron. It represents the first evidence of a turtle from the formation and is one of relatively few specimens known from this time interval in North America. The specimen comes from a sandstone which represents a point bar deposit much lower in the section than the fish-bearing unit. The fragment is broken, but appears to be a right hypoplastron with faint winding plications on the surface. The articular surface which forms the bridge with the carapace is preserved, and one transverse sulcus may be discerned from the sculpture. This transverse sulcus turns sharply posteriorly at the margin of the element and fades at the leg opening. Although skulls are the most diagnostic elements for differentiation of turtle taxa, the sculpture on this specimen most closely resembles that of Trinitichelys (4) from the Trinity Group of Texas or that described as "Glyptops" (5,6) from the Cloverly Formation of Wyoming and Montana.

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(88) CONTINUING PUBLIC EDUCATION IN ASTRONOMY AFTER HALLEY'S COMET

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Despite Halley's Comet lackluster "fuzz ball" appearance, its recent return captured the public's attention. Through a combination of history and media hype, public viewing sessions around the globe were overwhelmed with the masses who turned out for a glimpse of this "dirty snowball" (1). What was happening worldwide also took place in Valley City, North Dakota, where over a thousand people attended the eight scheduled observing sessions held between December, 1985, and June, 1986. The most notable of these sessions were the two March viewings held at 4 o'clock in the cold morning on a prairie road three miles southeast of town. Over 100 people gathered for both occasions.

The purpose of this paper is to describe the strategies employed in the Valley City area to encourage public education in astronomy and the ongoing efforts to continue this active interface between the public and science after Halley's Comet and its mystic have vanished. The techniques described will be useful to others in establishing similar efforts. Mark Twain says it best with, "The public is the only critic whose opinion is worth anything at all" (1), which serves as a challenge to the scientific community to continue to meet its responsibility to communicate with the public.

The main feature in this public education endeavor is a regular newspaper column called "Skywatcher's Corner" published in the Times-Record, Valley City's local daily newspaper. "Skywatcher's Corner" is designed for a 2-column by 8-inch format, and consists of the author's printed copy on a white background with a black reversal border denoting the universe. The printed copy averages approximately 300 words in length with a range of 130 to 560 words. The column began in November, 1984, and has appeared in the Times-Record nearly 30 times to date. Over the same time period, research by the Scientists' Institute for Public Information indicates a dramatic increase in science sections in daily newspapers. The primary resources used in writing the column have been: Sky and Telescope, Astronomy, Observer's Handbook published by the Royal Astronomical Society of Canada, Star Date--The Astronomy News Report published by the University of Texas at Austin McDonald Observatory, and Sky Calendar published by Abrams Planetarium, Michigan University.

"Skywatcher's Corner" has some unique features which sets it apart from the more typical astronomical articles appearing weekly or monthly in newspapers describing the events to follow. First, the column is printed the evening prior to the celestial event on which it reports. This allows a day's lapse for the delivery of the Times-Record to rural areas. The large dark border around the column serves to attract the attention of the regular reader. Second, many of the columns are reader active in that their intent is to encourage the reader to go outside and observe. Many of these columns also describe directed observing sessions to which the public is invited. During these sessions a Celestron 8 telescope is set up in various locations advantageous for observing.

Three effective strategies employed during the observing sessions should be noted. If possible, times and places for viewing were chosen to correspond to regular human traffic patterns. For example, a public viewing of the October 3, 1986, partial solar eclipse was held in the parking lot of a local supermarket; and two of the Halley's Comet watches were held just outside the SUND-Valley City fieldhouse prior to basketball games. This technique not only attracts column readers, but many spontaneously curious persons. A second strategy is to make a small drawing of what is actually being observed. Then, by showing the diagram to each person before they look through the telescope, they are better prepared to see and understand the image. Finally, volunteer assistance with the public sessions is obtained easily from interested students; and the experience augments their education. Frequently, even area residents who own telescopes have joined the observing session with their expertise and equipment.

The column has also been used to describe astronomical events, other than eclipses and comets. Planetary and lunar phenomena, technical advances (like the Voyager 2 flyby of Uranus) and meteor showers have been the subjects of this column. Particularly popular observing sessions are those where the rings of Saturn and moons of Jupiter are viewed. Recently, a successful "Skywatcher's Corner On-the-Road" observing session was held in a neighboring community. A new audience was exposed to a positive public/science interaction. Additionally, "Skywatcher's Corner" serves as a vehicle for announcing public lectures on astronomy (like the Harlow Shapley Lectureship Series) which are held at SUND-Valley City. Although no comprehensive editorial survey has been conducted since initiation of this column, one active subgroup of the "Skywatcher's Corner" audience, informally recognized, is important to note. These are the young persons of elementary school age. A recent survey by the National Science Teachers Association and Stanford School of Education revealed that an average of only 44 minutes out of a possible 25 hours per instructional week was devoted to science (3). The activities of this column add an enriching supplement to the science education of these students.

In conclusion, it is hoped that the description of these efforts will serve as a demonstration model for other interested individuals in their efforts to plan and promote public/science interactions. Certainly, attention needs to be given to the relationship between science and the public, and astronomy education seems to be an excellent vehicle for nurturing such exchanges.

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(105) SPATIAL AND TEMPORAL VARIATIONS IN A NORTH DAKOTA QUALITY OF LIFE INDEX: 1970-1980

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In spite of North Dakota's remarkable achievement in raising and maintaining a high standard of living since the 1950s, internal disparities in social well-being have increased. The purpose of this study is to assess quality of life and its variations among 53 North Dakota counties in 1970 and in 1980. In this investigation, the quality of life index (QLI) includes twenty objective variables which are categorized as: income (3), employment (1), educational attainment (2), health facilities (2), family breakdown and anti-social behavior (7), and population change and distribution (5). These variables were selected on the basis of availability for both periods and their relevancy to the social and physical conditions of the state. Environmental and perceptual variables were not considered at this stage.

A simple scaling method was used to convert variables into scores (S) that range between 0 and 100, by assigning 100 to the "best" and 0 to the "worst" values on every variable. Intermediate scores were determined by the following formula:

$$S = ((R - R\ WORST) / (R\ BEST - R\ WORST)) * 100 \text{ and } QLI = \text{Sum of } S / 20$$

Since none of the counties had the "best" or "worst" values on every variable, the QLI ranges between 44-71 and 36-75 in 1970 and 1980, respectively. This finding implies that in this state there is neither a perfect county offering the best quality of life nor a worst county suffering substandard life in all components.

The spatial distribution of the 1980 indexes is shown on Figure 1. In both 1970 and 1980 periods, Adams county has the highest QLI and Rolette the lowest. In general, counties with large urban centers score higher than rural counties. There are two distinct types of counties consistently ranked at the bottom of the list -- those with high proportions of Native Americans, and counties such as Oliver, Sheridan, Benson, and Mountrail which are in the "shadow" of a large city.

The Spearman correlation coefficient between the quality of life indexes for 1970 and 1980 was only 0.61, an indication of changes in the ranking of the counties during the decade. Although the mean remained unchanged ($\bar{x}$=59), the standard deviation increased from 5.05 to 7.14, a sign of the widening gap in the quality of life among the counties. The underlying causes of spatial inequalities are complex and varied. For example, apparent improvements in the aggregate QLI of Golden Valley, Foster, Divide, and Slope were due to reduction in crime, suicide and accident rates in 1980, rather than a substantial change in the socioeconomic well-being of their inhabitants. Conversely, Cass, Burleigh, and Adams maintained their higher position in terms of income, education, and health facilities. Furthermore, the seven top counties registered an increase in their scores, while the bottom seven dropped by as much as eleven percent. It is believed that this deteriorating trend is a result of deep-rooted cultural perceptions, local economic conditions, and historical circumstances.

The objective of this type of study is to stimulate actions toward the improvement of the overall quality of life for all people. Results from the application of quality of life index could help in various ways, ranging from resource allocations and new program development to regulatory compliance. This report represents a first step by identifying weaknesses and strengths for all counties in North Dakota. For policy decision makers who attempt to maximize the quality of life output for all constituents collectively, it offers a useful starting point.

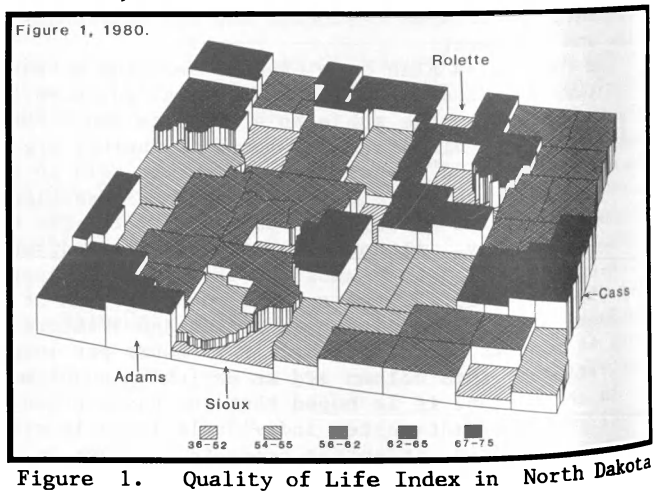

Figure 1. Quality of Life Index in North Dakota Counties, 1980

(107) REVIEW OF NORTH DAKOTA GNIS PHASE II EDIT

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A comprehensive data base of United States geographic names and basic reference information has been recognized as a critical need among various levels of government since the 1950s (2). In 1979, the United States Geological Survey (USGS) began efforts to create such a toponymic index through the development of a master computer-based catalog of American place-names and their derivatives. This data bank is known as the Geographic Names Information System (GNIS). There have been two stages of GNIS. The first phase was development of the initial national data base. The second phase, or Phase II Edit, has been the revision of specific state components that national toponymic index.

The purpose of this project was to conduct a Phase II Edit for North Dakota. Research to update the GNIS files on North Dakota was undertaken from January, 1986 through June, 1986. This type of research consists of determining variant names of known places and discovering place-names for sites not previously identified on maps. Working with the South Dakota State University Remote Sensing Institute (SDSU RSI), a team of an English toponymic specialist and cultural-historical geographers at the University of North Dakota was engaged in the Phase II Edit at various locations throughout North Dakota. Toponymic studies require this multidisciplinary approach (1,4), and the study of place-names is well-established both in geographical traditions (5,6) and English language investigations (3).

Methods of historical geography research were used for this toponymic study. The first step in this process required that potential sources for existing place-names variations and for place-names hitherto unidentified be obtained from various libraries and governmental agencies. This phase was followed by the second step of research: inventorying the data sources for variant place-names and "new" or "forgotten" place-names. As the research evolved, the principal sources of data were found to be current and historic plat books. The latter were instrumental in providing names for post offices, schools, and hamlets that have been abandoned. Step three of the project was recording data onto work maps and a GNIS coding form. The fourth step in this process involved having these and other pieces of data transformed into a computer-readable format. Data entry was handled at SDSU RSI.

Analysis of the data submitted to SDSU RSI revealed 223 variant names of existing GNIS locations and 485 acceptable "new" or "overlooked" place-names, particularly for township halls. Furthermore, over 5,000 oil well names were identified as being prospective GNIS Phase II entries, but acceptance of those names has been contingent upon the USGS changing its position relative to refusal to consider oil rig operating sites as "significant" cultural features.

There are three major implications of the Phase II Edit for North Dakota. First, further research is necessary to determine the nature of the current GNIS Phase II place-names in light of Stewart's typology of toponyms. No one yet has undertaken a statistical analysis of the GNIS Phase II entries, hence a "gold mine" of toponymic studies is waiting for researchers. Second, there is a pressing need to discover "in-group" and other vernacular place-names in this state. For example, Native American vernacular place-names are disappearing as tribal elders die and the younger generations fail to learn the "in-group" names for particular sites. Finally, persistence of "official" place-names is a topic in need of being researched. Railroad branchline elimination and abandonment of hamlets continue to be factors altering usage of current place-names. Hence, the question arises: "What will be future commonly used place-names in North Dakota?" With the Phase II Edit completed, a new era in toponymic studies can begin in North Dakota as a facet of North Dakota Statehood Centennial activities in 1989.

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LEAF SORI AND STUNTED CULMS PRODUCED BY (I-0X12)12 AND (I-14x12)I-14 BACKCROSSES OF USTILAGO HORDEI ON THREE BARLEY CULTIVARS

(114)

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Variations in the location of sporulation of Ustilago hordei (Pers.) Lagerh. in barley tissues are reported (1). Ustilago hordei, race 12, consistantly produced black, linear sori in more flag and penultimate leaves of susceptible Odessa (CI934) barley than all other races (unpublished data). These experiments were run to determine the symptoms produced on three suceptible cultivars by backcrosses to race 12 or I-14. Race 12 was crossed to races I-0 and I-14. Races I-0 and I-14 form no leaf sori on susceptible cultivars. The cross I-0x12, was backcrossed to race 12; and the cross, I-14X12, was backcrossed to race I-14. Seeds of the susceptible cultivars Odessa, Junior and UC_2-4 were dusted with teliospores of the backcrosses or check races 12, I-0 and I-14 and planted in greenhouse soil mixture or commercial Sunshine Mix #1. The location of each leaf with sori per each culm and the length of each healthy or smutted culm were recorded.

In the first experiment, twelve lines of the backcross (I-0x12)12 and fifty lines of the backcross (I-14X12)I-14 were each tested on nine Odessa plants. In both backcross series, smut infections similar to those of the parents on Odessa were noted. Backcrosses that produced milder symptoms than I-0 and I-14 were not recovered, but lines of both backcrosses were recovered with symptom severities greater than the most aggressive R12 parent. Two lines of (I-0x12)12 and five lines of (I-14X12)I-14 were chosen for the second experiment, and each was tested on twelve plants of each susceptible cultivar (Table 1). Two (I-0x12)12(9) and two (I-14x12)I-14(3) lines were chosen because they produced leaf sori on lower leaves of Odessa in the first trial than the parental races while the other three backcrosses produced milder symptoms than race 12 on Odessa.

Of the parental races, only race 12 produced leaf sori (Table 1). Backcrosses (15)3-1, (15)14-1 and (3x15)10-5 produced no leaf sori on UC_2-4, and (15)3-1 and (15)14-1 produced leaf sori in the flag or flag and penultimate (flag-1) leaves of Junior and Odessa (Table 1). Backcrosses (9)1-1, (9)1-2, (3)7-1 and (3)13-6 exceeded their race 12 parent in the number of leaves with sori per culm on all three cultivars (Table 1). Backcross (3x15)10-5 produced leaf sori in the upper four leaves of Odessa (flag-3) but caused only slight stunting. Backcrosses (9)1-1, (9)1-2, (3)7-1 and (3)13-6 stunted infected culms more than their parents and produced only leaf sori on infected culms of Junior and Odessa (Table 1). These four backcrosses produced symptoms of flag smut species rather than the head smut symptoms of U. hordei. Since seedling barley leaves develop acropetally, the position of leaves with sori on each culm indicates time of meristem invasion. Maturing host tissues are not successfully invaded by U. hordei. Therefore, the four backcrosses that produce leaf sori in the upper three to five leaves (F-2-I-4) invaded susceptible host tissues more rapidly than the other three backcrosses. The data indicate transgressive variation among backcrosses for factors governing rate of colonization of susceptible cultivars.

Table 1. Leaf sori and stunting of three spring barley cultivars susceptible to backcrosses of Ustilago hordei

Fungal Lines	Lowest Leaves With Sori[2]			Average Stunting Per Culm (Infected/non-infected x 100)[3]		
	UC_2-4	Junior	Odessa	UC_2-4	Junior	Odessa
				%	%	%
Race I-0 (ck)	0	0	0	93	84	94
Race 12 (ck)	F	F	F-2	100	88	76
Race I-14 (ck)	0	0	0	102	85	85
[(0x12)12](9)1-1	F-2	F-2[1]	F-4[1]	45	47	59
[(0x12)12](9)2-1	F-2	F-2[1]	F-3[1]	44	28	31
[(12x14)14](3)7-1	F-2	F-2[1]	F-4[1]	76	36	53
[(12x14)14](3)13-6	F-2	F-2[1]	F-3[1]	49	60	64
[(12x14)14](15)3-1	0	F-1	F-1	97	83	74
[(12x14)14](15)14-1	0	F	F	102	84	76
[(12x14)14](3x15)10-5	0	F-1	F-3	105	88	83

1/ Head formation prevented

2/ F = flag leaf; F-1 = penultimate leaf; F-2 = 3rd leaf from top etc. of each infected culm. 0=head sorus only.

3/ Average length of all infected culms/average length of all non-infected culms per each fungal line X100.

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(116) SEPTORIA MUSIVA AND MARSSONINA BRUNNEA LEAF SPOTS OF POPULUS SPP. IN WINDBREAKS IN THE NORTHERN GREAT PLAINS.

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Plains cottonwood (Populus deltoides var. occidentalis Rydb.) was planted throughout the northern and central Great Plains during the early years of settlement (2). Along with this native species, hybrid poplars such as Robusta poplar (P. x robusta Schneid.) and Northwest poplar (P. x jackii Sarg.) are still used for windbreak plantings and, more recently, for fuel wood production plantations in the Great Plains because of their rapid growth rate and ease of propagation by cuttings. The objective of this study was to determine the common leaf spot diseases of Populus species in windbreak plantings, native stands, stool beds and experimental plantations.

In 1983 and 1984 Populus species leaves with lesions were collected from windbreak plantings and native stands from 15 counties in eastern North Dakota, 6 counties in western Minnesota, and 4 counties in northeastern South Dakota. A total of 140 leaf samples were collected; 118 from windbreaks and 22 from native stands. Infected leaf samples were also collected from stool beds at Mandan, ND and from experimental plantations in Morton County and Burleigh County in central North Dakota. A total of 74 leaf samples were collected; 47 from the stool beds and 27 from experimental plantations. The stool beds and experimental plantations contained plants of diverse genetic background. Overall 214 leaf samples were collected and processed to identify fungal plant pathogens present. Leaf sections with lesions were surface-sterilized, plated on water agar, and incubated below fluorescent light at room temperature (24 $\pm$ 3 C). After 7 to 9 days, leaf sections were examined for the presence of fungi.

Of the 140 samples collected in windbreak plantings and native stands, incidence of Septoria musiva Peck. and Marssonina brunnea (Ell. & Ev.) Magn. was 47% and 18%, respectively. Septoria musiva was present over a wide geographical area, being identified on leaves from windbreaks from 9 counties in eastern North Dakota, 4 counties in northwestern Minnesota, and 1 county in northeastern South Dakota. The area of distribution for M. brunnea was more limited. It was identified primarily on samples from northwestern Minnesota and eastern North Dakota. It was identified on seven samples of the 14 samples collected from native stands in the Red River Valley. Cytospora sp. and Microsphaeropsis sp. were regularly isolated from the windbreaks and native stands but did not produce symptoms in pathogenicity tests.

Of the 74 leaf samples collected from stool beds and from experimental plantations, S. musiva and M. brunnea were identified on 77% and 8% of the samples, respectively. The incidence of S. musiva was higher in experimental plantations and stool beds than windbreaks and native stands. Septoria musiva has the potential to cause a serious foliage disease as well as a canker problem (1, 3). Considering that S. musiva is widely distributed, has the ability to infect a wide range of germplasm, and has the potential to cause serious disease problems, selecting for resistance to S. musiva should be part of a windbreak tree improvement program for Populus spp. Planting disease-resistant clones should be an important factor in controlling diseases in these long-term plantings.

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(118) THE EFFECT OF WHEAT LEAF RUST ON PHOTOSYNTHESIS

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The apparent rate of photosynthesis in wheat leaves infected by Puccinia recondita Rob. ex. Desm f. sp. tritici, the causal agent of wheat leaf rust, was compared to healthy leaves in resistant, moderately resistant, and susceptible wheat cultivars. Culture 70-1 (race 1) P. recondita was used in this study. A near isogenic line with resistance gene Lr19 chosen as the resistant line has infection type 0; (necrotic fleck) when inoculated with race 1. The near isogenic line with Lr16, has an infection type 2 (moderately resistant reaction) when inoculated with race 1. Thatcher was used as the susceptible cultivar and has an infection type 4. Both Lr16 and Lr19 have Thatcher backgrounds in which Thatcher was the maternal parent.

Seeds of the respective wheat lines were planted in 12 cm pots containing Sunshine mix and grown in the greenhouse at 20 ± 3 C under General Electric sodium vapor s52/bu lamps with an illuminance of 1400 lux. The third leaf of half the plants was inoculated with a suspension of spores in Soltrol 170 (Phillips Petroleum Co., Bartlesville, OK) (3 mg spores/mL Soltrol 170) and placed in a moist chamber for 24 hr. The experiment had four replications. Apparent photosynthesis was determined with an LI-6000 Portable photosynthesis system (liCOR, Inc., Lincoln, NE). Calculations of stomatal conductance and apparent photosynthetic rate are based upon the rate of change of humidity and CO_2 concentration in the closed system. The system uses an infrared gas analyzer to measure apparent photosynthesis similar to the system used by Ellis et al. (1981).

Measurements of apparent photosynthesis were made on day 0, 4, 6, 8, 12, 15 and 20 after inoculation. Apparent photosynthesis changed only slightly when the inoculated resistant line with Lr19 was compared to the healthy control. Photosynthesis was reduced significantly for the moderately resistant line Lr16 infected with race 1 on day 12, 15 and 20 after inoculation. Photosynthesis changed only slightly before day 12 for the line with Lr16. Photosynthesis was reduced on day 15 and 20 for the susceptible line inoculated with race 1 but changed only slightly prior to this time.

The earlier reduction in photosynthesis for Lr16 is probably due to the greater amount of necrosis associated with infection of the moderately resistant line. The significant reductions in photosynthesis are associated with reductions in chlorophyll content and yields of moderately resistant and susceptible wheat cultivars infected with P. recondita (Zitko et al. 1985, Statler 1974).

Table 1. Apparent photosynthesis rate (APR) of 3 cultivars; healthy (H) and inoculated (I) with Puccinia recondita.

Cultivar		Days after inoculation						
		0	4	6	8	12	15	20
Thatcher	H	.87	.68	.54	.69	.81	.71	.42
	I		.75	.51	.72	.72	.44	.10
Lr16	H	1.04	.69	.57	.73	.84	.61	.39
	I		.84	.77	.72	.33	.30	.06
Lr19	H	.94	.89	.58	.77	.56	.35	.28
	I		.61	.42	.78	.35	.32	.36
LSD (P=0.05)		NS	NS	NS	NS	.33	.20	.20

APR = mg CO_2 $m^{-2}s^{-1}$.

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(120) IMPACT OF DUTCH ELM DISEASE ON THE FOREST RESOURCE OF THE RED RIVER VALLEY IN NORTH DAKOTA AND MINNESOTA

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The Red River of the North meanders through a strip of originally forested land of which about 7000 ha of forest remain today. The American elm (Ulmus americana L.) is the most important tree species. The Red River forest is an important regional resource; it provides wildlife habitat, recreational values, and stabilizes the river channel by helping to slow floodwaters. The forest is also an economic resource to landowners (1).

Dutch elm disease (DED) is a lethal infection affecting the native American elm. It is caused by a parasitic fungus (Ceratocystis ulmi Buism) which grows in the water conducting vessels of the tree, causing wilting and death. The fungus is vectored by bark beetles. This disease was introduced into the United States about 1930 and reached the Red River valley around 1971, with the first case confirmed in Fargo in 1973. By 1981, the disease had been found in scattered locations throughout the length of the valley (2). In 1985, in response to requests from landowners, commercial interests and several public agencies, a survey of the forest resource of the Red River and the impact of DED on that resource was initiated jointly by the North Dakota Forest Service, Minnesota Department of Natural Resources and North Dakota State University. The complete report will be published in spring 1987 (1). The entire forested area along the Red River was aerially photographed using false color infrared (IR) film. The photos were used to verify forested land area and estimate damage due to disease. Only stands of trees of at least 2.2 ha area and 100 m width were included; there were 467 such stands. A second method was a ground survey of 32 representative forest stands along the length of the river. In this ground survey occurrence of DED was verified and number of trees affected was determined.

Dutch elm disease was widespread throughout all parts of the valley, with all counties showing some diseased trees at some locations (Table 1). Severity of Dutch elm disease, expressed as the proportion of dead and dying trees, was greatest in the southern part of the Red River valley and declined northwards (Table 1). According to the aerial IR survey 37% of stands in Richland and Wilkin counties showed major mortality of elm trees. In ground sampling in these counties 62% of elm trees were dead or dying from Dutch elm disease (Table 1). Counties at the northern end of the valley had much lower disease severities. Low levels of infection were more readily detected in the ground survey than by IR photography; this becomes apparent when one compares columns 3 and 5 in Table 1. The best correlation between the two methods occurred between the two severity measures (column 4 and 6 in table 1, $r = .93$). The levels of disease found in the southern valley are close to those projected for an epidemic 12-15 years underway (3). The lower levels in the northern valley probably reflect the more recent introduction of the disease to that part of the valley (2). The continued spread of DED has important implications for conservation, floodwater management, and resource utilization (1).

Table 1. Occurrence of Dutch Elm Disease (DED) in forested lands along the Red River in 1985.

Survey method	Aerial infrared photography (467 Stands - 7087 ha)				Ground sampling (32 Stands - 617 ha)	
	Stands >2.1 ha		Incidence[2]	Severity[3]	Incidence[4]	Severity[5]
Counties[1]	Number	Area (ha)	(%)	(%)	(%)	(%)
Richland-Wilkin	81	702	93	37	100	66
Cass-Clay	105	1451	79	11	100	23
Traill-Norman	62	946	35	2	75	19
Gr. Forks-Polk	84	1420	18	0	87	12
Walsh-Marshall	67	991	9	0	67	7
Pembina-Kittson	68	1578	1	1	83	3

1. Counties (ND-MN) are listed from South to North.
2. Disease incidence expressed as % of all stands affected.
3. Disease severity expressed as % of all stands where density of dead trees exceeded 30%.
4. Disease incidence expressed as % of sample stands where DED was present.
5. Disease severity expressed as % of dead or dying trees in sample stands.

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(121) NATIVE COLLATERAL HOSTS OF PHASEOLUS BEAN BACTERIAL PATHOGENS

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Bacterial pathogens of dry edible beans including Pseudomonas syringae pv. phaseolicola (Burkh.) Young, Dye and Wilkie (causes the disease halo blight), Pseudomonas syringae pv. syringae van Hall (causes brown spot), and Xanthomonas campestris pv. phaseoli (Smith) Dye (causes common blight and a variant causes fuscous blight) may cause devastating yield losses when environmental conditions are favorable for disease development. No single procedure can control these bacterial diseases. Use of certified blight-free western grown seed has been recommended, but the effectiveness of this procedure may be limited if the bacterial pathogens can survive on collateral hosts and spread to beans from these habitats. In Wisconsin P.s. pv. syringae surviving on hairy vetch has been correlated to bacterial brown spot disease on snap beans (2); in Michigan, X.c. pv. phaseoli and X.c. pv. phaseoli var. fuscans, pathogenic to beans survived on lambsquarter, pigweed, black nightshade, ragweed, and barnyard grass (1).

To determine the potential for collateral hosts to harbor bacteria pathogenic to beans in North Dakota, a total of 236 plants representing 17 families and 50 species were collected from 13 sites primarily in the dry edible bean growing regions of the state. These plants were tested for presence of bacterial pathogens by aseptically removing a 3 cm diameter leaf disc from an apparently sound leaf, triturating each disc with 10.0 ml sterile tap water, then dispersing 0.2 ml of the liquid on selective medium D-4 (3) and on nutrient agar (Difco) plates. Following seven days incubation at 23-26 C, colonies with morphologies resembling the pathogens were streaked to establish purity. Designated colonies were increased on nutrient agar for 48 hours, suspended in sterile tap water at a concentration of 10^6-10^7 cfu/ml (determined turbidometrically with a Bausch and Lomb Spectronic 20 at 600 nm). The suspensions were inoculated onto greenhouse-grown 'Manitou' light red kidney bean leaves to test for pathogenicity. Inoculations were made by airbrush infiltration of leaves with bacterial suspension or by swabbing inoculum onto spots previously watersoaked with sterile tap water. Leaf areas inoculated with sterile water or with known pathogens served as controls. All test plants were kept in a cool, moist chamber for 24 hours; and, after seven days greenhouse incubation at 23 $\pm$ 3 C, the plants were rated for disease reaction.

Twenty-eight samples from 19 plant species yielded bacteria with colony characteristics similar to those of X.c. pv. phaseoli and 13 samples from 11 plant species yielded bacterial with colonies similar to those produced by Pseudomonas pathogens of beans. None of the Xanthomonas-like bacteria were pathogenic. They produced hypersensitive or saprophytic reactions, and none produced typical, slowly-developed watersoak symptoms characteristically produced by pathogenic strains of the species. Pseudomonads from yellow sweetclover (Melilotus officinalis (L.) Lam.), hog peanut (Amphicarpa bracteata (L.) Fern.), and wild vetch (Vicia americana Muhl.) produced symptoms of watersoaking and spotting on 'Manitou' kidney bean leaves. Symptoms were identical to bacterial brown spot disease symptoms derived from a known culture of P.s. pv. syringae (culture courtesy of Dr. M. Schuster, University of Nebraska, Lincoln, NE). Reisolation confirmed bacterial type. Bacteria were gram negative rods with positive levan reaction. They produced fluorescent pigment on King's medium B (4) but no chlorotic halo or systemic chlorosis in diseased greenhouse plants. The bacteria which caused watersoaking in 'Manitou' kidney bean leaves were P.s. pv. syringae. Our results indicate strains of P.s. pv. syringae pathogenic to Phaseolus beans exist as microfloral components on North Dakota native or escaped legumes.

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(122) ISOLATION AND CHARACTERIZATION OF BACTERIA FROM INFECTED BEAN SEEDS

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Halo blight, common blight and bacterial brown spot are common bacterial diseases of snap and dry edible beans (Phaseolus vulgaris L.) grown in North Dakota and Minnesota. The diseases are caused by Pseudomonas syringae pv. phaseolicola (Burkh) Young, Dye and Wilkie, Xanthomonas campestris pv. phaseoli (Smith) Dye, and Pseudomonas syringae pv. syringae van Hall, respectively. The most effective control of these diseases has been through the planting of seed with little bacterial contamination. Environmental conditions may prevent disease expression on field-grown beans, yet the harvested beans that are to be used as seeds can be contaminated. Laboratory assays to test for seed contamination have been developed (3) but none is widely accepted. One proposed assay, called the dome test (2,4), may be a useful, inexpensive presumptive test for evaluating the relative amount of bacterial contamination in bean seeds. In the dome test, germinated bean seeds are infiltrated with infusion, presumably containing bacterial pathogens, from soaked bean seeds. The germinated seeds are grown in a humid environment in plastic domes, and symptoms develop on plants in 6-10 days.

The objective of this study was to determine if the symptoms on plants in the domes were caused by plant pathogenic bacteria. To isolate bacteria from leaves, single unifoliolate leaves with water-soaked spots were aseptically picked from plants then the leaves were triturated in 2 ml sterile deionized water. The sap was serially diluted then streaked onto plates of nutrient agar (Difco) or King's medium B (1). To isolate bacteria from the soaked bean infusion, 0.2 ml portions of the suspension were plated on the two media. Colonies were picked from the plates after 48-72 hr incubation at 27 C and streaked to insure purity. Pure cultures were characterized by pathogenicity on kidney bean leaves and by biochemical reactions. Pathogenic bacteria were recovered infrequently (4 of 91 strains) from diseased plants or the soak suspension when isolations were made on non-selective media. Most often, Erwinia herbicola was isolated from these plants. Semi-selective media were developed to restrict the fast-growing saprophytes on the isolation plates. Nalidixic acid, ampicillin, a high ionic concentration of NaCl, crystal violet and selected carbon sources (quinate and cellobiose) imparted selectivity. Using the semi-selective medium with quinate as the carbon source, seventeen bacterial strains were isolated in pure culture from infected plants in a dome assay and were characterized as phytopathogenic Pseudomonas syringae pv. phaseolicola. Isolations from the same plants on non-selective media yielded no plant pathogens.

These results show that plant pathogens can be recovered from diseased plants grown in the dome assay and are probably the cause of the symptoms. Saprophytic bacteria, especially Erwinia herbicola, are present in such high numbers that the pathogens cannot be readily isolated unless a selective medium is used.

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(123) A BIOTYPING SYSTEM FOR DIFFERENTIATING AMONG STRAINS OF STAPHYLOCOCCUS AUREUS.

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The current method for distinguishing among strains of Staphylococcus aureus is bacteriophage typing. This technique is time-consuming, expensive, difficult to perform, requires highly skilled professional interpretation, is available only in large reference laboratories and many strains of S. aureus are non-typable.

The heterogeneity of coagulase negative staphylococci is recognized (1). Our research suggests that coagulase positive staphylococci, identified as S. aureus, also represent a biochemically heterogenous group. The tests listed in Table 1 were selected for a working model of a biotyping system and applied to 518 strains of S. aureus resulting in 76 biotypes.

Table 1. Model biotyping system.

TEST	MAN	DNA	PHO	GEL	GAL	LAC	MAL	MNE	AMC
Typical test results	+	+	+	-	+	+	+	-	+
Numerical value of positive tests	1	2	4	1	2	4	1	2	4
Biotype code		7			6			5	

Staph-Ident and Staph-Trac systems have been compared with conventional methods for identifying staphylococci (2). The systems lack accuracy, and modifications of each are needed to permit accurate identification of S. aureus strains. Our data suggest that more extensive testing is required to accurately delineate the apparently highly heterogeneous group of coagulase positive staphylococci currently identified as S. aureus.

The Staph-Ident system identified 56% of a sample of S. aureus isolates as code number 7740. In one series, 9 isolates identified as biocode 7740 and 5 isolates as 5740 represented 8 different biotypes (757, 707, 767, 507, 557, 777, 463, 767, 577) and 5 different biotypes (547, 767, 577, 747, 561), respectively, using our model system. Two of our biotypes (767 and 577) appear in each Staph-Ident biocode. The difference between Staph-Ident codes 7740 and 5740 is a positive or negative urease test, respectively. Adding urease to our model system enables us to distinguish these strains (Table 2). In Table 2 representative strains of S. aureus were used to compare our biotyping model with data from Staph-Ident and bacteriophage typing.

Table 2. Comparison of Staph-Ident, our model, and bacteriophage typing.

S. Ident	7740	7740	7740	7740	7740	5740	5740	5740	5740
Our Model	767	707	507	777	577	747	767	577	547
Add Urease	7671	7071	5071	7771	5771	7470	7670	5770	5470
Phage Type	3A	3A	NT	NT	NT	NT	52	NT	3C/71

The Staph-Ident system grouped the isolates into only 2 biocodes, 7740 and 5740. Our model suggests that the specimens actually represent 7 biochemically different strains. Our system identified one Staph-Ident 7740 and one 5740 as biotype 767 and another set of Staph-Ident 7740 and 5740 strains as our biotype 577. Neither of the 577 biotypes were phage typeable. The two isolates in each biotype, 767 and 577, can be distinguished from each other by the urease test (Table 2). Two Staph-Ident 7740 isolates that both were phage type 3A were differentiated by our system as biotypes 767 and 707. Two isolates identified as 767 by our system phage typed as 3A and 52. We were able to distinguish these strains as 7671 and 7670, respectively, by adding the urease test. Five isolates were not phage typeable, but our model identified them as biochemically different.

Table 3. Biotype frequencies.

Biotype:	767	667	777	677	747	467	Misc.
Frequency(%)	36.3	14.3	9.1	4.4	4.4	2.7	28.8

As seen from Table 3, biotype 767 represents many isolates which may be further subdivided using urease. The miscellaneous group, representing about 29% of our isolates, consists of many strains usually identified as individual biotypes. Additional or different characters may be required to place these isolates into less diffuse groups. Moderate modification of the biotyping system should provide less scatter and more definitive grouping.

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(124) STUDIES ON THE TOXICITY OF NINHYDRIN FOR BACTERIA

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Ninhydrin has been used extensively as a reagent to detect amino-acids. In clinical microbiological laboratories, this reagent is used to detect hippurate hydrolysis by group B streptococci and other bacteria (1) by detecting the glycine formed when hippurate is hydrolyzed.

Statements regarding antibacterial activity of ninhydrin (2,3) either are unsubstantiated (2), or show only inhibitory rather than killing activity (3). In this study, viability of bacteria after exposure to ninhydrin is determined.

Reaction mixtures consisting of Streptococcus agalactiae in aqueous (distilled water only), saline (0.5% NaCl) or buffered (0.05 M PO_4, pH 7.5) solutions of ninhydrin (0.01-3%) were incubated at 0°, 22°, 37°, and 45°C. Viability of the cells during incubation was monitored at each test temperature by performing plate counts of reaction mixtures at 0, 15, 30, 45 and 60 minutes.

The initial viable count of bacteria was 1.55×10^9 per ml. At 0°C, concentrations of ninhydrin up to 2% showed no effect on viability up to 60 minutes exposure.

At 22°C, ninhydrin at 0%, 0.01%, 0.1% and 0.3% caused no decrease in viability in 60 minutes. Concentrations of 1, 2 and 3% caused 2.7, 3.3 and 3.7 log decreases in viability, respectively.

Bacterial cells incubated at 37°C for 60 minutes in water alone showed a 0.7 log decrease in viability. Under these same conditions 0.01, 0.1 and 0.3% aqueous ninhydrin solutions showed 1.4, 3.4 and 9.2 (complete killing) log decreases, respectively (Fig. 1A). Within 15 minutes, decreases in viability were observed in 0.1 and 0.3% ninhydrin solutions.

Bacteria incubated in water alone at 45°C showed a 2 log decrease in viability even at 15 minutes. The presence of ninhydrin (0.01, 0.1, 0.3%) caused additional 1.1 to 2.4 log decreases in viability (Fig. 1B). In 45 minutes at 45°C all concentrations of ninhydrin had caused a complete loss of viability (9.2 log reductions) and the control, in water only, exhibited a 4.1 log reduction in viability. The viability results at the various temperatures demonstrate that increasing the temperature of exposure to ninhydrin increases its killing effect (Fig. 1A, B).

When made in 0.5 M PO_4 buffer (pH 7.5) and 0.5% NaCl, the killing effect of ninhydrin was decreased when compared to ninhydrin solutions made in water (Fig. 2). Both 0.5% NaCl and PO_4 buffer showed greater protective effect at 37°C than at 45°C.

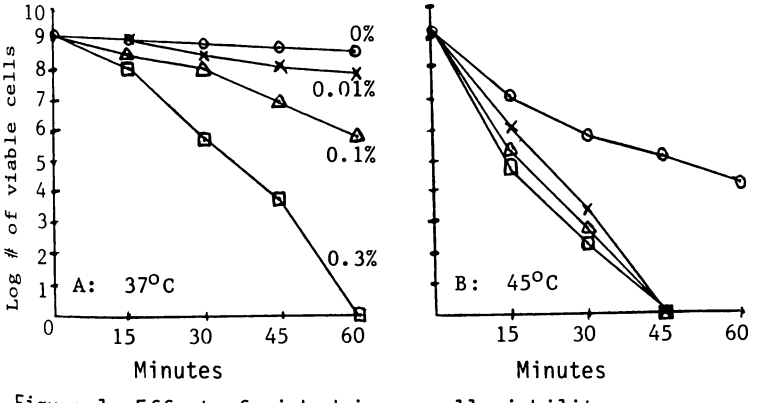

Figure 1. Effect of ninhydrin on cell viability.

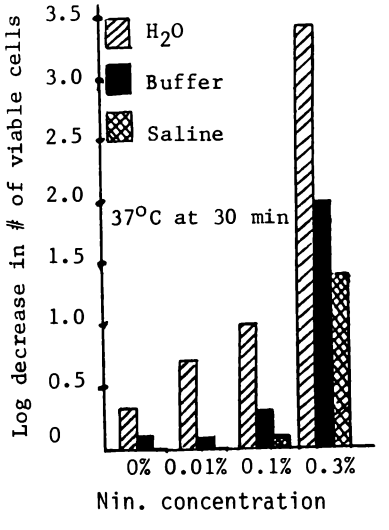

Figure 2. Protection by buffer and saline.

This study has shown that: 1) ninhydrin has potent bacteriocidal activity; 2) temperature greatly enhances the bacteriocidal effect; 3) phosphate buffer and saline (used to prepare cell suspensions and reaction mixtures) exhibit protective effects on viability; 4) since 1-1.5% ninhydrin usually is used to detect amino acids, treatment of bacteria with such concentrations will kill the bacteria and disposal of potentially pathogenic organisms will be simplified.

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(125) MULTIELEMENT ANALYSIS OF FOODSTUFFS USING INDUCTIVELY COUPLED ARGON PLASMA

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Determinations of major, minor and trace elements in foods are necessary for human nutritional assessments. Tables of food composition serve as references for preparing experimental and household diets, but accurate analytical analyses are needed to determine any variability due to storage, lot changes, sample preparation and manufacturer processing. An inductively coupled argon plasma spectrometer (ICAP) was evaluated for usefulness in the multielement analysis of foodstuffs. The inherent physical properties of a plasma system offer analytical performance characteristics that allow extended linear dynamic range, low detection limits, relative freedom from matrix and chemical interferences and true simultaneous determinations (1).

The purpose of this investigation was to establish the feasibility of using an ICAP for multiple trace element analysis of selected foodstuffs and diets. Recoveries from spiked samples, precision tests, and analyses of reference materials demonstrate the reliability and accuracy of the procedure. In this study, an ICAP was used to determine nine elements (Ca, Cu, Fe, K, Mg, Mn, Na, P, Zn) in diet composites, individual food items and National Bureau of Standards (NBS) Reference Materials. Samples were homogenized, aliquoted, weighed, digested with concentrated nitric and perchloric acids, and then brought to volume with 2% nitric acid (2). The quality control consisted of blanks, diet pools, NBS standard reference liver and spinach, and recovery spikes (93.0-104.9%). Analyzed values (µg/g) of 116 ± 7, 156 ± 5, 192 ± 11, 10020 ± 190, 598 ± 10, 10.0 ± 0.5, 2460 ± 90, 10950 ± 500, 119 ± 3.3 compare well with NBS bovine liver certified values of 120 ± 7, 158 ± 7, 194 ± 20, 9960 ± 70, 600 ± 15, 9.90 ± 0.80, 2430 ± 130, 11100 ± 400, 123 ± 8 for the nine elements, respectively. Table 1 represents values listed as milligrams per 100 gm fresh or as is weight.

Table 1. Mineral Concentrations (mg/100g ± SD) as Determined by ICAP of Selected Food Items from the Four Main Food Groups

Element	Fresh Chicken Breast		2% Milk		Whole Wheat Bread		Peaches Canned Water Packed	
	ICAP	Reference[3]	ICAP	Reference[3]	ICAP	Reference[4,5]	ICAP	Reference[3]
Ca	7.11±0.08	11.0	112±1.01	122	64.5±5.63	126	3.84±0.13	2.00
Cu	0.03±<0.01	0.04	0.01±<0.01	---	0.27±0.01	0.24	0.10±<0.01	0.05
Fe	0.41±<0.01	0.72	0.05±<0.01	0.05	4.84±0.03	3.50	0.47±0.08	0.32
K	157±7.64	255	139±1.53	154	278±11.0	138	89.6±6.11	99.0
Mg	21.1±0.57	28.0	10.6±0.12	14.0	78.2±1.20	46.0	4.94±0.08	5.00
Mn	0.01±<0.01	0.02	0.02±<0.01	---	1.79±0.03	---	0.03±<0.01	0.05
Na	42.8±0.95	65.0	50.7±0.30	50.0	890±28.4	539	4.08±0.09	3.00
P	120±6.51	196	84.7±0.38	95.0	193±3.61	184	7.29±0.78	10.0
Zn	0.36±0.04	0.80	0.37±0.01	0.39	2.00±0.06	1.05	0.06±<0.01	0.09

The results indicate that because of greater specificity, newer analytical methods, including plasma emission spectroscopy, may yield lower concentrations of elements in foodstuffs than the older spectrophotometric techniques. In addition, the improved sensitivity of newer methodology may detect elements previously reported not to be present in foods. Some food composition handbooks still in use date back to the 1960's. The values in these handbooks should not be considered static entities; they must be reconsidered as better data are reported. Tables may be referenced when preparing diets of specified mineral content or calculating RDA's, but our findings indicate that the concentrations should be verified by current analytical technology.

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(126) THE REMOVAL EFFICIENCY OF TOTAL ALUMINUM BY THE SETTLING AND FILTRATION UNITS vs. pH AND TEMPERATURE

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The purpose of this study was to investigate the performance of the settling and filtration units of a water treatment plant in removing total aluminum as a function of pH and temperature. The plant chosen was the Arthur Rollins Water Treatment facility located in Durham, New Hampshire.

Aluminum salts are widely used as coagulants in water treatment to remove turbidity and color. Recent studies indicated that there is a good probability that the aluminum concentration of finished water can be increased above the original raw water by the process of coagulation with alum. High levels of aluminum has been linked to several medical disorders such as Alzheimer's Disease, Dialysis Encephalopathy and Renal Failure in man.

The data was collected during the period of September 28, 1984 through March 31, 1985. During this period, the raw water had the following characteristics: temperature varied from 1 to 15°C, color varied from 30 to 140 cu, alkalinity varied from 8.5 to 28.5 mg/l as $CaCO_3$, turbidity varied from 1.7 to 12.5, and the raw water pH varied from 6.4 to 7.1. The pH range for the filter effluent and the finished water were 4.3 to 6.5 and 6.0 to 10.3, respectively. The pH values of the rapid mix chamber and settling tank outlet were measured during the sampling period only and they varied from 4.9 to 6.3 and 5.0 to 6.3, respectively. The finished water showed higher amounts of total aluminum compared to the raw water. The average concentration of total aluminum in the finished water was 322 ppb compared to 22 ppb for the raw water, an increase of 14.6 times.

Figure 1 shows the removal efficiency of total aluminum by settling and filtration units versus pH. One can observe an interesting relationship between pH and the percentage of removal. While this relationship is not strong for the settling tank, the filtration units show a strong pH dependence. This is due to the fact that pH affects the solubility of aluminum. As the amount of soluble aluminum increases, the performance of the settling and filtration units decreases, since soluble aluminum cannot be removed by sedimentation and filtration. Therefore, it is of utmost importance to control pH for the best removal for both units. Figure 2 shows the removal efficiency of total aluminum by the settling and filtration units versus temperature. It is apparent that the variation in temperature did not affect the removal efficiency of either unit. In the case of low removal efficiency at 4.5 and 9.5°C, the pH is the dominant factor as discussed earlier. The sedimentation unit showed an average total aluminum removal of 82 percent compared to 95 percent for the filtration units, not including the 4.5 and 9.5°C data. The results obtained from monitoring of the Arthur Rollins Water Treatment Plant indicate that the sedimentation and filtration units can remove up to 99 percent of the total aluminum added to the system under optimum pH.

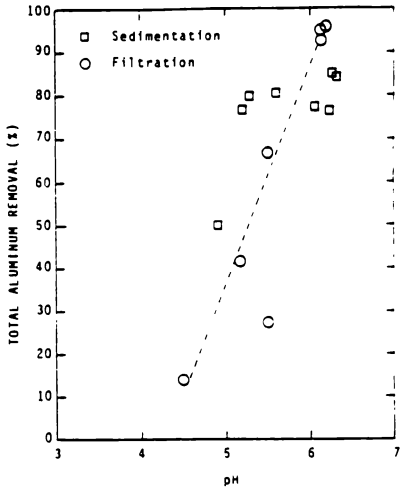

Figure 1
The Removal Efficiency of Total Aluminum by The Settling and Filtration Units vs. pH.

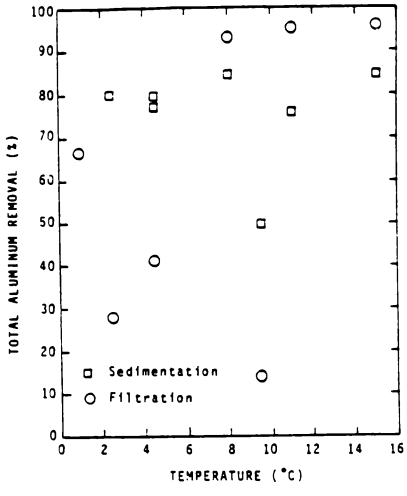

Figure 2
The Removal Efficiency of Total Aluminum by The Settling and Filtration Units vs. Temperature.

(127) REACTION OF VASKA'S COMPLEX WITH TRANS-STILBENE EPISULFOXIDE

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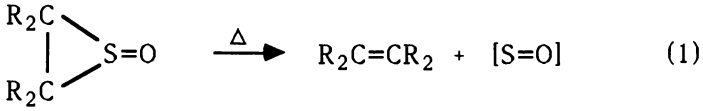
Sulfur monoxide (SO) is a very unstable species, with lifetimes of less than milliseconds in the free state (1). Both organic (2) and inorganic (3,4) reagents have been used to trap SO and make it available for study. We have attempted by a number of means to prepare new compounds containing SO bound in a transition metal complex. We report here the results of the title reaction, which occurred while attempting to trap transient SO generated in solution.

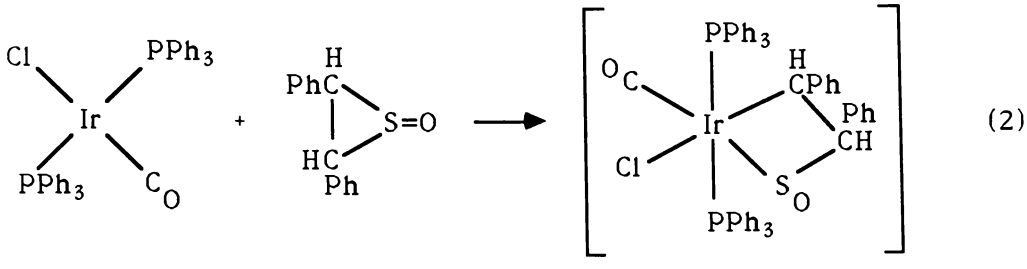
Sulfur monoxide is extruded into solution by the thermal decomposition of organic episulfoxides:



(1)

Vaska's complex, $IrCl(CO)(PPh_3)_2$, is suitable for trapping SO generated in this fashion, because it is able to oxidatively add unsaturated bonds in small molecules such as ethylene (5) and dioxygen (6). In order to trap the transient SO and not the alkene formed in reaction 1, trans-stilbene episulfoxide (R_2 = Ph,H) was chosen as the sulfur monoxide source. With a decomposition rate constant (7) of 1.1×10^{-5} s^{-1} at 26°C, the half-life of this episulfoxide should be over 25 hr at room temperature, and substantially higher temperatures should be required to observe appreciable reaction.

In contrast to these predictions, we see a rapid reaction between two equivalents of stilbene episulfoxide and Vaska's complex at room temperature, and at -30°C the same reaction has a half-life of about two hours. A metastable intermediate is formed within 15 minutes in the low temperature reaction. Based on P-31 NMR spectra, and analogous reactions of epoxides (8,9), the intermediate is most likely formed in a metal-activated ring-opening reaction in which a sulfur-carbon bond is oxidatively added to iridium:



(2)

A second reaction with episulfoxide converts this intermediate to the ultimate product $IrCl(CO)(PPh_3)_2(S_2O_2)$. This orange-yellow complex exhibits new bands in the infrared spectrum at 2054 [ν(CO)], 1070 and 1024 [ν(SO)] cm^{-1}. The proton-decoupled phosphorus-31 NMR spectrum shows a singlet at -10.3 ppm. These spectral parameters are consistent with the formulation of this compound as an Ir(III) complex of the $S_2O_2^{2-}$ ligand, with trans-phosphine ligands on iridium.

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EFFECTS OF HYPERTONIC ANTICOAGULANTS ON THE ANALYTICAL DETERMINATIONS OF CONSTITUENTS IN PLASMA

(128)

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Variations in the plasma constituent "normal values" reported among laboratories may be caused in part by the use of different anticoagulants.

In 1968, Foley reported a 16% higher zinc value in serum than in plasma from blood anticoagulated with 0.010 ml of 30% Na citrate per ml (1). The higher value for serum was attributed to zinc contamination arising from the platelets and erythrocytes during the clot formation. An increased fluid volume was found with citrated plasma, but was not recognized as being caused by a dilution resulting from use of a hypertonic anticoagulant. The acceptability of heparin, widely used in clinical chemistry techniques, for mineral analyses continues to be questioned because of reported zinc contamination in early products. Disodium EDTA, the anticoagulant of choice in hematological studies because of its cell preservative qualities, has been viewed as unacceptable because of its chelation properties. The higher mineral concentrations found in EDTA anticoagulated plasma are believed to be the result of sequestering elements from cellular membranes.

Recently we compared the osmolarities of the various anticoagulants and their effects on plasma or serum zinc analyses. We tested serum in two ways. One was prepared as a normal serum; to the other we added 0.10 ml of 9% NaCl to reproduce the osmotic tension induced by the citrate and oxalate anticoagulants.

Table 1. Osmolarities of the Different Anticoagulants and Their Effects on the Apparent Zinc Concentration in Plasma

	Serum	Heparin	EDTA	Citrate	Oxalate	9% NaCl
Osmolarity* (mOsmol/kg)	--	285 ± 5	295 ± 3	2960 ± 60	2800 ± 30	2830 ± 30
Plasma zinc** (µg/dl)	85 ± 3	85 ± 3	83 ± 5	74 ± 2	75 ± 5	75 ± 4

*Mean ± SD of 6 samples.
**Mean ± SD of 18 samples.

The data show that zinc concentrations were reduced 6-18% whenever hypertonic solutions were added to plasma or serum. The addition of even small amounts of hypertonic solutions (e.g., 30% citrate or 20% oxalate) can cause significant shifts of water from the cellular to the plasma compartment. Normal plasma has an osmolarity of 275-305 mOsmols/kg. Adding just 0.010 ml of a solution approximately ten times normal osmolarity to a ml of whole blood, which is approximately 55% plasma and 45% cell bound water, should cause a theoretical efflux of 0.100 ml of water from the cells. This efflux would increase plasma volume by 18%, thus reducing the concentration of every analyte measured. Furthermore, this phenomenon may impact the analysis of all biochemical and elemental constituents of plasma. Moreover, this dilution effect is not limited to a simple constant reduction of analyte concentrations. More dramatic reductions of analyte concentrations will occur in samples with high hematocrits. Thus, if hematocrits change during the course of a study, there may be a resultant artifactual trend in plasma constituent concentrations. An additional source of variability when using hypertonic anticoagulants is the variable or uncontrolled volume used. Overaddition of isotonic solutions would cause no problems, but with hypertonic oxalate and citrate this overaddition can have severe repercussions. Our present findings are consistent with the findings of Heller and Paul (2), and Magath and Hern (3). However, their work is often overlooked by proponents of citrate and oxalate anticoagulants.

Our findings indicate that analyses of serum, or plasma, prepared with EDTA or heparin, yield more accurate and consistent results than samples prepared with hypertonic anticoagulants such as 30% citrate or 20% oxalate.

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(130) SIMPLIFIED ANALYSIS OF MICROSTRIP CIRCUITS ON ANISCTROPIC LAYERS

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In the last few years the analysis of strip transmission lines with uniaxial anisotropic layers has been considered (1-5). In part this is due to the fact that many of the dielectrics commonly used in microwave integrated circuits (MIC) present dielectric anisotropy. Moreover, it has been shown that the use of anisotropic substrates can improve the performance of MIC circuits such as directional couplers and filters (3,5).

The analysis of strip transmission lines with anisotropic layers is usually performed by mapping (1,2) or by numerical methods such as variational and integral equation approaches (1,3). In the numerical methods, the study is developed directly for the structure with anisotropic layers. In the mapping method an equivalent structure (having the same capacitance per unit length) with isotropic layers is used. As a result, the use of the mapping method makes the analysis of planar transmission lines (and circuits) on anisotropic layers easier. It should be mentioned that the simplicity of the analysis through the mapping method depends on the simplicity of the method used to characterize the equivalent structure with isotropic layers. For example, a quasi-static analysis for both striplines and microstrip lines on anisotropic layers can be very simple (1,2). Furthermore, the results of the mapping method are in close agreement with the results of numerical methods (1).

Nevertheless, the mapping method is not the only alternative for easy design of microstrip lines on anisotropic layers. The equivalent isotropic permittivity method (4) also provides good results and uses a transformation to get an equivalent structure with isotropic layers. In this case, the equivalent microstrip line is obtained assuming that the anisotropic layer is removed and replaced by one isotropic layer with the dielectric constant being a function of the microstrip dimensions in order to obtain the same characteristic impedance (4).

In this work, as an example, the effect of the finite conducting strip thickness on the characteristics of microstrip lines on anisotropic substrates is developed in a simple way, using both the mapping and the equivalent isotropic permittivity methods. Results were obtained for microstrip lines on sapphire (3). Curves for characteristic impedance and effective permittivity versus the microstrip geometry were developed. A good agreement was observed with the results of a rigorous variational method (3).

The methods mentioned in this work can be used to take into account arbitrary dielectric anisotropy (3,5). Furthermore, the mapping method has been used to analyze inverted and suspended microstrip layers. The analysis of coupled microstrip lines also has been performed.

The study of planar transmission lines constructed using dielectric anisotropy through the methods described is a useful tool in research that has the objective of obtaining results for transmission line structures with anisotropic layers for (a) comparison with theoretical results based on numerical methods, and (b) proposal of new results (quasi-static) for planar structures not previously considered.

This work was partially supported by the Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPq), Brazil and by the Faculty Development Institute of North Dakota State University through a Bush Foundation grant.

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(131) MICROSTRIP ANTENNAS ON MULTILAYER ANISOTROPIC SUBSTRATES

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A growing interest has been observed in the analysis of microstrip patch resonators on dielectric anisotropic layers.[1] This is due in part to some of the intrinsic properties of these materials, such as low loss and high reproducibility from batch to batch, and in part because many of the materials used as substrates for patch resonators exhibit dielectric anisotropy.

A fullwave analysis for determining the resonant frequency of rectangular microstrip patches on multiple uniaxial anisotropic layers with or without an isotropic or anisotropic overlay is presented. Two different spectral domain techniques were used independently to derive the immittance matrix for the structure being considered. Numerical results are presented which show the effect of dielectric anisotropy on the resonant frequency of the rectangular patch for various substrate configurations.

The structure being considered is shown in Fig. 1. Two different methods were used to derive the immittance matrix for this structure. The first method uses Hertz vector potentials oriented along the optical axis, which is assumed to be in the y-direction for each anisotropic layer. Expressions for the electric and magnetic fields in the Fourier transform domain are derived in terms of the Hertz potentials. Boundary conditions on the electric and magnetic fields are then used to obtain the coefficients of the fields, from which the immittance matrix is determined. The second method uses a transverse transmission line technique, modified to include anisotropic substrates. Equivalence between the two methods is observed. Galerkin's method is then used with the immittance matrix to obtain the resonant frequency of the microstrip patch.

Results for the single layer case ($H_2 = H_3 = 0$) are shown in Fig. 2. Note that the anisotropy ratio is given as $n_x/n_y = \sqrt{\varepsilon_{xx}/\varepsilon_{yy}}$ where ε_{xx} and ε_{yy} are the tensor components of the permittivity along the x and y axes, respectively. Note also that $n_x/n_y = 1$ corresponds to the isotropic case. The results in Fig. 2 for the isotropic case agree with those given by Itoh and Menzel [2]. The resonant frequency of several other patch configurations has also been investigated, including a suspended microstrip resonator and a resonator with an overlay. The results clearly show the effect of the anisotropy on the resonant frequency.

Two independent methods have been used to determine the immittance matrix for a rectangular microstrip resonator with several anisotropic layers. The effect of the anisotropy on the resonant frequency is shown for several configurations, including a suspended patch, as well as a patch with isotropic and anisotropic overlay.

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(+) On leave from the Federal University of Rio Grande Do Norte, Natal, Brazil.

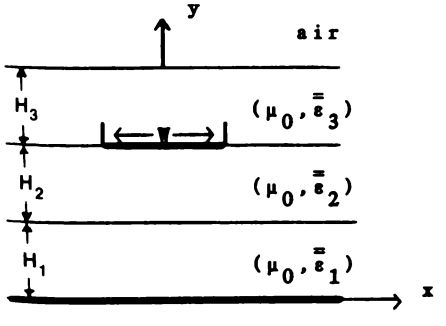

Fig. 1 Rectangular resonator on two iso/anisotropic layers with an iso/anisotropic overlay.

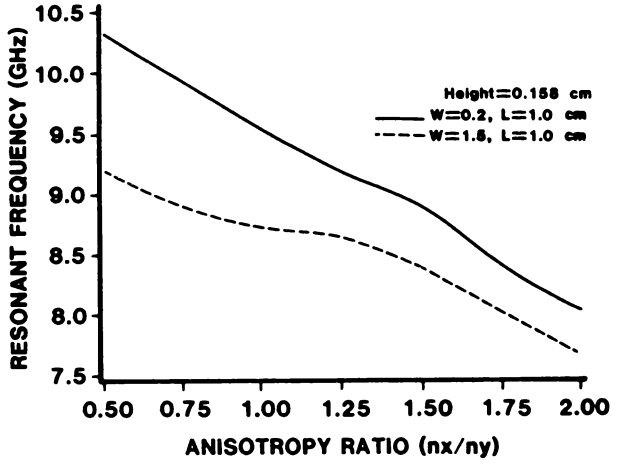

Fig. 2 Resonant frequency vs. anisotropy ratio.

(132) THE VECTOR PROCESSOR; LOW-COST PARALLEL COMPUTING

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The Vector Processor is an adjunct to a personal computer in which a sequence of data is passed from the host's memory to a row of math coprocessors (MCs), operated on simultaneously by each of a sequence of coprocessor instructions, and then the results are passed back to main memory. It is a single-instruction, multiple-data auxiliary computer. Its purpose is to speed up all those operations which can be expressed in vector-matrix forms by parallel execution of the data operations.

The general arrangement of the major elements of the Vector Processor (VP) are shown in figure 1 [1]. Figure 2 [2] shows the functional blocks, and signals managed, in the Vector Control Unit (VCU) in an implementation for the IBM PC. This design depends on both hardware and software elements. The VCU monitors the queue status lines of the GPP (8088 CPU) to detect a clear-queue condition. This means that the next byte to appear on the bus is an instruction. The decoder then decodes the next two bytes to see if it is one of the three vector instructions. These are VECTOR-SQ to start sequential mode for loading the MCs, VECTOR-OP to go into parallel mode, and SCALAR to return to scalar mode and also act as a reset between the other two modes. In each mode, the VCU selects the MC by its READY and Queue Status lines.

A prototype using two MCs was built [2] to demonstrate the operation. It has recently been rebuilt, with three MCs, in better form. Software will be written and time trials run in the Spring of 1987.

The motivation for this architecture, given in the first paragraph, assumes that the MC takes significantly longer to execute than transfer data with memory. A measure of the improvement to be expected may be defined as the ratio of the total time to process data with a single MC to the time with N MCs in a VP. For a given function, let E=execution time for one result element, T=total data transfer time for that result element, and N=the number of elements and MCs. Then the improvement is $R=N(E+T)/(E+NT)=N(1+(E/T))/(N+E/T)$. The range of R is 1 to 1+E/T. If $E/T \gg 1$, $R \approx (NE/T)/(N+E/T)$. If $E/T \gg N$ then $R \approx N$, or if $N \gg E/T$ $R \approx E/T$. The highest improvement/cost occurs when $E/T \gg N \gg 1$. Table 1 shows estimates of R for some typical scientific functions. These are for an 8088 CPU, 8087 MCs, 64-bit floating-point numbers, and times from [3]. These choices of processor and number type yield the lowest values of E/T for the Intel-PC family. Testing will give better and more results for various functions and the effect of vectors with more elements than MCs in the VP. The estimates suggest that the greatest improvements will be for software which does the most processing between data transfers. Assembly language at one end and APL at the other end of the range of language level seem good candidates.

Table 1. Improvement factor, R

Function	E/T	N=3	N=5
Z=SQRT (X*X*+Y*Y*)	2	1.8	1.9
Z=COS (X)	5.9	2.3	3.3
Z=(COS(2*pi*X))/X	7.3	2.4	3.4

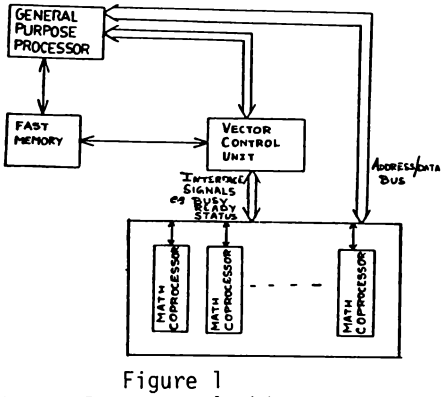

Figure 1
Vector Processor Architecture

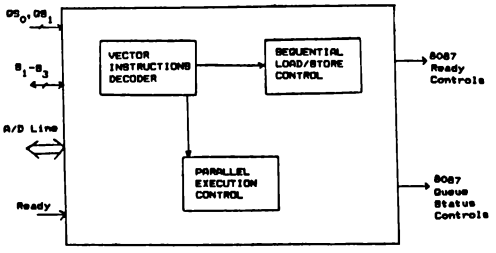

Figure 2. Vector Controller

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(133) COMPUTER-AIDED CONTROL SYSTEMS LABORATORY

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Laboratory experience is an important part in teaching undergraduate control systems engineering. However, conventional laboratories using discrete components are often inordinately tedious and inaccurate, making in-depth treatment of essential topics almost prohibitive. To overcome this difficulty, we have recently developed a personal computer-based system for automated data collection and analysis as a means to enhance student learning in the laboratory. The use of a computer as an experimental tool allowed the inclusion of more sophisticated experimental procedures as well as more detailed data analysis without an increase in the student's time requirement. The computer serves the following functions: (1) automation of certain experimental data collection procedures; (2) relaxation of the computational burden of data simulation, processing, and display; (3) on-site supervision and evaluation of the experiment.

The organization of the computer-aided laboratory is as shown in Fig. 1. The system being controlled is a DC motor configured as a positional control system with positional and velocity feedbacks. This exemplary system is used in most introductory courses in control systems engineering. The central command unit of the laboratory is an IBM personal computer (PC) with dual floppy disk drives, a graphics monitor and a graphics printer. Programmed to run in the interactive mode, the PC is used to perform such tasks as student orientation, on-line data collection, data processing, simulation and design. All computer programs are manu-driven with input specifications and design parameters being set by the user. Data outputs are in tabular and graphics forms.

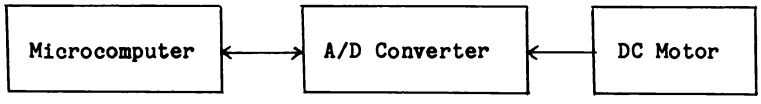

Fig. 1 System oraganization

Data collection is accomplished by means of a high-speed analog-to digital converter (A/D) board (Dash 8) with 8 analog time-multiplexed input ports. The data collection hardware can be used for a variety of measurements by using different wiring connections and software. The data input routines are written in assembler but can be called as a subroutine from Basic. All other parts of the data collection software are written in Basic. The experimental protocols involve measurement of the step and frequency responses of the DC motor in both open-loop and closed-loop modes. Stored data are processed by subroutines that compute the analytical parameters in both time and frequency domains (time constants, oscillatory frequency, magnitude and phase angle responses, etc.) as specified by the user.

In addition, the student is required to compare the experimental results with theoretical predictions using a linear systems analysis and design program (Parametrics). Thus, complex analytical methods such as transient and frequency response simulations, Nyquist and root locus plots of the system transfer function, which are otherwise difficult to obtain within the duration of the laboratory session, can be generated on-line with relative ease.

In conclusion, the computer-aided system extends the scope of the control systems laboratory. In comparison to other microcomputer-based systems for similar application (1), the present one based on the PC can be easily reprogrammed for more advanced experimentation, and is adaptable to a variety of application programs that are compatible with industrial standards. The current prototype, which has been operational for two years, is welcomed by both students and instructors. We propose that computer-aided engineering is a useful tool in engineering and scientific education.

This project was supported in part by the Bush Foundation through a grant to the Faculty Development Institute of North Dakota State University.

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(31) INTERACTIONS BETWEEN NICKEL AND VITAMIN B-12 IN THE METHYL-DEPLETED RAT: EFFECT ON GROWTH AND BLOOD INDICES

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The physiological role of nickel in higher animals still is unclear. However, recent findings have demonstrated that nickel functions as a cofactor or structural component in specific metalloenzymes in microorganisms (1). Many of these enzymes are associated with the metabolism of the methyl moiety. Furthermore, in some microorganisms nickel apparently is incorporated into a low molecular weight compound containing a tetrapyrrol structure. Because vitamin B-12 contains a similar structure and is associated with methyl metabolism in animals, we decided to study the effect of dietary nickel, vitamin B-12 and their interaction on the methyl-depleted rat.

Male weanling Sprague-Dawley rats were assigned to groups of six in a fully-crossed, two way 2x2 design. Choline was omitted from the basal dried skim milk-ground corn diet (2) which was supplemented with 10 g of guanidoacetic acid and 25 g of arginine/kg; these dietary modifications were done to induce methyl depletion. The dietary variables were supplements of nickel at 0 and 1 µg/g and vitamin B-12 at 0 and 5 ng/g. Environmental conditions have been described (2). The rats were fed their respective diets for seven weeks, fasted overnight, weighed and anesthetized before cardiac exsanguination and decapitation. Several organs were removed and weighed. Microhematocrits and hemoglobins were determined. Plasma urea and cholesterol were determined using standard commercially available kits. Selected findings are summarized below.

Effects in Methyl-Depleted Rats of Nickel, Vitamin B-12 and Their Interaction on Selected Indices

Treatment		Body	Liver,	Kidney,	Spleen,	Plasma Urea,
Ni	Vit. B-12	Weight, g	g/100 g body wt.	g/100 g body wt.	g/100 g body wt.	mg/100 ml
µg/g	ng/g					
0	0	264	5.11	0.288	0.223	1.08
1	0	264	5.16	0.293	0.218	1.09
0	5	238	4.55	0.332	0.205	0.99
1	5	279	4.26	0.278	0.202	1.08
			Analysis of Variance - P Values			
Nickel effect		0.005	NS	0.04	NS	0.02
Vit. B-12 effect		NS	0.003	NS	0.01	0.02
Ni x Vit. B-12		0.005	NS	0.02	NS	0.07
Error Mean Square		240	0.27	0.0007	0.0002	0.002

Regardless of dietary nickel, vitamin B-12 deprivation elevated the spleen wt/body wt and liver wt/body wt ratios. However, dietary nickel affected the growth, kidney wt/body wt ratio, and plasma urea response to vitamin B-12 deprivation in the methyl-depleted rat. Omitting vitamin B-12 from the diet enhanced growth and decreased the kidney wt/body wt ratio in the nickel-deprived rat, but depressed growth and increased the kidney wt/body wt ratio in the nickel-supplemented rat. Plasma urea was higher in vitamin B-12 deprived than vitamin B-12-supplemented nickel-deprived rats. Plasma urea was unaffected by dietary vitamin B-12 in the nickel-supplemented rat. The findings indicate that nickel may have a physiological role related to vitamin B-12 metabolism.

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(32) IS THE ORGANOPHOSPHATE INSECTICIDE MALATHION MUTAGENIC?

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The organophosphorus insecticide malathion is in extensive use in regional agriculture. Its ability to inhibit cholinesterase activity strongly, specifically in insects, makes it an effective insecticide. The compound also biodegrades rapidly, and therefore must be applied frequently. Primary concern for genotoxicity is the fact that malathion is a known alkylating agent of nucleic acid bases and thus it could cause gene substitution mutations and chromosome damage.

The informations available on genotoxicity indicates that malathion did not induce mutations in bacteria (2). The cytotoxic tests in the higher organisms have been few that show a tendency for increased chromosome damage with increasing concentrations. Recent study in this laboratory indicates that a significant increase in chromosome damage occurs in human lymphocyte culture at a concentration of 40 µg/ml or higher. Sister chromatid exchange (SCE) test is recognized as a modern and reliable technique for determination of mutagenicity (4). Malathion dissolved in alcohol had a significant increase, at 40 µg/ml following a single exposure and at 5 µg/ml or higher concentrations following double exposures (3) in fibroblast culture. However, lymphoid cell lines had no increase in SCE rates at 40 µg/ml following activation by the rat-liver microsomal S9 fraction (5).

The objective of this study was to test the mutagenicity of malathion in cultured human lymphocytes by conducting, (a) SCE test at 5, 20, and 50 µg/ml concentrations of the compound dissolved in DMSO along with a DMSO-control (b) mitotic indicies determination for the control and the three treatments and (c) an exploration if the compound is a mitotic poison. Chemical grade malathion (over 98% pure) was procured from the U.S. Environmental Protection Agency for the study.

Fasting blood of the donor was used for lymphocyte culture by the whole blood culture technique. The donor's chromosome was analyzed by GTG banding (G bands by trypsin using Giemsa) to ensure that no structural abnormality was present. Using the Latt's (1) technique rates of sister chromatid exchanges were analyzed in the control and the three treatments. Highly significant increases were observed at the 20 µg/ml and higher concentration. The level of mitotic indicies based on the analysis of 1000 cells for each of the control and treatments, indicated a decrease with increasing concentrations. Lymphocytes were cultured without the use of colcimid and slides were prepared without dropping the fixed cell-suspension on to wet slides to determine if the compound interferes with the mitotic microtubular formation. Based on the analysis of 200 cells for each of the treatments and controls only three polyploid cells were seen at the highest level. Though it can be argued that malathion induced the polyploidy, the data is too preliminary to arrive at a firm conclusion. The SCE results and the mitotoic indicies do indicate that the compound is cytotoxic and mutagenic at relatively low dosages. There seems to be enough evidence from this study and those of others to warrant that conclusion. Since malathion biodegrades rapidly these results should be a warning to those that come in direct and frequent contact with the compound. It is also hoped that such studies would stimulate development of safer methods of insect control.

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(33) RADIANT FLASH PYROLYSIS OF PEAT

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In the past decade there has been a substantial effort made to find alternate sources of energy to replace a decreasing fossil fuel supply. Biomass and solid fossil materials such as peat have a limited value if they are burned only to produce steam. Conversion of these materials to combustible gases by gasification with subsequent formation of methane and synfuels gives the material a greater value. It would be even more desirable to convert peat and other biomass material directly to premium liquid fuels. A potential sequence of conversion of peat to liquid fuel is shown below:

Peat → Fast Pyrolyzer → Catalytic Vapor Cracker → Condenser → Liquid Fuel

Recent studies indicate that biomass can be converted to liquid fuel and upgraded by catalytic hydrogenation (1).

The purpose of our research was to determine if peat subjected to radiant flash pyrolysis instead of thermal pyrolysis could be converted to materials with potential for conversion to liquid fuel via the Mobile ZSM-5 Zeolite catalyst. Originally, Lincoln in 1965 found that oil yields from cellulose could be increased by rapid flash pyrolysis with a flash lamp (2). Recently, radiant flash pyrolysis has been used to convert biomass to a number of different gases. Radiant flash pyrolysis of coal has shown to produce such gases as hydrogen, acetylene and carbon disulfide (3). Our own recent research concentrated on the conversion of biosludge to fuels (4).

Three types of peat, which differed in their state of decomposition, were obtained from the state of Minnesota. Approximately 0.1 g of dried peat was put into glass tubes, which were about 15 cm long and 1 cm in diameter. The samples were held in the tubes by glass wool and Nichrome wire. Nitrogen gas was used as a carrier gas throughout the experiment. Each sample was "flashed" three times, and the gases that appeared flowed through a glass apparatus and into a Tenax trap. The traps were prepared and cleaned by allowing helium to flow through the packing for 24 hours at 240°C. A 73% conversion of the peat was observed by comparison of weights before and after the radiant flash pyrolysis. The traps were desorbed at 200°C for ten minutes onto a 60 m J and W 0.025 i.d. DB-5 column and the compounds analyzed by mass spectrometry. The residues on the Tenax traps obtained from hemic and sapric peats showed a large number of small alkenes, benzene, toluene, styrene, and alkenes containing up to 26 carbon atoms. Fibric peat showed some similarity to sapric and hemic but contained more carboxylic acids. Table 1 indicates some of the similarities and differences.

Table 1

Compounds Present in the Radiant Flash Pyrolysis Of Various Peats

	Benzene	Toluene	Styrene	Carboxylic Acids	High M.W. Alkenes	Furfural
Fibric		X	X	X		X
Hemic	X	X	X		X	
Sapric	X	X	X		X	

These results are important in that the major constituents of fuels are benzene, toluene, and unsaturated compounds which, upon hydrogenation or reaction with specialized Zeolite catalyst, could produce high-grade fuels.

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*Advisor: Dr. James J. Worman

(34) EFFECT OF ELEVATED TEMPERATURE ON LUTEINIZING HORMONE AND OVARIAN STEROID SECRETION IN GILTS

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The adverse effect of elevated ambient temperatures on reproductive performance of large animals has been reported extensively. What is lacking is the endocrinological data correlated to these responses to explain the detrimental effects on reproduction. Our purpose was to expose cycling females to elevated ambient temperature to determine its effect on pituitary and ovarian activity during and after heat exposure. Five cycling female pigs were cannulated via the cephalic vein and maintained at 17-22 C for approximately 20 days to obtain control samples. Thereafter they were maintained at 32.2±1.0 C for 20 days, then returned to 17-22 C for an additional 3-week period. Plasma samples were drawn 4 times daily throughout most of the cycle. Sampling frequency was increased to every two hours from 2 days prior to estrus until one day after estrus in all collection periods. Heparinized samples were centrifuged at 3000 rpm (4C) for 10 minutes and the plasma stored at -20C until analyzed for LH, progesterone and estradiol by RIA procedures. Rectal temperatures and respiration rates were recorded daily. Elevated ambient temperature did not produce any measurable effect on body temperature and rate of respiration. All animals did decrease physical activity during elevated temperature exposure. Elevated ambient temperature suppressed estrous behavior with only 2 of 5 gilts expressing estrus. Mean peak LH concentration were 8.2±1.3 vs. 6.2±1.1 ng/ml ($P<.05$) for the control and treatment (32C) cycle. The post-treatment LH peak was 3.9±1.1 ng/ml with 2 gilts not expressing any LH activity. Preovulatory estradiol secretion was suppressed ($P<.05$) during the elevated temperature period. The interval between preovulatory estradiol and LH peaks was longer ($P<.01$) in gilts exposed to 32C than in gilts not maintained at elevated temperatures. The mean interval from the estradiol peak to the LH peak was 8.0±3.3 h for control temperature gilts and 14.0±1.9 h for the elevated temperature situations. Progesterone secretion patterns were not dramatically affected by elevated temperature but the lack of estrus and ovulation in two post-treatment gilts resulted in baseline progesterone values. No significant change was found in duration of progesterone secretion. Our results would indicate that elevated ambient temperatures had an adverse effect on both pituitary and ovarian activity with a suspension of external estrous signs in some females.

(35) DIBENZOFURANYL POLYSILOXANE STATIONARY PHASES FOR CAPILLARY GAS CHROMATOGRAPHY

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Two important characteristics of stationary phases in gas chromatography are polarity and thermal stability. Phases that are stable at high temperatures can be used to separate compounds with high boiling points and high affinity for the phase. A polar phase has greater selectivity for polar compounds, which increases the number of compounds that can be properly resolved. Unfortunately, polarity of the phase is usually inversely proportional to the thermal stability of the phase.

Most commercially available phases are siloxane polymers. The polarity of the phases are determined by the percentage of polar groups substituted on the polysiloxane backbone. Recently polarizable stationary phases, apolar phases that can acquire dipole moments when exposed to polar compounds, have been produced using compounds such as biphenyl and diphenyl ether (1), the phenyl ether being the more polar and more thermally stable.

Dibenzofuran was incorporated into a siloxane polymer. The monomer, dimethoxymethyl (2-dibenzofuranyl) silane, was synthesized using procedures by Gillman (2) and Lee (3). Dibenzofuran was brominated at the 2 position, lithiated with butyllithium, and added to the appropriate chlorosilane. This was stirred in trimethyl orthoformate and vacuum distilled. Three stationary phases were produced containing 5%, 25%, and 50% dibenzofuran, the other groups being methyls, using Lee's procedure for the synthesis of the biphenyl phase (3). The mixtures of methoxy silanes, containing 1% vinyl for crosslinking, were hydrolyzed in water, polymerized with tetramethylammonium hydroxide, and then endcapped in methylene chloride. The dibenzofuran content of the polymers were determined by ^{1}H NMR, and thermal stability was determined by thermal gravimetric analysis.

The polymers were statically coated (4) on deactivated 25 m x .32 mm fused silica capillary tubing (5) and conditioned at 250°C. The columns were tested with Grob's test mixture and standard solutions of methyl esters, carboxylic acids, and chlorinated biphenyls.

The columns coated with 25% and 50% phases exhibited poor resolution and retention, which is characteristic of hard phases. Resolution of the phases remained poor at higher temperatures, but retention time increased for the 25% phase. This could suggests a softening of the phase at high temperatures, and the separation of high boiling compounds may be possible.

The column coated with the 5% phase showed retention times comparable to SE54, a commercially available 5% phenyl substituted polysiloxane. The resolution for polar compounds, such as underivitazed carboxylic acids and methyl esters, however, was superior to that of SE54. The phase showed particularly good separation of aromatic compounds. The 5% phase column resolved 2,4- and 2,5-dimethylphenol at approximately 15 minutes, whereas SE54 usually doesn't resolve them. The 5% phase also showed good resolution of polychlorinated biphenyl mixtures, which could make it useful in the area of environmental testing.

Thermal gravimetric analysis of the dibenzofuran polymers showed the phases to be stable up to 500°C, which is approximately the same as SE54. Comparable polar phases are less thermally stable; therefore a dibenzofuran polymer may resolve a greater range of compounds than phases presently used.

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(36) COPPER ABSORPTION AND STATUS IN RATS FED VARYING LEVELS OF DIETARY COPPER

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Copper is an essential nutrient for humans and animals. Little is known about the effects of dietary composition on the absorption of copper. This experiment was done to determine how copper absorption and the rate of Cu excretion in rats vary in relation to each other and the copper content of the diet, and to determine if whether some biochemical indices would be predictive of copper absorption and excretion.

One hundred eight male weanling Long-Evans rats weighing approximately 50 g were fed a diet based on casein, sucrose, and cornstarch, and containing recommended amounts of all nutrients except copper. The copper contents of the diets were 0.4, 1.7, 2.6, 3.8, 10.6, or 16.5 mg/kg diet. Rats were divided by weight into six groups and fed one of the diets for four weeks. After an overnight fast, six rats from each dietary group were fed a test meal containing 3 g of their respective diets labeled with 3 µCi Cu-67. Six other rats from each group were injected intramuscularly with 3 µCi Cu-67 in a saline-glycine solution. Rats were counted immediately in a small animal whole-body gamma counter, and at intervals for 14 days, while they continued to eat the 6 diets. Apparent absorption (AA) for the rats fed test meals was calculated as the y-intercept of the linear portion of a plot of ln (% retention) vs. time. A similarly calculated intercept for the data from injected rats was designated R. True absorption (TA) was defined as AA/R. The turnover rate was defined as the slope of the linear portion of the retention curves (ln % retention/d) (1). Indices of copper status were measured in the thirty-six remaining rats after six weeks of consuming the experimental diets. Factors measured were plasma Cu, plasma ceruloplasmin, RBC-superoxide dismutase (SOD) and liver superoxide dismutase activity, and liver cytochrome c oxidase activity.

Results are shown in Figure 1 and Table 1. In general, as dietary Cu increased, Cu absorption decreased and the rate of turnover increased (slope of retention curve became more negative). The total amount of Cu absorbed from the meals increased linearly up to a dietary level of 10.6 ppm Cu ($r = 0.998$, $p < 0.001$), and then leveled off. A notable exception to these trends was the drop in the per cent Cu absorption from 60% at 1.7 ppm dietary Cu to 36% at 0.4 ppm dietary Cu. Rats fed the 0.4 ppm diet were obviously sick and might have been unable to absorb Cu well. No correlations were found between any of the biochemical indices (Table 1) and percent Cu absorption. There was more than a two-fold difference between the highest and lowest value for per cent Cu absorption while the rate of excretion varied only about 20% over this range of Cu intake. This demonstrates that Cu absorption plays a significant role in Cu homeostatis. The homeostatic response of Cu absorption to dietary supply fails if Cu supply is too deficient.

Table 1

Biochemical Indices of Cu Status in Rats Fed Varying Levels of Copper

Dietary Cu (mg/kg)	0.4	1.7	2.6	3.8	10.6	16.5
Ceruloplasmin (U/l)	3	13	71	88	111	92
Plasma Cu (ug/dl)	5	32	81	85	98	84
RBC-SOD (U/g Hb)	548	1069	1301	998	876	935
Liver SOD (U/g wet wt)	137	509	744	645	720	705
Liver Cyt-C oxidase (umol/min/g wet wt)	7	16	19	22	20	21

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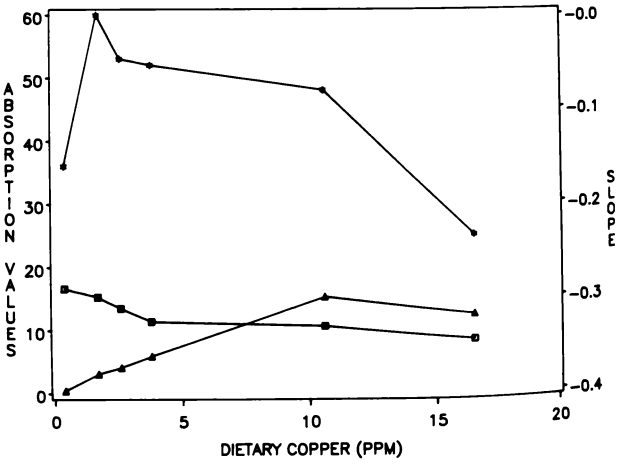

Figure 1. *Per cent Cu absorption as a function of dietary Cu. □ Slope of retention curve. More negative slope indicates faster Cu turnover. ▲ Total Cu absorbed from test meal, µg.

(37) TRANSITION STATE STRUCTURES FOR THREE INSERTION REACTIONS

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The closed shell singlet states of CH_2 and SiH_2 are thought to react predominantly by inserting into available bonds. Experimental[1] and theoretical[2] evidence indicate that methylene inserts into H-H and C-H bonds with little or no energy barrier. The most recent experimental[3] and theoretical[4] results establish the barrier for silylene insertion into H-H as near zero. Likewise the barrier to methylene insertion into the C-H bond of methane and the Si-H bond of silane is near zero according to recent studies. A 20 Kcal/mol barrier has been reported[5,6] for the silylene insertion into the methane C-H bond however.

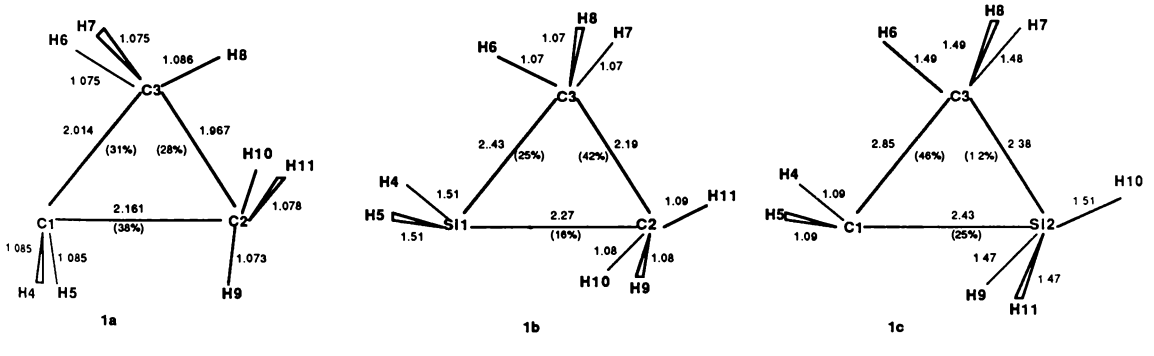
The rates of insertions of methylene and silylene into single bonds between heavy atoms X, Y (C or Si) are apparently much slower than those for X-H insertions. This could be due to statistics (six X-H bonds to one X-Y bond) or the barrier could be much larger for these reactions.

We are presently studying what happens when methylene and silylene are inserted into the X-Y bonds of ethane, silaethane, and disilane as well as their insertions into X-H (or Y-H) bonds using ab-initio quantum mechanics. We are presenting the transition state geometries for three of the reactions in this article.

Optimized geometries for RHF stationary points were obtained using the 3-21g basis set and the Schlegel[7] optimization method in Gaussian82[8]. Transition states were verified by establishing that the matrices of the energy second derivatives have one negative eigenvalue.

Sketches of the 3-21g transition state structures are drawn in figure 1. All transition state optimizations were carried out in C1 symmetry; (no symmetry elements) but the saddle point structures are essentially Cs symmetry. (one plane of symmetry) For each structure the atom labelled 1 is the heavy atom of the incoming methylene or silylene. In all three reactions the hydrogens of the incoming group are oriented in such a way as to avoid steric interactions with other atoms. The lines connecting the atoms labelled 2 and 3 represent the bond that is being broken and the lines connecting the atoms labelled 2 and 3 represent the bond that is being broken and the lines connecting 1 and 2 and 1 and 3 represent bonds that are forming. The bond lengths are typed next to the lines and the quantities in parantheses are the amounts these bonds are stretched relative to the normal values for that type of bond. In comparing 1a. to 1b., note the silylene causes the C2-C3 bond to stretch by 42% relative to 28% for methylene. Whereas the methylene only causes a 1% elongation of the Si2-Si3 bond. Sterically this makes sense as Si is larger than C. Also for methylene insertions the saddle point usually comes earlier in the entrance channel than for silylene. In looking at the bonds that are forming, the bonds to methylene begin to form earlier than those for silylene in figures 1a. and 1b. respectively. Also in each structure one of the forming bonds is always stretched to a lesser extent. In each case this appears to be a steric effect. Consider 1b.; H4 and H5 are bent away from H10 and H9 and this allows Si1 to approach C2 more closely than it can C3.

FIGURE 1



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(62) RETINAL MICROVESSEL ENDOTHELIAL CELL GROWTH IN VITRO IS PROMOTED BY RETINAL PIGMENT EPITHELIAL CELL CONDITIONED MEDIUM

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Retinal extracts are known to contain factors that facilitate neovascularization in vivo, and growth of microvessel endothelial cells in vitro (1). Although the cellular source of these factors has not been identified (2), one possible location could be the retinal pigment epithelium which is located subjacent to the sensory retina. The current in vitro study tests this hypothesis by demonstrating the effects of retinal pigment epithelial cell conditioned medium (RPECM) on the growth of retinal microvessel endothelial cells (RMEC).

Bovine eyes were obtained from a local abattoir, and the retinas were removed aseptically within 48 hours of slaughter. Following a rinse with 30 mM HEPES buffered minimum essential medium (MEM), retinas were homogenized using a glass homogenizer with a teflon plunger. Homogenates were successively sieved over 210 μm and 88 μm screens, and collected vessel fragments were incubated for 6 hours at 37°C in 0.1% collagenase/dispase with constant rotation. Vessel digests, which consisted of individual cells and cell clusters, were centrifuged, rinsed, and suspended in 1 ml of HEPES buffered MEM. These suspensions were loaded on Percoll/HEPES MEM gradients (1:1, vol./vol.), and centrifuged 15 minutes at 670 x g. The RMEC, which layered between the pericytes and erythrocytes, were removed, rinsed, and plated on 35 mm plastic culture dishes in Dulbecco's modified Eagle's medium, 20% fetal bovine serum, 26 mM bicarbonate, 50 μg/ml ascorbic acid, and 50 μg/ml gentamicin. RPECM, obtained from semi-confluent bovine retinal pigment epithelial cell cultures, was added to half the cultures (2:1, vol./vol.).

Primary RMEC cultures supplemented with RPECM grew to confluence in polygonal monolayers, showed contact inhibition, and stained strongly positive for Factor VIII-related antigen by immunofluorescence. Following serial passage through four generations, however, the typical RMEC morphology was gradually replaced by stellate cells with overlapping cell processes. These cells stained negatively for Factor VIII-related antigen. Unsupplemented RMEC did not become confluent in primary culture and could not be passaged. These cultures senesced and stained poorly for Factor VIII-related antigen.

These data suggest that secretory products of cultured retinal pigment epithelial cells may promote growth of RMEC in vitro, and may assist in sustaining their typical morphological features. Moreover, the close physical association of retinal pigment epithelial cells and RMEC in vivo may allow these substances to promote or sustain retinal neovascularization in various disease states including diabetic retinopathy.

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(63) THE EFFECT OF FIBER INTAKE BY GRAVID SWINE DURING THREE CONSECUTIVE PARITIES ON DAM AND PROGENY PERFORMANCE

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A frequent problem associated with sow productivity is a delay in the interval from weaning to rebreeding. As a result production schedules are disrupted, thus more feed and labor are required to maintain sows that are slow to return to estrus postweaning. Research suggests that restricted energy intake during lactation interferes with normal postweaning estrus for sows. Therefore, an increase of feed intake during lactation should increase energy intake and reduce the interval from weaning to rebreeding. An experiment was initiated to determine the effects of fiber intake during gestation on lactation feed intake and subsequent reproductive performance of the sows. In addition the influence of fiber source (alfalfa hay, sunflower hulls) on sow reproductive performance was studied.

Seventy-one gilts were bred and assigned to one of three gestation diets, 1 day postcoitum. Gestation diets were: corn-soybean meal (CS), fed at a level of 1.9 kg/d; 50% ground alfalfa hay diet (AFH), 2.22 kg/d; and CS + 22% ground sunflower hulls (SFH), 2.45 kg/d. The CS, AFH, and SFH diets were formulated and fed to provide 67, 421, and 427 g/d acid detergent fiber (ADF), respectively. All gilts were fed a CS diet ad libitum during lactation and 1.9 kg/d from weaning to rebreeding. After the sows were rebred, the previously assigned gestation diet was fed and the same protocol was followed for three parities. Sows not returning to estrus by day 35 postweaning were slaughtered and their reproductive tracts were examined for any physiologic abnormalities. Also, pigs were transferred among litters to equalize lactation stress on the sows.

Response criterion included in table 1 are: gilts bred (NB); gilts farrowed in parity 1 (NF1); postweaning anestrus, parity 1 (AN1); sows farrowed, parity 2 (NF2); postweaning anestrus, parity 2 (AN2); sows farrowed, parity 3 (NF3); postweaning anestrus, parity 3 (AN3); average gestation weight change (GWC; kg, 0-110 d); lactation weight change (LWC; kg, 28 d); daily lactation feed intake, (LFI; kg); pigs born alive (PBA); average birth weight, (BWT; kg); average pig weight gain, (PWT; kg, 28 d); and pig survivability at weaning (PS; %).

TABLE 1. SUMMARY OF DAM AND PROGENY PERFORMANCE AVERAGED OVER THREE PARITIES.

TRT	NB	NF1	AN1	NF2	AN2	NF3	AN3	GWC[a]	LWC[a]	LFI[b]	PBA[b]	BWT[b,c]	PWT[a]	PS
CS	24	18	1	16	1	14	0	45	-2.2	5.3	9.1	1.7	4.6	89.3
AFH	23	20	1	17	1	15	0	38	5.1	5.7	10.3	1.5	4.3	88.5
SFH	24	20	6	12	0	12	0	53	-4.7	5.4	10.0	1.6	4.8	91.9

[a]AFH vs SFH (P<.05); [b]CS vs AFH+SFH (P<.05); [c]AFH vs SFH (P<.10).

More sows conceived, farrowed and completed three parities when fed alfalfa hay during gestation than sows fed the corn or sunflower hull diets. Sows fed the AFH diet consumed more feed during lactation, had more pigs born alive and maintained more weight during lactation than sows fed CS or SFH diets. However, progeny birth weights and weaning weights were lower for sows fed AFH diets compared to those offered CS or SFH diets. The results suggest that higher fiber intake during gestation increases the intake of a corn-soybean meal diet during lactation.

(64) CLASTOGENIC INFLUENCE OF THE INSECTICIDE MALATHION IN CULTURED HUMAN LYMPHOCYTES.

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The insecticide malathion has been in extensive use agriculturally and commercially since 1970s. It is an organophosphorous compound with a strong cholinesterase inhibiting influence in insects, enabling it to be a potent insecticide. The compound is hydrolysed in mammals to malathion acid which is a weak cholinesterase inhibitor. Malathion also biodegrades rapidly. It has been therefore considered relatively safe to humans.

The concern for genotoxicity stems from the fact that malathion and malathion acid readily alkylate guanine, adenine and cytosine. Thus the compound has the potential for gene substitution mutations and chromosome damage (2). Mutagenicity testing in microorganisms have been generally negative. In the higher organisms genotoxic effects based on sister chromatid exchanges (SCE) have generally been positive, that includes the results from this laboratory. The clastogenic influence in mammals have been few and inconclusive (3). Chromosome damage based on human lymphocyte culture has not been reported.

This investigation involved the use of 5, 20, 40, and 50 µg/ml treatments with 0-control and DMSO (solvent)-control, in three replications each for 4-hour (direct) and 24-hour (indirect) effects. Chemical grade malathion (over 98% pure) was provided by the U.S. Environmental Protection Agency (EPA). All the tests were performed in cultured human lymphocytes. The protocol is in close agreement with the U.S. EPA's genetox recommendations (4).

The most common aberrations observed were interstitial gaps and breaks. Fifty cells for each treatments and controls in each replication (total of 150) were analyzed for the 4-hour and 24-hour study, separately. The data were subjected to ANOVA, and one tailed Dunnett's multiple comparison test. The total aberration (gaps plus breaks) in both the 4-hour and 24-hour study had a pattern of generally progressing from a low in the controls to greater values at higher concentrations. The similarities of statistically significant increases for the 4-hour and 24-hour exposures, generally at the two highest concentrations, suggest that the observed genotoxicity was due primarily to the direct effect of the compound itself. The general decline of dividing cells with increasing concentrations as measured by the mitotic index also is evidence of the cellular toxicity of the compound as it approaches the physiologically toxic level of 50 µg/ml level. This finding is similar to that reported by Chen et al. (1).

The present investigation indicates that malathion causes chromosome damage in cultured human lymphocytes at relatively low dosages at a statistically significant level. Since it is established that the compound causes significant elevation in the rates of SCE also, the finding should be of particular interest to those who are repeatedly and directly exposed to the compound. We would also encourage efforts to develop ways of insect control that are safer.

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(65) CROSSLINKED POLY(4-VINYLPYRIDINE) FILM ELECTRODES FOR PLATINUM MICROPARTICLE ELECTRODEPOSITION WITH ELECTROCATALYTIC APPLICATIONS

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A continuing objective of this laboratory is the utilization of polymer modified electrodes for electrocatalytic purposes. In particular, we are interested in the deposition of catalytically active metal microparticles in polymer films. These three-dimensional arrays of metal microparticles in polymer matrices should be designed to maintain high catalytic activities with concomitant long-term stability. We have recently used linear and crosslinked poly(4-vinylpyridine) (PVP) as a matrix for the deposition of platinum (1). Crosslinking of the linear PVP was accomplished by a free radical process which utilized benzoyl peroxide and a triallyl substituted benzene as the crosslinking agent.

Glassy carbon electrodes were anodically pretreated to improve the bonding between the carbon surface and the polymer film. Previous reports have indicated that oxygen functionalities can be introduced on glassy carbon surfaces by oxidative pretreatment techniques (2). Such functionalities include hydroxyl, carbonyl, and carboxylate type groups.

Recently, a simple method for preparing reproducibly stable, crosslinked films of PVP with a minimal amount of synthetic effort has been developed (3). Films of crosslinked PVP were prepared in our laboratory on the anodic pretreated glassy carbon by micropipetting precise volumes of a mixture of linear PVP and the crosslinking agent (dibromohexane). After allowing the solvent to evaporate, the electrodes were then maintained at 108°C for extended periods of time (16-24 hrs) to promote the desired "solid phase" crosslinking reaction.

The crosslinked polymer electrodes were placed in contact with acidic hexachloroplatinate solutions several hours in order to swell the polymer film and to permit penetration by the chloroplatinate anionic species. Platinum was subsequently electrodeposited using potential-step techniques including double-potential-step chronoamperometry (DPCA) and single-potential-step chronoamperometry (SPCA) (Table I).

Catalytic activities of the Pt/crosslinked PVP/glassy carbon electrodes were examined by measuring the current for hydrogen evolution in acidic solutions. Exchange current densities based upon carbon geometric areas were found to be dependent on Pt loading levels with typical values of 0.5 mA/cm^2 obtained from Tafel plots in the lower overpotential region (Table I). These data were obtained at overpotentials of less than 50 mV and resulted in slopes of 30 mV from the Tafel plots.

It is interesting to note the significantly higher exchange currents obtained by DPCA *vs.* SPCA. This can be attributed to the hydrogen evolution on the deposited Pt occurring concomitantly with the SPCA experiment making it impossible to ascertain what proportion of the total current is utilized solely for Pt deposition.

The increase in exchange current with contact time (see entries 7 and 8) is apparently due to the depth at which the Pt is deposited into the polymer matrix. SEM photomicrographs reveal that those polymer coated electrodes which are exposed to acidic conditions for a nominal length of time undergo a degree of swelling which will allow a greater deposition depth of the Pt microparticles into the polymer matrix. Relatively short contact times do not allow the polymer to swell, hence there is essentially an agglomeration of Pt microparticles on the surface upon deposition. Since the relative surface area of the microparticles has decreased, there is a marked decrease in activity. All of these crosslinked PVP-coated electrodes have shown excellent activity and remarkable stability under acidic conditions (i.e., 0.5 M H_2SO_4).

Table I. Crosslinked Poly(4-vinylpyridine) Films/Platinum Electrodeposition/Catalytic Hydrogen Generation Activity Data.

Electrode	Pt Loading Level (ug/cm^2)	Film Contact Time (5 mM K_2PtCl_6/H_2SO_4)	Hydrogen Generation Exchange Current (mA/cm^2)
GC-20-G	DPCA, 5	3 hrs	0.5
GC-20-K	DPCA, 7	3 hrs	0.8
GC-30-XXI	DPCA, 10	3 hrs	1.0
GC-30-XV	DPCA, 15	3 hrs	1.3
GC-20-A	SPCA, 8	3 hrs	0.5
GC-20-5	SPCA, 15	3 hrs	0.6
GC-20-XL	SPCA, 13	15 min	0.5
GC-30-V	SPCA, 13	13 hrs	1.3

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(66) A MICROSCOPIC MOLLUSCAN FAUNA FROM THE STONY MOUNTAIN FORMATION (UPPER ORDOVICIAN) IN THE SUBSURFACE OF NORTH DAKOTA

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The Gunn Member of the Stony Mountain Formation crops out in the vicinity of Winnipeg, Manitoba. It exists in the subsurface in southwestern Manitoba, southeastern Saskatchewan, most of North Dakota, northwestern South Dakota, and eastern Montana. These rocks have been dated as Richmondian (Late Ordovician). Southeast of the occurrence of this unit, an irregularly linear feature, known as the Transcontinental Arch, extended from the western tip of Lake Superior to southwestern Colorado and was apparently emergent during the Richmondian Age.

An assemblage of several hundred microscopic mollusks (most smaller than 1 mm) has been collected from core from four wells in eastern and central North Dakota. This assemblage is composed largely of gastropods, but includes pelecypods, possible scaphopods, and hyolithids. All of these fossils consist of molds of the interior that are composed of a calcium phosphate mineral; no shell material, either original or replaced, remains.

Without the shells, it is not possible to make species assignments, and generic assignments are, in most cases, only tentative. The planispiral gastropods (about 300 specimens) have been assigned to Cyrtolites, Bucania, and Sinuites; the low-spired forms (about 50) to Liospira; the medium-spired forms (about 125) to Cyclonema (=Cyclora), Trochonema, and Lophospira; and the high-spired gastropods (18 specimens) to Hormotoma. The pelecypods (4 specimens) have been assigned to Palaeoconcha and "Palaeoneilo." The sparse "scaphopod" and hyolithid material has been tentatively assigned to, respectively, Plagioglypta and Hyolithes.

Diminutive molluscan faunas are fairly well known from the Upper Ordovician. They have been reported from northern Arkansas to northeastern Iowa and from northern Michigan to southwestern Ohio, and even from the subsurface between some of these areas (1,2,3). These faunas have been reported from throughout the Upper Ordovician, and also from the Lower Silurian (3). All these reports, however, have been from the southeastern side of the Transcontinental Arch. This is the first report of a microscopic molluscan fauna from the northwestern side of the Arch.

Four possible causes have been advanced for the existence and preservation of these microscopic animals. They are, first, stunting, which results when physical or chemical conditions produce a reduced adult size; second, paedomorphosis, which is the attainment of sexual maturity at an early age; third, transportation, which tends to sort sedimentary grains by size and thus concentrate the microfossils in a lag deposit; and fourth, juvenility, referring to mortality at an early age (4).

The diminutive Stony Mountain mollusks are found in the same strata as articulate brachiopods and bryozoans that are of normal size for their species. This would seem to rule out stunting and paedomorphosis as a result of local conditions, as only a portion of the total fauna was affected. The widespread occurrence of these faunas also argues against local environmental factors being responsible. The presence of the much larger brachiopods and bryozoans, as well as finer-grained material, seems to rule out transportation as a possible cause. This leaves juvenility as the probable cause for the Stony Mountain microfauna.

Most gastropods produce hundreds to tens of thousands of eggs per spawning per individual. However, larval and juvenile mortality rates usually exceed 99% (5). I am here suggesting that what has been preserved in the Stony Mountain Formation is the result of normal juvenile mortality, without invoking special conditions. What is uncommon, though by no means rare, is that they have been preserved. This preservation is due to precipitation of calcium phosphate within the microenvironment of the juvenile shell. This is shared in common with other occurrences of diminutive mollusks in the Upper Ordovician record, and it suggests a similarity of depositional conditions on both sides of the Transcontinental Arch.

The significance of this study, then, is first, that the microscopic molluscan fauna occurs on both sides of the Transcontinental Arch during the Richmondian; second, that depositional conditions were similar enough on both sides of the Arch to permit the precipitation of calcium phosphate in selected microenvironments; and third, that available evidence indicates that the Stony Mountain assmeblage was the result of normal juvenile mortality, rather than unusual conditions.

I would like to thank A. J. Martin (Dept. of Geology, Univ. of Georgia) for generously sharing an unpublished manuscript that provided helpful background material. I thank my Department, the Graduate School, the North Dakota Geological Survey, and Dr. F. D. Holland, Jr., for providing financial and other support.

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(67) THE SYNTHESIS AND THE MECHANISM OF FORMATION OF NEW N-3-SUBSTITUTED HYDANTOINS

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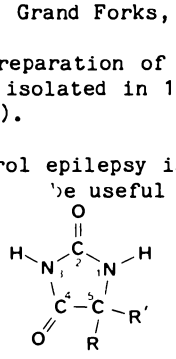
Hydantoins, precursors for the preparation of amino acids and known to have biological activity as anticonvulsant agents, were first isolated in 1861 by Baeyer, and the structure was determined by Strecker a few years later in 1870 (1).

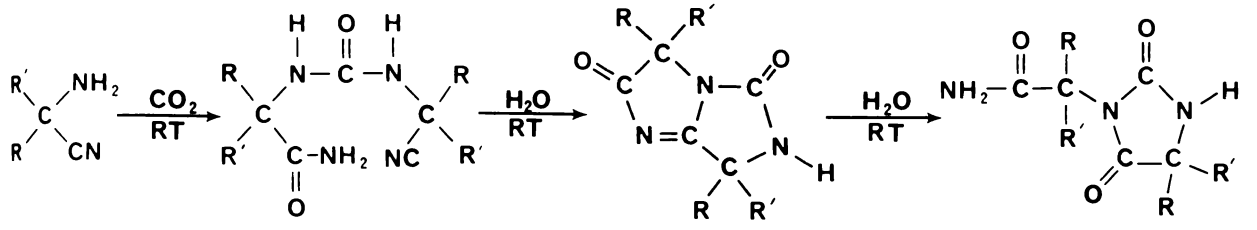
The compound widely used to control epilepsy is 5,5-diphenylhydantoin (Phenitoin, Dilantin) (I), and other derivatives have been shown to be useful as antiarrythmic and antidiabetic agents (2).

R = R^1 = phenyl (Dilantin)



(I)

The most general synthesis of hydantoins is via the Bucherer-Bergs reaction involving the addition of potassium cyanide and ammonium carbonate to a compound containing carbonyl functionality. During the investigation relating to the mechanism of formation for 5,5-disubstituted hydantoins, a novel synthetic method for the preparation of N-3-substituted hydantoins was discovered and reported (3). A potential mechanistic pathway is shown in Scheme 1.



(II) (III) (IV) (V)

R=R^1=Methyl R=Methyl;R^1=Ethyl R=R^1=Ethyl R=Methyl;R^1=Propyl

Scheme 1

The α-aminonitriles were prepared via a modified procedure described by Szabo (4). Carbon dioxide was introduced into a neat solution of several different α-aminonitriles (II) at room temperature. An immediate precipitation occurred when R=R^1=Methyl and R=Methyl,R^1=Ethyl. Other alkyl substituents required a longer period of carbon dioxide addition and subsequent refrigeration for 24 hours to promote precipitation.

The white solids formed were identified and found to be disubstituted ureas, (III). When the disubstituted ureas were stirred in water at room temperature for a period of 24 hours, N-3-substituted hydantoins (V) crystallized upon slow evaporation of the water. It was possible to isolate bicyclic imidazole intermediates (IV) by extraction of the aqueous solution with methylene chloride or by slow evaporation of the water solution after only 10 hours of stirring at room temperature.

Structures of the α-aminonitriles, disubstituted ureas, bicyclic imidazole intermediates, and N-3-substituted hydantoins were confirmed using FT-IR, ^{13}C and ^{1}H NMR, mass spectroscopy, GC/FTIR/MS, elemental analysis, and alternate synthesis. Of specific importance was the structure of the bicyclic intermediate which gives a similar UV absorption and mass spectrum to that of an imino bicyclic system isolated by an alternate synthesis (5).

This synthetic pathway offers a new facile route for the preparation of a series of new N-3-substituted hydantoins, the hydrolysis of which will lead to unusually substituted amino acids.

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(68) REPRODUCTIVE RESPONSE TO HCG SUPPLEMENTATION DURING EARLY PREGNANCY IN SWINE

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Sow productivity or litter size is a major concern in swine production. The mean ovulation rate in sows is 17.0 with 95-100% of the eggs fertilized. Day 25 of gestation 30-40% will have suffered embryonic mortality. Progesterone secretion is essential throughout pregnancy in the pig to maintain myometrial quiescence and endometrial receptivity. A reduction in the rate of progesterone production by the corpora lutea may cause pregnancy failure. Pregnant sows exhibit a 40-50% decrease in plasma progesterone concentrations between Days 14-25 of gestation which has been attributed to metabolism by the pregnant uterus (feto-placental unit and uterine endometrium) of progesterone and estrogen, not a decrease in corpus luteum function (3).

Previous experiments have shown that a single injection of HCG (human chorionic gonadotropin) on Day 12 of the estrous cycle increased plasma concentrations of progesterone (1, 2). The purpose of this study is to evaluate the significance of HCG in reinforcing the corpora lutea at Day 12 and altering embryonic mortality rates during early pregnancy in the pig.

Forty-one mated sows were randomly divided into three HCG treatment groups on Day 12 of gestation: 1) saline, 2) 500 I.U. HCG, and 3) 1000 I.U. HCG. At 9 days postbreeding the sows were cannulated via the cephalic vein to facilitate blood collections. Blood samples were drawn every 12 hours (0800 and 2000) from Day 10 to Day 25 of gestation. HCG was administered subcutaneously in 5 ml saline on Day 12. Sows were slaughtered on Day 25 and the number of normal, abnormal, and dead embryos were determined. Corpora lutea were counted to determine ovulation rate. Conception rates were determined by dividing total number of embryos by number of corpora lutea. Plasma samples were analyzed for progesterone using radioimmunoassay procedures. All data was statistically analyzed by general linear models and Student Newman-Keuls procedures.

The reproductive parameters assessed at slaughter are presented in Table 1.

Table 1. Reproductive Traits of Sows Treated with HCG on Day 12 of Pregnancy

Treatment group	N	Ovulation rate	Total number of embryos	Number of live embryos	Number of embryos resorbed	% Embryo mortality
1 (saline)	16	17.9 ± 1.0	15.9 ± 1.0	12.8 ± 1.0	3.3 ± .6	20.8
2 (500 IU HCG)	10	17.7 ± 1.3	14.3 ± 1.5	12.0 ± 1.2	2.3 ± .7	15.9
3 (1000 IU HCG)	15	19.0 ± 1.3	15.5 ± .8	13.9 ± .8	1.6 ± .4	10.4

Embryonic mortality was decreased by 50% for Group 3 (1000 IU HCG) versus Group 1 (saline). This difference amounted to 1.5 more embryos at Day 25 of gestation in Group 3. Mortality decreased 33% for Group 2 and resulted in 1 more embryo per sow than Group 1. Ovulation rate was similar for Groups 1 and 2. Group 3 had a slightly higher ovulation rate with one sow having thirty-four corpora lutea. Total embryo numbers were similar throughout treatments. Number of live embryos was approximately one embryo more in Group 3.

Plasma progesterone (P_4) from Groups 2 and 3 exhibited a transitory increase after HCG injection on Day 12. Group 3 consistently maintained slightly higher P_4 concentrations than Group 1 and 2 throughout the trial period. Plasma P_4 increased 12% from Day 12 to a peak at 22.17 ng/ml on Day 15. Group 3 P_4 levels were 30% higher than Group 1 (saline) at Day 22 of gestation. Group 2 maintained slightly higher P_4 levels than Group 1 (saline). Group 1 (saline) had higher progesterone levels on Day 10, which dropped 17% by Day 12 then peaked at 20.14 ng/ml P_4 on Day 14. Concentrations declined steadily from Day 14 to Day 23.

The results indicate a dose related response in embryo resorption. Injection of 1000 IU HCG at Day 12 resulted in 1.5 more live embryo per sow. This can have significant economic impact for swine producers. HCG at this time of the cycle may stimulate the formation of accessory corpora lutea capable of elevating plasma progesterone concentrations. The transitory increase in plasma progesterone after HCG on Day 12 may provide more substrate for the pregnant uterus, thus aiding embryo survivability.

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(69) REPRODUCTIVE RESPONSE OF MATURE EWES TO DIFFERING NUTRITIONAL REGIMES

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Nutritional expenses account for approximately sixty percent of the production budget in a ewe flock (1). It has also been shown that nutrition has a significant effect on reproduction of the ewe (2, 3). This effect can be seen as a change in number of lambs born per ewe and/or a change in body weight of the ewe. The purpose of this experiment was to determine if substituting inexpensive, lower quality roughages for more expensive dietary components during the maintenance and early gestation periods has a detrimental effect on ewe reproduction.

Seventy-five ewes were randomly assigned to one of five nutritional treatments; I-100% alfalfa (A), II-80% A/20% straw (S), III-60% A/40% S, IV-40% A/60% S, V-(negative control) -60% A/40% S. Twenty-five of the ewes were housed in individual pens to allow measurement of nutritional and endocrinological parameters. Ewes were maintained on treatment diets from weaning until two weeks prior to breeding. All received a flushing diet from then through the breeding phase except Treatment V. These ewes were kept on 60% A/40% S throughout the entire treatment period. After breeding all ewes were returned to their respective treatment until forty days post-breeding. Blood samples were collected at five time intervals to assess luteinizing hormone (LH) secretion patterns and twenty-five times for measuring progesterone concentrations. The progesterone data was used to determine time of conception and occurrence of pregnancy.

There was no significant difference between treatments in the number of lambs produced per ewe exposed although Treatment V had approximately 0.5 less lambs per ewe. The 100% alfalfa diet had the greatest number of lambs per ewe. Live weight change of the ewes was not altered (P>.05), indicating that the changes seen could be attributed to the normal variation encountered by individual animals throughout a relatively long treatment period. It should be noted that the direction of live-weight change (gain or loss) was the same over all treatments in the last two weigh periods. Concentrations of plasma LH were similar and number of episodes were not different across treatments.

The results would indicate no detrimental live-weight response to the amount of straw in the rations. Substitution of up to sixty percent low quality roughage in the diet did not significantly reduce the number of lambs produced although a trend toward fewer lambs did occur as straw level was increased. Feeding of low quality roughages during the maintenance did not alter pituitary activity during the breeding season.

Table 1. Number of lambs born per ewe exposed

Treatment	N	Lambs/ewe exposed
1	13	1.71
2	10	1.46
3	15	1.67
4	12	1.57
5	12	1.27

mean = 1.53 lambs born/ewe exposed

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REECE L. BRYANT
(Died December 20, 1985)

Reece Bryant received his baccalaureate degree from the University of Kentucky, and both the M.S. and Ph.D. degrees from Cornell University with a major in poultry genetics. He served as Chairman of the Poultry Science Department at North Dakota State University from 1946 to 1970. Dr. Bryant was a member of the Academy of Science from 1948 until his death.

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EDGAR A. HAUNZ
(December 12, 1910 - June 27, 1986)

Edgar Haunz was born in London, England. After coming to the United States he attended Canisius College and the University of Buffalo, receiving the M.D. in 1943. In 1947 he received the M.S. from the University of Minnesota.

Dr. Haunz practiced internal medicine and was a specialist in diabetes at the Grand Forks Clinic commencing in 1947. He was chief of staff at the former Deaconess Hospital in Grand Forks and professor and chairman of the UND Department of Medicine. He was recognized in 1975 as the nation's outstanding clinician in the field of diabetes, was published widely, and was sought after as a guest lecturer and visiting professor. Haunz was awarded the honorary degree, Doctor of Science, from UND in 1978.

In 1953 Dr. Haunz founded Camp Sioux, a summer camp for diabetic children at Turle River State Park. In 1957 a similar camp near Nemo, South Dakota was named in his honor.

Haunz served as Chairman of the Board of Governors of the American Diabetes Association. In 1984 he received the North Dakota Governor's Award for service to the handicapped and received the Sertoma Club Service to Mankind Award. Haunz also was an accomplished cellist, having played with the Buffalo Symphony Orchestra, the Grand Forks Symphony Orchestra, and over the Mutual and CBS radio networks. Haunz was a member of the North Dakota Academy from 1951 until his death.

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CHRISTEN JENSEN
(December 13, 1899 - March 3, 1986)

Christen Jensen was born in Denmark and moved to the United States with his parents in 1911. The family moved from Iowa to Kenmare, North Dakota where Jensen attended public school. He received his bachelor's degree from Iowa State University in 1926 and later returned to receive the M.S. in 1939 and the Ph.D. in 1940, both in bacteriology.

Jensen joined the NDSU staff in 1926 as a dairy products instructor in the Dairy Husbandry Department. In 1946 he was promoted to full professor of dairy technology and was chairman of the Animal Science Department from 1946 to 1970. Jensen was a specialist on the dairy industry, and published articles on butter quality, butter manufacturing, and pasteurization. Jensen was a member of the North Dakota Academy of Science from 1927 through 1967.

NICHOLAS N. KOHANOWSKI
(February 27, 1905 - September 18, 1986)

Nicholas Kohanowski was born on a refugee train near Russia's Ural Mountains during the Russo-Japanese War. He grew up in his family home in Vladivostok, Russia. He fought on the side of the czar during the Russian Revolution and after defeat returned home and enrolled at the University of Vladivostok. Eventually he fled first to China, then to Japan, from which he entered the United States in 1923. He studied at the Colorado School of Mines from which he received the degree Geological Engineer in 1932.

Following completion of his education the Kohanowski family moved to Bolivia, South America where he worked for Aramayo Mining Company. In 1949 he joined the faculty of the University of North Dakota where he taught geological engineering until his retirement in 1975. During a leave from 1961-63 the Kohanowski's lived in Tripoli, Libya where he helped organize the geology department at the University of Libya. Kohanowski was active in local organizations including the North Dakota Society of Professional Engineers, Sigma Xi, and the American Institute of Mining Engineers. He was a member of the North Dakota Academy of Science from 1949 until his death.

F. L. MINNEAR
(August 4, 1895 - August 17, 1985)

F. L. Minnear was born in Parkersburg, West Virginia. After receiving his Ph.D. degree in Chemistry he worked in the chemical industry for 30 years. He joined North Dakota State University's chemistry faculty in 1953 as an associate professor of chemistry. He retired in 1966 and moved to Olympia, Washington. Minnear was a member of the Academy from 1954 through 1968.

GREGORY B. MULKERN
(March 27, 1931 - September 23, 1984)

Gregory Mulkern was born in Tulsa, Oklahoma but grew up in Chicago. He earned the B.S. degree from the University of Illinois in 1953, and master's and Ph.D. degrees from Kansas State University, the latter in 1957.

Mulkern joined the faculty of the NDSU entomology department in 1957. He was responsible for course offerings in morphology and physiology, and also taught courses in scientific writing and information retrieval. He was an internationally recognized expert in grasshoppers and their host relationships. He participated in international forums in Argentina, England, the Netherlands, and Hungary.

Mulkern served on the council of the Pan American Acridological Society for several years. He was a member of the North Dakota Academy from 1958 through 1961.

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DRYER, PAMELA	ND PARKS AND RECREATION	BISMARCK	ND 58501
DUERRE, JOHN A.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
DUXBURY, ALEXIS	GAME AND FISH DEPARTMENT	BISMARCK	ND 58501
DUYSEN, MURRAY	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
EDERSTROM, HELGE E.	903 NORTH 26TH STREET	GRAND FORKS	ND 58201
EDGERLY, CHARLES G.M.	1317 EIGHTH AVENUE SOUTH	FARGO	ND 58103
EGINTON, CHARLES T.	VETERANS ADMINISTRATION CENTER	FARGO	ND 58102
EIDE, JOHN D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
ERBES, PAULA M.	1042 1/2 16TH STREET NORTH	FARGO	ND 58102
ERICKSON, DUANE	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
ERICKSON, J. MARK	ST. LAWRENCE UNIVERSITY	CANTON	NY 13617
ESSLINGER, MONICA	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
EVANS, HAROLD W.	2624 OLSON DRIVE	GRAND FORKS	ND 58201
FARNUM, BRUCE	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
FARNUM, SYLVIA	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
FAUSKE, GERALD M.	1308 NORTH 10TH STREET #5	FARGO	ND 58102
FEIL, VERNON J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
FERDINAND, STAR M.	705 25TH STREET NORTHWEST	MINOT	ND 58701
FILLIPI, GORDON M.	1005 SOUTH 20TH STREET	GRAND FORKS	ND 58201
FISH, HAROLD F.	BOX 338	WATFORD CITY	ND 58854
FISK, ALLEN L.	1122 AVENUE B WEST	BISMARCK	ND 58501
FIVIZZANI, ALBERT J.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
FLEETWOOD, CHARLES W.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
FLETCHER, ALAN G.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
FOSSUM, GUILFORD O.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
FOWKES, WALTER W.	422 WEST FARMER	INDEPENDENCE	MO 64050
FRANCKOWIAK, JEROME	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
FRANK, RICHARD E.	1020 BOYD DRIVE	GRAND FORKS	ND 58201
FREEMAN, MYRON L.	DICKINSON STATE COLLEGE	DICKINSON	ND 58601
FULTON, GARY W.	1910 TOWER GROVE 2-S	ST. LOUIS	MO 63110
FUNKE, B. R.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GABRIELSON, DAVID	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GALEGHER, SHEILA J.	504 CHESTNUT	GRAND FORKS	ND 58201
GALLAHER, DANIEL D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GANO, DAVID R.	SUND-MINOT	MINOT	ND 58701
GARVEY, ROY	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GLASS, THOMAS L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GODFREAD, CAROLYN	409 ASPEN AVENUE	BISMARCK	ND 58501
GOETTLER, HANS J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GRAU, BRENDA	1710 - 5 1/2 AVENUE NE	JAMESTOWN	ND 58401
GRAU, GERALD A.	1710 - 5 1/2 AVENUE NE	JAMESTWON	ND 58401
GREENWALD, STEPHEN	253 COLLEGE STREET, SW	VALLEY CITY	ND 58072
GROENEWOLD, GERALD	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
GULLICKSON, KIMBERLY K.	P.O. BOX 1184	DOUGLAS	WY 82633

HALLEY, LAVONNE K.	113 16TH STREET NORTHWEST	MINOT	ND 58701
HALVORSON, GARY A.	BOX 459	MANDAN	ND 58554
HAMILTON, ROBERT G.	CROSS RANCH	HENSLER	ND 58547
HANSEN, SUSAN	301 - 30TH AVENUE NORTH, #301	FARGO	ND 58102
HANSON, DAVID D.	RURAL ROUTE 1, BOX 48	TURTLE LAKE	ND 58575
HARMONING, ARLEN	1708 NORTH 4TH STREET	BISMARCK	ND 58501
HARRISON, JOSEPH G.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
HARRISON, STEPHEN	12424 NE 142ND LANE, D-104	KIRKLAND	WA 98034
HASSETT, DAVID J.	20 FENTON AVENUE	GRAND FORKS	ND 58201
HASSETT, DEBRA	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HASTINGS, MICHAEL	DICKINSON STATE COLLEGE	DICKINSON	ND 58601
HEGLUND, JENNIFER C.	1156 21ST STREET WEST, #713	DICKINSON	ND 58601
HEIDEL, BONNIE	GAME AND FISH DEPARTMENT	BISMARCK	ND 58501
HEINTZ, MARK	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HELENBOLT, KENNETH S.	3563 LONGFELLOW ROAD	FARGO	ND 58102
HEMMASI, MOHAMMAD	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HENDERSON, WILLIAM	3014 NORTH ELM STREET	FARGO	ND 58102
HENKE, KEVIN R.	424 NORTH 26TH	GRAND FORKS	ND 58201
HERBEL, JOLAYNE	1109 SOUTH FRONTIER	MANDAN	ND 58554
HERTSGAARD, DORIS	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
HESSE, LISA JOY	P. O. BOX 44	GRAND FORKS	ND 58206
HICKOK, FLOYD	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HILL, ALISON	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
HINTZ, DENNIS D.	BOX 235	GLEN ULLIN	ND 58631
HNOJEWYJ, WASYL S.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
HOBBS, JOHN T.	BOX 264	FORDVILLE	ND 58231
HOEPPNER, JEROME J.	2518 NINTH AVENUE NORTH	GRAND FORKS	ND 58201
HOFF, DONALD L.	402 EAST FIRST STREET	VELVA	ND 58790
HOFFMAN, CHARLES A.	MINOT STATE COLLEGE	MINOT	ND 58701
HOFMANN, LENAT	317 SATURN DRIVE	BISMARCK	ND 58501
HOGANSON, JOHN W.	NORTH DAKOTA GEOLOGICAL SURVEY	GRAND FORKS	ND 58202
HOLLAND, F.D., JR.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HOLLOWAY, HARRY, JR.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HOUGHTON, ROBERT L.	U.S. GEOLOGICAL SURVEY	BISMARCK	ND 58501
HOWELL, FRANCIS L.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HUESERS, LLOYD B.	1900 HIGHLAND DRIVE	MINOT	ND 58701
HUNG, YUNG-TSE	CLEVELAND STATE UNIVERSITY	CLEVELAND	OH 44115
HUNT, CURTISS D.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HUNT, JANET	1513 BARON BOULEVARD	GRAND FORKS	ND 58201
HUSAIN, SYED	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
IVIE, HUBERT L.	608 28TH AVENUE SOUTH	GRAND FORKS	ND 58201
JACKSON, JON A.	UND SCHOOL OF MEDICINE	GRAND FORKS	ND 58202
JACOBS, FRANCIS A.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JACOBSON, ARLEN L.	1119 SOUTH 9TH, #302	BISMARCK	ND 58501
JALAL, SYED M.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JOHANSEN, DOROTHY	MAYVILLE STATE COLLEGE	MAYVILLE	ND 58257
JOHANSEN, ROBERT H.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
JOHNSON, A. WILLIAM	629 HIGH PLAINS COURT	GRAND FORKS	ND 58201
JOHNSON, ARNOLD R.	MINOT STATE COLLEGE	MINOT	ND 58701
JOHNSON, DOUGLAS H.	BOX 2096	JAMESTOWN	ND 58402
JOHNSON, LESTER E.	RURAL ROUTE 2, BOX 92	BOTTINEAU	ND 58318
JOHNSON, LYNDON L.	RURAL ROUTE	ALAMO	ND 58830
JOHNSON, MARY LYNN	2302 SOUTH 18TH STREET	MOORHEAD	MN 56560
JOHNSON, PHYLLIS E.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JONES, MARTIN B.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JORDAN, DAN R.	1325 THIRD AVENUE EAST, #13	HIBBING	MN 55746
JORDE, DENNIS	U.S. FISH AND WILDLIFE SERVICE	LAUREL	MD 20708
JUHL, NYLA H.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JYRING, RONALD	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KALUZNIAK, MIKE	3904 UNIVERSITY AVENUE, #117	GRAND FORKS	ND 58201
KANNOWSKI, PAUL B.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KANTRUD, HAROLD A.	ROUTE 7	JAMESTOWN	ND 58401
KARNER, FRANK R.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KELLEHER, JAMES J.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KENT, HEIDI M.	BOX 286	MINNEWAUKAN	ND 58351
KENT, JOHN D.	BOX 286	MINNEWAUKAN	ND 58351
KERESTES, GEORGE W.	315 DUKE DRIVE #213	GRAND FORKS	ND 58201

KEYS, ROSS D.	2215 FIFTH AVENUE NORTH	GRAND FORKS	ND 58201
KIESLING, RICHARD	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KIHM, ALLEN J.	MINOT STATE COLLEGE	MINOT	ND 58701
KIRBY, DON	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KLEVAY, LESLIE M.	223 27TH AVENUE SOUTH	GRAND FORKS	ND 58201
KLOSTERMAN, HAROLD J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KLUK, EDWARD	162 9TH AVENUE EAST, #9	DICKINSON	ND 58601
KNOBLICH, JEROME	233 14TH AVENUE NORTHEAST	JAMESTOWN	ND 58401
KNUDSON, CURTIS L.	711 NORTH 25TH STREET	GRAND FORKS	ND 58201
KOENKER, WILLIAM E.	6403 GARRET ROAD	DURHAM	NC 27707
KOLSTOE, RALPH H.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KOMPELIEN, MELANIE G.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KOST, KENT	615 NORTH 39TH, #308A	GRAND FORKS	ND 58201
KOTCH, ALEX	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KRAFT, DONALD J.	BEMIDJI STATE UNIVERSITY	BEMIDJI	MN 56601
KRALJIC, KATHLEEN M.	1821 SEVENTH STREET SW	MINOT	ND 58701
KRAUSE, DANIEL	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KRESS, WARREN D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KRUGER, ROBERT M.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KRUPINSKY, JOSEPH M.	BOX 459, USDA-ARS	MANDAN	ND 58554
KRUSCHWITZ, EARL H.	431 SIXTH STREET SOUTHWEST	VALLEY CITY	ND 58072
KUCERA, HENRY L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KUIPERS, GILBERT	VALLEY CITY STATE COLLEGE	VALLEY CITY	ND 58072
KUKUK, GRANT	S & T TRAILER COURT, #166	HAZEN	ND 58545
KUMAR, GIRISH	UNIVERITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LABORDE, JOYCE M.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LADENDORF, THOMAS R.	622 FIFTH AVENUE NORTHWEST	MINOT	ND 58701
LAIRD, WILSON M.	101 SPANISH OAK LANE	KERRVILLE	TX 78028
LAMBETH, DAVID	1909 20TH AVENUE SOUTH	GRAND FORKS	ND 58201
LARSEN, KIM	509 11TH AVENUE NE, APT. B	MINOT	ND 58701
LARSEN, RICHARD	3605 MANITOBA, #213	GRAND FORKS	ND 58201
LARSON, LINDA	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LARSON, OMER R.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LEADBETTER, LARRY	UND SCHOOL OF MEDICINE	GRAND FORKS	ND 58202
LEAGUE, LARRY	DICKINSON STATE COLLEGE	DICKINSON	ND 58601
LEHR, EUGENE R.	BOX 724	LINTON	ND 58552
LENO, GREGORY H.	78 ASHLEY HALL PLANTATION ROAD	CHARLESTON	SC 29407
LINDLEY, JAMES A.	1421 NORTH UNIVERSITY DRIVE	FARGO	ND 58102
LIPP, WILLIAM V.	3024 NORTH 10TH STREET, #19	FARGO	ND 58102
LIU, BING H.	2279 BERNE AVENUE	TERRE HAUTE	IN 47805
LIVESAY, MARK T.	2001 SECOND AVENUE SW, #6	MINOT	ND 58701
LOBDELL, FREDERICK	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LOCKWOOD, KARL L.	MAYVILLE STATE COLLEGE	MAYVILLE	ND 58257
LOENDORF, LAWRENCE L.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LORD, MARK L.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LORENZ, RUSSELL J.	1924 NORTH GRANDVIEW LANE	BISMARCK	ND 58501
LOW, FRANK N.	2511 ST. CHARLES AVENUE	NEW ORLEANS	LA 70130
LOWE, STEPHEN	MINOT STATE COLLEGE	MINOT	ND 58701
LUKASKI, HENRY C.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LURA, CHARLES L.	NDSU-BOTTINEAU BRANCH	BOTTINEAU	ND 58318
LYKKEN, GLENN I.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MAAS, LORI	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MACCARTHY, RONALD F.	5211 CHESTNUT STREET	GRAND FORKS	ND 58201
MADHOK, OM P.	MINOT STATE COLLEGE	MINOT	ND 58701
MAGILL, STEVE	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MAGILL, THOMAS R.	3510 7TH AVENUE NORTH	GRAND FORKS	ND 58201
MAGNUSSON, ADELYNN M.	1703 SOUTH 20TH STREET	GRAND FORKS	ND 58201
MAIANU, ALEXANDRU	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MARKELL, CLARK	MINOT STATE COLLEGE	MINOT	ND 58701
MARTIN, DEWAYNE C.H.	2104 SEVENTH AVENUE NORTHWEST	MINOT	ND 58701
MARTIN, JAMES E.	SD SCHOOL OF MINES/TECHNOLOGY	RAPID CITY	SD 57701
MARWIN, RICHARD M.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MASON, HARRY	P.O. BOX 1116	JAMESTOWN	ND 58401
MASTEL, JEROME A.	51 CORTHELL ROAD	LARAMIE	WY 82070
MATHSEN, DON	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MATTHIES, DONALD L.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MCCARTHY, G. J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MCCOLLOR, DONALD P.	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202

MCDONALD, CLARENCE E.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MCLEOD, MURDICK	#34 BISON COURT	FARGO	ND 58102
MCMAHON, KENNETH J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MEARTZ, PAUL D.	MAYVILLE STATE COLLEGE	MAYVILLE	ND 58257
MELCHIOR, ROBERT C.	615 SOUTH MOVIL LAKE ROAD NE	BEMIDJI	MN 56601
MELDRUM, ALAN	512 COLUMBIA ROAD	GRAND FORKS	ND 58201
MESSENGER, THEODORE	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MEYER, DWAIN W.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MILLER, BRUCE G.	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
MILLER, DAVID	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
MILLER, JAMES E.	3807 MICHAEL LANE	GLENVIEW	IL 60025
MIRON, DOUGLAS	SOUTH DAKOTA STATE UNIVERSITY	BROOKINGS	SD 57007
MITCHELL, E.N.	220 GLENHILL LANE	CHAPEL HILL	NC 27514
MOLLAND, GIBBS	1205 NORTH 22ND STREET	BISMARCK	ND 58501
MORETTI, CHARLES J.	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
MORGAN, ROSE M.	823 SIXTH STREET SOUTHWEST	MINOT	ND 58701
MORLEY, JAMES	3712 BERKELEY DRIVE, APT. 6	GRAND FORKS	ND 58201
MOWER, ROLAND D.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MUDDERMAN, DENIS E.	107 NORTH THIRD STREET, APT. 7	GRAND FORKS	ND 58201
MUNSKI, DOUGLAS	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MUNYER, PAUL D.	3306 BELMONT ROAD	GRAND FORKS	ND 58201
NALEWAJA, JOHN D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
NEEL, JOE K.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
NELSON, BERLIN D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
NELSON, C.N.	NORTH DAKOTA STATE UNIVERSITY	BOTTINEAU	ND 58318
NELSON, DENNIS R.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
NELSON, HARVEY K.	10515 KELL AVENUE SOUTH	BLOOMINGTON	MN 55437
NELSON, WALLACE T.	ROUTE 1, BOX 214	PARSHALL	ND 58770
NICHOLAS, JOSEPH	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
NIELSEN, FORREST H.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
NIESAR, SHERRY L.	215 4TH STREET NORTHWEST	MINOT	ND 58701
NORDLIE, ROBERT C.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
NOWOK, JAN W.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
O'BRIEN, RICK	2417 UNIVERSITY AVENUE	GRAND FORKS	ND 58201
O'CONNELL, JAMES W.	535 EIGHTH AVENUE SOUTHWEST	VALLEY CITY	ND 58072
OECHSLE, LOIS H.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
OLSON, LINDA S.	RURAL ROUTE 1, BOX 408	COOPERSTOWN	ND 58425
ORING, LEWIS W.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
ORR, PAUL H.	1010 RIVER DRIVE SOUTHEAST	EAST GRAND FORKS	MN 56721
OWEN, ALICE K.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
OWEN, JOHN B.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
OWEN, SHUBEL D.	210 SOUTH 12TH STREET	GUTHRIE CENTER	IA 50115
OWENS, THOMAS C.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
PADMANABHAN, G.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
PARK, CHUNG S.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
PARMAR, SURENDRA	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
PATTERSON, DONALD D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
PEDERSON, A. ROBERT	414 20TH AVENUE NORTH	FARGO	ND 58102
PEDERSON, VERNYL D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
PERSSON, TERYL	825 14TH STREET NORTH	FARGO	ND 58102
PETERKA, JOHN J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
PFISTER, PHILIP C.	30 MEADOWLARK LANE	FARGO	ND 58102
POLK, GLENDA C.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
POON, CHI-SANG	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
POPOVIC, MILORAD	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
PRATT, GEORGE L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
PRUNTY, LYLE	318 23RD AVENUE NORTH	FARGO	ND 58102
RALSTON, NICK V.C.	4859 FIFTH AVENUE NORTH	GRAND FORKS	ND 58201
RALSTON, ROBERT	MAYVILLE STATE COLLEGE	MAYVILLE	ND 58257
RAND, ROGER W.	542 FIFTH AVENUE SOUTHWEST	VALLEY CITY	ND 58072
RATHMANN, FRANZ H.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
RAWAT, BANMALI	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
RAY, PAUL D.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
RAYNIE, DOUGLAS E.	BRIGHAM YOUNG UNIVERSITY	PROVO	UT 84602
REDLIN, SCOTT C.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
REICHMAN, GEORGE A.	306 SIXTH AVENUE NORTHWEST	MANDAN	ND 58554
REID, JOHN R.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
REINKE, ROBERT	BOX 391	RAY	ND 58849

REZANIA, SHAHIN	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
RICHARDSON, J.L.	1245 NORTH 9TH STREET	FARGO	ND 58102
RIES, RONALD E.	908 SECOND AVENUE NORTHWEST	MANDAN	ND 58554
RIGLEY, LOUIS	DICKINSON STATE COLLEGE	DICKINSON	ND 58601
RINDT, DIANE	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
RODEWALD, RANDOLPH F.	MINOT STATE COLLEGE	MINOT	ND 58701
ROGERS, DAVID A.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
ROGLER, GEORGE A.	BOX 459	MANDAN	ND 58554
ROWELL, JIM	#9 SIXTH STREET SW	MINOT	ND 58701
ROYER, RON	BOX 88	BURLINGTON	ND 58722
RUDESILL, JAMES T.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
SAMARAWEERA, INDRANI	28 BISON COURT	FARGO	ND 58102
SAMBOR, KEN R.	1638 SOUTH THIRD	BISMARCK	ND 58501
SANDBERG, BRIAN S.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
SAOUDY, S. A.	WINNIPEG, MANITOBA	CANADA	R3T3M2
SARGEANT, ALAN B.	N PRAIRIE WILDLIFE RES. CENTER	JAMESTOWN	ND 58401
SAUMUR, JEAN H.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
SCHEIBE, PAUL	3 STILL CREEK ROAD	WOODSIDE	CA 94062
SCHELHAAS, DOUGLAS P.	600 20TH STREET N.W.	EAST GRAND FORKS	MN 56721
SCHELKOPH, GWEN M.	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
SCHIMMELPFENNIG, DIANA	BOX 1227	HETTINGER	ND 58639
SCHLICHTING, JAMES D.	2222 BIRCHMONT DRIVE	BEMIDJI	MN 56601
SCHLOSSER, ISAAC	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
SCHMIDT, AUDREY E.	ROUTE 1, BOX 183AA	HORACE	ND 58047
SCHMIDT, CHERYL K.	815 DUKE DRIVE, #102	GRAND FORKS	ND 58201
SCHMIDT, CLAUDE H.	STATE UNIVERSITY STATION	FARGO	ND 58105
SCHMIDT, JOHN	ROUTE 1, BOX 183AA	HORACE	ND 58047
SCHNEIDER, DAVID J.	5601 - 37TH SW	SEATTLE	WA 98126
SCHNEIDER, FREDERICK	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
SCHUE, HOLLY S.	2905 WICKERSHAM WAY, T-1	FALLS CHURCH	VA 22042
SCHULZ, JOHN T.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
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SCHWERT, DONALD P.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
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SHULER, TERRENCE R.	2974 COLUMBINE COURT	GRAND FORKS	ND 58201
SIDERS, WILLIAM A.	2459 LAWNDALE ROAD	GRAND FORKS	ND 58201
SILVERMAN, LOUIS B.	2524 OLSON DRIVE	GRAND FORKS	ND 58201
SIMONS, PAUL B.	ANG COAL GASIFICATION	BEULAH	ND 58523
SIMS, RODGER L.	718 25TH STREET NORTH	GRAND FORKS	ND 58201
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STENDELL, REY C.	1806 FIFTH STREET NORTHEAST	JAMESTOWN	ND 58401
STEWART, JAMES A.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
STICKLER, JOSEPH C.	547 NE SIXTH STREET	VALLEY CITY	ND 58072
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STOAKS, RALPH D.	8047 EL CAPITAN DRIVE	LE MESA	CA 92041
STOY, W. MICHAEL	1826 NORTH BELL STREET	BISMARCK	ND 58501
STREEPER, JOSEPH B.	BOX 253	SAWYER	ND 58781
STROTHEIDE, DIANE L.	1317 4TH AVENUE EAST	WILLISTON	ND 58801
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SUMMERS, LAWRENCE	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND	58202
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SWANSON, RICHARD J.	507 THIRD STREET COURT	WEST FARGO	ND	58078
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TAYLOR, RAYMOND	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND	58105
THOMPSON, MICHAEL B.	2208 CRESCENT DRIVE	MINOT	ND	58701
THRASHER, LAWRENCE C.	104 KUCHENSKI DRIVE	DICKINSON	ND	58601
TILTON, JAMES E.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND	58105
TIMIAN, ROLAND G.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND	58105
TIMPE, RONALD C.	604 STANFORD ROAD	GRAND FORKS	ND	58201
TIMPSON, MICHAEL E.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND	58105
TODD, ROBERT G.	221 SEVENTH AVENUE WEST	DICKINSON	ND	58601
TORKELSON, DAVID R.	ECON. DEVELOPMENT COMMISSION	BISMARCK	ND	58505
TRIEBOLD, BEVERLY	253 COLLEGE STREET SW	VALLEY CITY	ND	58072
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