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77th Annual Meeting

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of the
NORTH DAKOTA
ACADEMY OF SCIENCE

Volume 39 April 1985

NORTH DAKOTA ACADEMY OF SCIENCE
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77th ANNUAL MEETING

April 26-27, 1985

Minot, North Dakota

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 first section of this volume of the Proceedings contains the 19 papers presented in the three symposia at the 1985 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 the 33 communications presented in the Professional section of the 1985 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 the six collegiate communications representing 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 and second place 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 analysis (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

NORTH DAKOTA'S RARE SPECIES

Presiding: Robert W. Seabloom
Biology Department, UND
Grand Forks, ND

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Michael G. McKenna*
North Dakota Game and Fish Department
Bismarck, ND

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Botany Department, NDSU
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Fargo, ND

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S.C. Kohn*
North Dakota Game and Fish Department
Bismarck, ND

23 Overview of Rare Animal Species in North Dakota

Michael G. McKenna, Natural Resource Coordinator*
North Dakota Game and Fish Department
Bismarck, N.D. 58505

Recognition of the status and needs of rare animals within geopolitical boundaries is an important part of any natural heritage preservation effort. While these efforts should not be confused philosophically with preservation of federal endangered species, they nonetheless may serve as an intermediate stop gap prior to genetic endangerment.

This paper describes the rationale for a state's rare species program. The history of rare species management efforts is outlined, and the status of North Dakota's rare animals is presented. Additionally, strategies for protection and future management of rare species is discussed.

24 OVERVIEW OF ENDANGERED AND THREATENED VASCULAR PLANT SPECIES IN NORTH DAKOTA

William T. Barker *
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Fargo, N.D. 58105

During the last 100 years in North Dakota there has been considerable alteration of the natural landscape. People are becoming more sensitive to these alterations and are becoming concerned about losing species through extinction due to man's activities. As a result rare and endangered species lists are being compiled by biologists everywhere.

In 1976 the North Dakota Public Service Commission requested that I prepare a list of endangered vascular plant species for North Dakota. They were concerned primarily with energy development and its potential threat to our endangered plant species. Based upon the study of NDSU Herbarium records Drs. Gary Larson and Richard Williams (graduate students at that time) and myself developed a mimeograph list entitled, "Rare and Unique Plants of North Dakota" which included 130 vascular plants. This list was widely distributed and was used by the N.D. Public Service Commission in their permitting process with energy development.

With the establishment of the North Dakota Natural Heritage Program this list has been studied and expanded. Mr. Richard Warner and Miss Alexis Duxbury have visited and studied endangered species in all the herbaria of the state. In addition to this they have conducted several summers of extensive fieldwork concentrating on the endangered species. They have contributed valuable knowledge to the botanical knowledge of North Dakota.

The North Dakota Chapter of the Wildlife Society established an endangered species committee several years ago to develop lists of endangered and threatened biota. Recently a vascular plant subcommittee of this group was formed consisting of Dr. Dennis Disrud, Minot State College, Miss Alexis Duxbury, N. D. Natural Heritage Program, Dr. John LaDuke, University of North Dakota Herbarium, Mr. Hal Kantrud, USF&W-Northern Prairie Research Center Herbarium and myself, NDSU Herbarium. This group, which represents all the herbaria of the state, have collectively developed lists of endangered and threatened N.D. vascular plants. Tables 1 and 2 show the habitats, number of families, genera and species for the endangered and threatened species lists. Space does not permit enumeration of these species in this communication but copies will be available at the 1985 annual meeting of the North Dakota Academy of Science.

Table 1. Habitats and number of families, genera and species of N. D. endangered vascular plant species.

Habitats	Families	Genera	Species
Grasslands	11	14	14
Woodlands	7	7	9
Wetlands	9	12	19
Totals	27	33	42

Table 2. Habitats and number of families, genera and species of N. D. threatened vascular plant species.

Habitats	Families	Genera	Species
Grasslands	19	36	44
Woodlands	28	37	46
Wetlands	22	34	46
Aquatics	5	5	13
Totals	74	112	150

Many of the species included on these lists reach their limits of distribution in North Dakota. The majority of the endangered and threatened species are found in eastern North Dakota. All vascular plant records indicate that we lack considerable knowledge of the vascular flora of northcentral North Dakota. These lists are dynamic and are subject to change as more distribution data become available and as species are added due to further deterioration of our environment. Conservation efforts should certainly be made to protect these species.

25 NORTH DAKOTA'S FEDERALLY THREATENED AND ENDANGERED WETLAND BIRDS

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The interior population of the least tern (Sterna antillarum) was proposed for endangered status by the U.S. Fish and Wildlife Service in June 1984 and the piping plover (Charadrius melodus) was proposed as threatened in North Dakota in November 1984. Both species have breeding populations which have been inventoried by the North Dakota Natural Heritage Inventory since 1982.

Piping plovers nest on bare shorelines of saline wetlands in the Missouri Coteau and Drift Plain and on sparsely vegetated sandbars on the Missouri River in North Dakota. The North Dakota Natural Heritage Inventory searched potential habitat for breeding piping plovers to determine population size and to set priorities for sites in greatest need of protection. Potential habitat was sought from secondary sources such as literature and knowledgable individuals and from aerial color slides available through county U.S. Agricultural Stabilization and Conservation Service offices. Readily visible bare shoreline of saline lakes was noted and marked on 7½ minute U.S.G.S. topographic maps in all counties in the Missouri Coteau and in Benson, Pierce, and McHenry counties in the Drift Plain.

Habitat was searched, using the above described methods in 1983 and 1984. Preliminary inventory work was conducted in 1982. In 1983 and 1984, 157 and 132 breeding pairs were found respectively. Over 30% of the known population is located in one complex of saline lakes in McLean County and 18% is located on Missouri River sandbars. Threats to the breeding adults and fledgling chicks include predation, human disturbance, cattle disturbance, and unnatural water fluctuations caused by water development projects.

Least terns nest on sparsely vegetated sandbars on the Missouri River, often associated with piping plovers. The U.S. Fish and Wildlife Service and the North Dakota Natural Heritage Inventory have censused the breeding population since 1982. Territorial adults are readily visible and easy to census when a human intrudes nesting colonies. All sandbars from Garrison Dam to the Oahe Reservoir headwaters were checked for the presence of adult terns. A dredge spoil island at the mouth of the Cannonball River was also censused. In 1982, 1983, and 1984, 98, 86, and 136 territorial adults were censused respectively. Three colonies were used traditionally all three years.

Water fluctuates on the Missouri River unnaturally from mainstem dam operations for flood control and electricity generation. This unnatural fluctuation affects least terns by exposing and flooding available habitat during the nesting period. Continued productivity of least terns is threatened by this unnatural flooding during the breeding season, and also by human disturbance and potential loss of habitat by future water projects and river maintenance.

Further research on both species must continue to ensure effective protection of these birds and their habitat. This needs to include research on productivity, habitat requirements, feeding ecology, threat documentation, and site fidelity through banding studies. Inventory of breeding populations should also continue to determine population trends.

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SURVEYS OF SENSITIVE RAPTORS OF WESTERN AND SOUTHWESTERN NORTH DAKOTA

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The U.S. Fish and Wildlife Service (FWS), as the primary steward of our migratory bird resources, has responsibilities under the Migratory Bird Treaty Act, Endangered Species Act, and Bald Eagle Act to inventory, monitor, protect, and manage birds of prey or raptors. Until 1980, only limited inventories had been conducted on raptor populations in the western half of the state. Raptor information was woefully inadequate to address the needs of resource management agencies for land use planning. Of particular concern were the potential impacts to sensitive and rare raptors from accelerated development of the lignite resource in the Fort Union Coal Region and oil and gas reserves in the Williston Basin. Therefore, in 1980 the FWS embarked upon an effort to expand the raptor database.

Development of the raptor database required the coordination and cooperation of a large number of individuals from various State and Federal resource agencies and universities. Initial acquisition of existing raptor data and new inventory efforts were primarily focused on the private and Federal lands south and west of the Missouri River, but also included the breaks habitats and Federal coal planning areas on the north and east side of the river. Indian lands were not formally included at that time because no imminent threats from energy development existed. Although primary consideration was given to the golden eagle, prairie falcon, ferruginous hawk, burrowing owl and merlin, information was also gathered on additional species including the bald eagle, Swainson's hawk and red-tailed hawk.

The major thrust of our effort has been to identify raptor nests and important habitats, organize the data in a systematic and standardized format, develop a computerized database, and disseminate the data to interested parties for resource management and land use planning. Through yearly monitoring and inventory efforts since 1982, we have gathered extensive information on activity status, species utilization, and habitat preferences but only limited information on productivity.

To date, raptor data has been gathered for a large part of western North Dakota. In 1982, the FWS funded a raptor inventory of Federal coal areas totaling 8,590 square miles in McKenzie, Williams, Dunn, Billings, Stark, Slope, Bowman, Adams, Hettinger and Grant Counties. The Bureau of Land Management (BLM) had previously funded inventories for portions of McLean, Mercer, Oliver and Dunn Counties. Due to the interest, cooperation and funding assistance of the National Park Service and the Three Affiliated Tribes, respectively, both units of Theodore Roosevelt National Park and the Fort Berthold Indian Reservation were inventoried for raptors in 1984. Portions of the Little Missouri National Grasslands, under the administration of the U.S. Forest Service, have also been inventoried. Extensive as these inventories may seem, significant data gaps remain.

In 1979, approximately 40 known golden eagle nests and only a handful of prairie falcon eyries and ferruginous hawk nests had been reported in western North Dakota. Through the assistance of various cooperators, many new nests have been identified during ground and aerial inventories. At the end of 1984, the FWS had compiled records for 277 golden eagle nests, 85 prairie falcon eyries and 74 ferruginous hawk nests. Total nests represent nests in various conditions ranging from poor to excellent and should not be construed as representing a minimal number of breeding pairs. We are currently analyzing nest data to determine total number of territories.

Due to our Federal Mandates regarding raptors and the need for a centralized database, the FWS has assumed the responsibility for compilation, storage and retrieval of raptor data for western North Dakota. Specific data such as nest locations, substrate, exposure, activity status, land ownership and potential land use impacts are currently being computerized into a database entitled "RAPTOR". This capability will enhance our ability to analyze data and provide timely responses to requests from such groups as resource management agencies, private consultants, private industry and academic facilities.

The raptor data developed over the past 5 years has been useful in a variety of research and environmental planning activities. Included among these activities are the Federal Coal Leasing Program, seismic activity, oil and gas development, and transportation networks. If we are to adequately preserve and manage our birds of prey in western North Dakota, we must continue our inventory and monitoring efforts.

27 RARE PLANTS FROM LOWER SHEYENNE RIVER WETLANDS[1]

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Many seepage emergent wetlands occur along the length of the lower Sheyenne river as it traverses the ancient Sheyenne River delta in Richland and Ransom Counties of southeastern North Dakota.

These wetlands support biotic communities which are unusual in the Great Plains region. They include bog-like associations dominated by, Alnus incana, Betula glandulosa, Salix discolor, Cornus stolonifera and a concentration of herbaceous plants characteristic of calcareous peat wetlands.

In surveys conducted during 1982-84, special effort was made to locate species listed by North Dakota Natural Heritage Inventory as rare in North Dakota. Occurrences from 33 sites, involving 19 species, were recorded (Table 1). These included 96 occurrences on privately owned land, 19 on state owned land and 32 on the Sheyenne National Grassland. Eighteen sites received regular grazing pressure, while 4 sites were partially, or intermittently, grazed while the balance of 12 sites were ungrazed.

Table 1. Incidence of Rare Plant Species From Lower Sheyenne River Seepage Emergent Wetlands.

Species	No. of Sites Richland Co.	Ransom Co.
Equisetum palustre L.	1	3
Botrychium minganense Vict.		1
Anthyrium filix-femina (L.) Roth	10	9
Dryopteris carthusiana (Vill.) H.P. Fuchs	10	14
Dryopteris cristata (L.) Gray	5	11
Gymnocarpium dryopteris (L.) Newmn.		1
Onoclea sensibilis L.	3	1
Thelypteris palustris Schott	4	8
Salix pedicellaris Pursh		3
Menyanthes trifoliata L.		4
Pycnanthemum virginianum (L.) Durand & Jacks.		2
Mimulus guttatus DC.	1	
Campanula aparinoides Pursh		10
Galium labradoricum Wieg.		8
Carex leptalea Wahl.	1	6
Carex pseudo-cyperus L.	1	1
Leersia virginica Willd.	1	1
Cypripedium calceolus L.		16
Cypripedium reginae Walt.	1	10

[1]Supported, in part, by a contract with the North Dakota Natural Heritage Inventory. Dept. of Parks and Recreation. Bismarck, ND. 58501

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AN INCOME TAX CHECK-OFF FOR NONGAME WILDLIFE

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Americans are spending more time in wildlife-related activities not associated with hunting and fishing. Nationwide, less than 10% of the wildlife species receive greater than 90% of the available funding. Virtually all wildlife management programs in the past have been funded by hunters, trappers, and fishermen. The nonconsumptive users of wildlife have been enjoying the benefits without paying any of the costs.

State wildlife departments initiated funding programs to spread the cost of managing nongame wildlife (those species not traditionally sought for food or sport) over a greater segment of the population. Present sources of money used by other states for nongame species include:

1) The Fish and Wildlife Conservation Act of 1980
2) Endangered Species Act of 1973
3) State Sales Tax
4) Sales of Stamps and/or Other Items
5) Pittman/Robertson Federal Aid Funds
6) General Appropriations
7) Voluntary Nongame Income Tax Check-off System

The voluntary income tax check-off has many advantages. The most noteworthy is that it works (Table 1). This wildlife check-off is not a tax, but a voluntary contribution with the money going to preserve, inventory, perpetuate, and conserve nongame wildlife and its habitat.

Table 1

Nongame Tax Check-Off Contributions for 1984

State	Percent of Eligible Taxpayers Contributed (%)	Average Amount of Contribution ($)	Total Amount Contributed ($)
Minnesota	8.1	3.33	647,551
Montana	3.8	5.34	35,000
Colorado	8.5	5.47	447,693
Idaho	6.0	4.43	89,000
Wisconsin	1.6	6.27	291,730

House Bill No. 1232, creating a nongame wildlife fund for North Dakota and providing that an optional contribution to the fund be included on the state income tax returns, was introduced into the North Dakota Legislature in January, 1985. The bill would allow North Dakota taxpayers to contribute one dollar or more to the nongame fund. Some projects the money could be used for include:

1) Reintroduction of exterpated species
2) Design an urban wildlife habitat program
3) Habitat programs for state and private lands
4) Initiate management programs for species in need
5) Establish education programs in the schools
6) Collect biological information on nongame wildlife
7) Help preserve natural or unique habitats in North Dakota.

House Bill No. 1232 was heard in the House Natural Resources Committee on 24 January 1985. No action was taken on the bill pending additional information from the State Tax Department.

Whether the bill passes or fails, the tax check-off continues to draw public support. Most people feel such efforts are long overdue, and they are enthusiastic about the potential benefits which can accrue to our wildlife from this program.

SYMPOSIUM

on

CURRENT STATUS OF PALEONTOLOGY IN NORTH DAKOTA

Presiding: Allen J. Kihm
Department of Earth Science, Minot State College
Minot, ND

29. Paleontology in North Dakota: Gradualism or Punctuated Stasis
Allen J. Kihm*
Department of Earth Science, Minot State College
Minot, ND

30. Subsurface Paleontological Research at the University of North Dakota
F.D. Holland, Jr.*
Department of Geology, UND
Grand Forks, ND

31. Fossils in Deciphering Past Environments: Cannonball Formation (Paleocene, Danian), Central North America
A.M. Cvancara*
Department of Geology, UND
Grand Forks, ND

32. Paleobotanical Research at the Wannagan Creek Site
Robert C. Melchior*
Department of Geology, Bemidji State University
Bemidji, MN

33. Palynomorphs of the Hagel Bed (Lignite), Sentinel Butte Formation, North Dakota
E.N. Steadman*
Coal Science Division, UND Energy Research Center
Grand Forks, ND

34. Paleoenvironment at the Almont Fossil Site
Don Richardson*
ND Paleontological Society
Minot, ND

35. The Vertebrate Fauna and Paleoecology of the Dickinson Member, Brule Formation (Oligocene) in Stark County, North Dakota
John W. Hoganson* and George E. Lammers
ND Geological Survey, Grand Forks, ND and Manitoba Museum of Man and Nature, Winnipeg, Canada

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PALEONTOLOGY IN NORTH DAKOTA: GRADUALISM OR PUNCTUATED STASIS

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Paleontology has been termed the "last of the apprentice sciences". Covering more than three billion years of Earth history; pollen, protozoans and dinosaurs; as well as the fields of biostratigraphy, taxonomy, and evolution, no single individual can claim to be completely versed in the science of paleontology. Backgrounds vary from those trained in geology, biology, or even anthropology. The enormity of the field forces us to specialize in restricted areas, not only paleobotany versus paleozoology, but invertebrate versus vertebrate, and Tertiary gastropods versus Devonian horn corals. Too often our studies begin and end at the limits of our particular specializations and we remain ignorant of the methods and technology used by others. And it is seldom that a study wouldn't be enriched by information from a related field.

The purpose of this symposium is threefold.

(1) to bring together as many paleontologists interested in North Dakota paleontology as possible that they may establish or reestablish contacts with their fellow workers.
(2) to allow the exchange of current information as a means of updating our database and seeking ideas from other workers on solving problems or developing joint projects.
(3) to give people outside the profession, specifically those from land management and regulatory agencies, and business representatives a chance to meet with professional paleontologists and discuss points of common concern on the paleontological resources of the state.

We need not confine ourselves to these points. They are intended only as starting points for further discussion. We are not here to provide answers, but instead to determine what questions we should be asking ourselves and others.

30 SUBSURFACE PALEONTOLOGICAL RESEARCH AT THE UNIVERSITY OF NORTH DAKOTA

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Correlation of stratigraphic units in the North Dakota portion of the Williston Basin has been largely lithocorrelation based on well cuttings, cores, and, to a greater extent, on well logs. This has resulted in a relatively clear picture of the stratigraphy and structure of the Basin but seldom have chronostratigraphic assignments of lithic units been assessed by paleontologic means. While earlier studies by Holland and Waldren (1), Carlson (2), Ziebarth (3), and Morgan (4) may have indicated potential for paleontological studies in the subsurface, only in recent years has enough material been accumulated and made accessible, through the North Dakota Geological Survey at the Wilson M. Laird Core and Sample Library on the campus at UND, to permit extensive biostratigraphic studies. Stratigraphic studies need from paleontology (a) more accurate time lines through the Basin to evaluate depositional models developed from lithologic association, (b) paleoecological refinement of such models, (c) a method of assessment of presumed time-parallel intervals (log marker-defined units), (d) a way to trace units into areas where lithologic differentiation of units is difficult, and (e) a geologic age for stratigraphic units or erosion surfaces whose age is not well documented. To fill this latter need and to provide paleoecologic data, Grenda (5) undertook a faunal study of the Tyler Formation. His work (6), principally with the macrofossils, solidified an early Pennsylvanian age for the Tyler.

Current activities center on the Mississippian System where a major problem has been placement of the Devonian-Mississippian systemic boundary. The Bakken Formation, initially considered Mississippian and consisting of two black shales separated by a middle siltstone, is one of the best markers in the Paleozoic; but its age has not been well documented in North Dakota until Hayes (7) broke down the black shale and recovered nearly 700 conodonts. Occurrences of conodont taxa bracket the Devonian-Mississippian boundary. The lower black shale is largely of the Devonian (Famennian), Upper Polygnathus styriacus Biozone, and the upper shale member is of the Lower Siphonodella crenulata Biozone of Mississippian (Kinderhookian) age. Rocks of intervening conodont biozones were not identified, but T. P. Huber is studying these rocks in greater detail. A current study by L. C. Thrasher of macrofossils of the Bakken seems to indicate that the upper part of the middle member is Kinderhookian and that the Devonian-Mississippian boundary lies within the middle member.

Waters (considering the third and fourth needs above) used (8) corals of the Madison Group to develop a sequence of four local biostratigraphic units or "zonules." These four coral zonules, defined on the occurrence of particular coral taxa, maintain consistent stratigraphic positions within the commonly recognized Madison marker-defined intervals; boundaries of these zonules are remarkably parallel to the thin, fine-clastic "marker horizons" bounding the named intervals. For example, Stelechophyllum banffense occurs in a thin (4.5-6 m) zone, in various lithologies, everywhere 6 m below a well-defined gamma-ray deflection which parallels the top of the Frobisher-Alida interval. This parallelism of paleontologic zonules to the log markers lends credence to the consideration of these marker-defined intervals as para-time-rock units (i.e., essentially time parallel). Moreover, Waters was able to carry the coral zonules west into lithologies, indicative of more open marine conditions, beyond the limits of the log markers which define the intervals in shallow-water parts of the Basin. This indicates the usefulness of coral biostratigraphy for subsurface exploration west of the Nesson anticline. K. E. Eylands is now studying foraminiferid-algal associations for the possibility of comparable microfossil zonation of Mississippian strata.

F. K. Lobdell is seeking answers to the first and second of the above needs in comparison of the subsurface fauna of the Stony Mountain Formation to that of outcrops of Ordovician rocks in Manitoba. Utilizing foraminiferids from well cuttings, C. A. Maldonado is studying the Jurassic Swift Formation and has been able to date it as principally Oxfordian. With charophyte oogonia she was able to date strata above the Swift, suspected of belonging to the Jurassic Morrison Formation, as Cretaceous and likely part of the Inyan Kara Group. Jeremy Reiskind is finding calcareous nannofossils from stratigraphic test wells contributory to dating the Niobrara Formation in eastern North Dakota as Santonian and to providing information on the position of the pycnocline in Upper Cretaceous seas.

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FOSSILS IN DECIPHERING PAST ENVIRONMENTS: CANNONBALL FORMATION (PALEOCENE, DANIAN), CENTRAL NORTH AMERICA

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The Paleocene (Danian) Cannonball Formation, record of the latest marine incursion into central North America, is known positively only from western North Dakota and northwestern South Dakota but likely extends into southwestern Manitoba and southeastern Saskatchewan. It is a non-lignite-bearing sequence of principally poorly consolidated sandstone and mudstone wedged within nonmarine, lignite-bearing, medium and fine clastics. The Cannonball biota consists of foraminiferids; corals; bryozoans; scaphopod, bivalve, gastropod, and nautiloid mollusks (most abundant macrofossils); ostracodes; crabs and lobsters; an echinoid; trace fossils of at least Ophiomorpha and rhizocorallid burrows; sharks, skates, rays, turtles, and crocodiles or alligators; and dinoflagellates and hystrichosphaerids. The gastropods are being revised and the scaphopods and sharks require that treatment as well; the bryozoans, the echinoid, another crab, and other vertebrates remain to be identified.

Macrofossils, not generally abundant, occur more frequently in sandstone than in mudstone, near the middle of the formation; greatest concentrations prevail in muddy, glauconitic sandstone. The best known microfossils, foraminiferids, occur primarily in mudstone, most frequently nearer the middle of the formation. Relatively few fossils are known from South Dakota.

Fossils of presumed normal salinity occur in outcrop mostly in southwest-central North Dakota but extend east to northwestern Kidder County, north to northeastern Bottineau County, and west to southeastern Bowman County. Lower diversity brackish assemblages are known in outcrop from two tongues adjacent to the Little Missouri River in northwestern Slope and southern Golden Valley Counties. Diagnostic genera are the bivalves Crassostrea, Ostrea, and the foraminiferids Trochammina and ?Haplophragmoides (1). Dominance of agglutinated foraminiferids--including Ammobaculites--in two wells in southeastern Bowman and southwestern Adams Counties (2) suggests predominantly brackish conditions extended well to the east of the Little Missouri River Valley.

Cannonball fossils generally reflect shallow sublittoral depths. Glycymeris and Ophiomorpha, in particular, suggest high-energy conditions along the strandline. Lignitized plant fragments in both mudstones and sandstones imply shallower waters. And rare, smaller-than-normal planktonic foraminiferids suggest a general lack of open, deep water (3).

Mollusks give some indication of general water temperature. The Cannonball bivalves Nucula, Nuculana, and Arctica and aporrhaid gastropods prevail in cooler seas today, such as the North Atlantic.

Fossils and associated lithology connote a complex of sedimentary environments, including beach--mainland or barrier island--, shoreface, shelf, lagoon, and tidal flat (4). Low and high diversity bivalve associations (5) relate to these environments. Characteristic low diversity associations in organic mudstone (or sandstone), well-sorted sandstone, and sandy mudstone reflect lagoonal or tidal flat (both may be brackish), beach or upper shoreface, and offshore shelf environments (perhaps, too, that of a marine lagoon). Highest diversity occurs in a muddy sandstone facies that may represent an ecotonal association--between that of well-sorted sandstone and sandy mudstone--that perhaps occupied an environment resembling that of the lower shoreface.

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32 PALEOBOTANICAL RESEARCH AT THE WANNAGAN CREEK SITE

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The Wannagan Creek Site is located in the NW 1/4 of Sec. 18, T. 141 N., R. 102 W., Billings County, North Dakota. The site has been under active investigation by the Science Museum of Minnesota since the summer of 1974. A large number of fossils have been recovered and catalogued from the locality including representatives from nearly every major animal phylum, as well as a large and varied flora.

The site is located in the Boullion Creek Formation of Paleocene age at a position 19.8 meters below the overlying Sentinel Butte Formation. The beds exposed represent a sequence of events on a floodplain beginning with a channel segment that became isolated by a chute or oxbow cutoff (bed 1). This was followed by the accumulation of a presumably anoxic black organic muck in the isolated channel basin (bed 2). The sequence is terminated by the burial of the previous deposits by an overbank crevasse splay derived from an adjacent active channel (bed 3).

Paleobotanical work at the site has included the collection of a large number of megafossils (leaves, stems, fruits, seeds, etc.) in place in the field, the examination of the 120 mesh fraction of the matrix for intermediate size materials (megaspores, small seeds, cuticle fragments, etc.), and the chemical maceration of the matrix for small sized materials (pollen and spores of vascular plants, fungal and algal spores, etc.).

Preliminary analysis of these materials has resulted in number of tentative conclusions, and a series of published reports. The upper portion of bed 1 and the lower portion of bed 2 has produced a diverse flora consisting of 55 species of leaves. This flora is presumably riparian in nature and in addition to a terrestrial element dominated by Cercidiphyllum genetrix and Palaeodoxites plicatus, contains a number of aquatic types such as Porosia verrucosa, Isoetes horridus, Equisetum (2 sp.), and Nelumbium tenuifolium. The shoreline morphology and average wavelength on the "oxbow" lake surface during this stage is inferred by stratigraphic relationships. Reports detailing the first Paleocene occurrence of the Hydropscyhideae (1), the biological affinities of Minerisporites mirabilis (2), the only known fossil fruit of Oreopanax (3), and freshwater ichnofossils (4), have been published to date. Future work on this, and the flora described below will involve cuticle analysis, pollen analysis, and paleoecological relationships in addition to further taxonomic categorization.

The upper portion of bed 2 contains an additional flora which differs both in diversity and taxonomic content from that recovered from bed 1. Bed 1 contains 35 species that are not found in bed 2, and bed 2 contains 14 species that do not occur in bed 1. The dominant terrestrial element in bed 2 is Metasequoia occidentalis, and the major aquatic is Azolla stanleyi. The terrestrial flora in bed 2 is felt to be the successional derivative of that in bed 1, and represents a community which developed on a somewhat more stable substrate than that of an active stream bank. Published reports from bed 2 include a description of the only known vegetative remains of Azolla stanleyi, and a description of anomalous megaspores of that species (1)

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PALYNOMORPHS OF THE HAGEL BED (LIGNITE), SENTINEL BUTTE FORMATION, NORTH DAKOTA

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The Hagel bed is an important economic lignite and is the lowermost named lignite in the Sentinel Butte Formation (1). The Hagel bed extends throughout the Knife River Basin coal-mining area of central North Dakota. Stratigraphic sections were measured from the highwalls of the Center mine, Glenharold mine and Falkirk mine. Samples from these stratigraphic sections were described and analyzed (using standard palynological techniques) for their palynomorph content. Pollen and spores proved to be well preserved and abundant.

Over seventy palynomorph species and morphotypes were identified. Common constituents of the Hagel Bed palynoflora include representatives of the modern classes Gymnospermae, Angiospermae, Filicineae, and Musci. Listed in Table 1 are some the the significant species present and their modern-day equivalents. The genera present suggest a wet, temperate, depositional environment.

The palynologic data has been quantified (using conventional percentage-frequency data) to elucidate trends present. The samples have a relatively consistent palynoflora and typically contain a combination of lowland swamp taxa (e.g. Sphagnum, and some Taxodiaceae) and an upland element (e.g. Corylus, Alnus, Pinus). This combination is interpreted as representing taxa living in the depositional environment (a swamp) along with taxa brought in as detritus from adjacent upland source areas.

Palynomorphs of the family Taxodiaceae (such as redwoods, cyprus and yews) are commonly the dominant forms in Hagel bed samples and are a major constituent in all of them. An abundance of this sort of microfossil suggests a very moist "forest-moor" (2) type of depositional environment. The abundance of the Taxodiaceae in the associated claystones and siltstones suggests that these were deposited in swamp marginal environments in the area studied.

TABLE 1 - SIGNIFICANT PALYNOMORPHS FOUND IN THE HAGEL BED.

Species Name	Botany Affinity (3)	Common Name (Botanic Affinity)
Taxus sp.	Taxus	yews (conifers)
Spheripollenites subgranulatus	Taxus	yews (conifers)
Pinus semicircularus	Pinus	pine trees
Abietineaepollenites sp.	Pinaceae	pine trees
Sequioapollenites paleocenicus	Siquoia	redwoods and relatives
Taxodiaceaepollenites hiatus	Taxodiaceae	redwoods, cyprus
Tricolpopollenites clavireticulatus	Salicaceae	willow family
Corylus sp.	Corylus	hazel tree
Engelhardtia microfoveolata	Juglandaceae	nut trees (walnut, etc.)
Caryapollenites simplex	Carya	pecan-hickory trees
Alnipollenites trina	Alnus	alders
Cingulatisporites dakotaensis	Selaginella	herbs resembling mosses
Foreasporis triangulus	Selaginella	herbs resembling mosses
Osmunda comaumensis	Osmunda	ferns
Laevigatesporites haardti	Polypodiaceae	ferns
Laevigatesperites sp.	Polypodiaceae	ferns
Steriosporites antiguasporites	Sphagnum	Peat moss

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34 PALEOENVIRONMENT AT THE ALMONT FOSSIL SITE

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Recent research at the Almont Fossil Site in the northwest corner of Morton County (SW¼ SE¼ Sec. 26 T. 140 N. R. 86 W.) has provided evidence for a lowland forest community. Fossil flora evidence is as follows:

Ampelopsis acerifolia (Newberry) Brown
Carya antiquorum Newberry
Cercidiphyllum arcticum (Heer) Brown
Cinnamomum sezannense Watelet
Cyclocara brownii
Ginkgo adiantoides (Unger) Heer
Juglandicarya species?
Metasequoia occidentalis (Newberry) Chaney
Viburnum species?

Lithology at the locality is brown to dark brown, siliceous, fine-grained shales that break in concoidal fractures. These shales are part of the Paleocene, Sentinel Butte Formation. The fossils at Almont are indigenous to the enclosing sediment as evidenced from the remains of Juglandicarya seed nuts which indicate transport prior to deposition as being minor. Further sedimentation studies in the Sentinel Butte point towards a flood geography resembling the Mississippi R. with a myriad of lakes and oxbows. Adding to the data is fish scales found in close proximity to the fossil leaves.

Taking this into account with the fossil evidence suggests a lake or oxbow flanked by the various trees. The high silica content would suggest volcanic ash, carried by wind currents that settled out in the water. The silica leached from the ash would act as a cement to provide a good matrix for fossil preservation.

Based on what we know of living species of Ginkgo, Metasequoia and Cercidiphyllum found in China the environment would have been a temperate, lowland forest. The temperatures probably ranged from -1 to -29 C and rainfall ranged between 102-203 cm a year.

The Shui-hsa Valley, in the mountainous tableland southeast of the Yangtze River in China, is the site of the discovery in 1944 of Metasequoia glystostroboides, the living counterpart of Metasequoia occidentalis. These trees thrive along the banks of streams at the lower ends of ravines at an elevation of 1,000 meters.

The seedlings of the Metasequoia are found only in crevices between rocks and boulders or in moist sandy places. There is relatively poor reproduction; however, it is shade-tolerant and the dense thicket offers protection. After its first early stages it develops rapidly.

The winters there are warm with little or no snow. Precipitation in the valley is evenly disributed throughout the year and the humidity is high. Associated shrubs and the other species are unevenly distributed. The modern species of Cercidiphyllum, Ginkgo, and Viburnum are also found in this valley. This coincides in large part with the flora assemblage found at the Almont Site. This connection leads to the conclusion that the paleoenvironment was similiar to the present day environment of the Shui-hsa Valley.

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THE VERTEBRATE FAUNA AND PALEOECOLOGY OF THE DICKINSON MEMBER, BRULE FORMATION (OLIGOCENE) IN STARK COUNTY, NORTH DAKOTA

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Although isolated occurrences of numerous vertebrate taxa have been reported from the Dickinson Member of the Brule Formation in North Dakota, the fauna has not received comprehensive treatment until now. Equivalent-age faunas from South Dakota, Nebraska, Texas, Wyoming, Montana, and Saskatchewan have drawn more attention and are better-known. Consideration of the North Dakota fossils is important because outcrops in Stark County are the furthest northeast exposures of Oligocene terrestrial sedimentary rocks in North America. The objectives of this study are: (1) to determine the types of vertebrates and associated organisms that inhabited western North Dakota 35 million years ago and to produce a comprehensive faunal list; (2) to compare the Stark County fauna to those of equivalent age from other geographic areas to determine paleozoogeographic affinities and differences; and (3) to determine the paleoenvironmental and paleoecological conditions in which the North Dakota fauna lived. The area studied includes the Little Badlands and outlying buttes located southwest of Dickinson, Stark County. The Dickinson Mbr. is the basal member of the Brule Formation, the uppermost formation of the White River Group. It consists of a sequence of clay, claystone, silty claystone and cross-bedded sandstone ("Fitterer Bed") locally intercalated with tuffaceous horizons and fresh-water limestones. An unknown number of paleosols punctuate the sequence.

The greatest diversity of taxa was recovered by prospecting at all stratigraphic levels and from a variety of lithologies within the Dickinson Mbr. The greatest bulk of bones was quarried from an area concentrated within, and just beneath, the "Fitterer Bed" at the Fitterer Ranch Site. No complete skeletons were discovered but preservation was generally excellent. The specimens are believed to represent in situ death assemblages. The vertebrate taxa recovered during this study are: Osteichthyes (2 taxa), Amphibia (Ranidae), Reptilia (Stylemys, Testudo, Lacertilia--2 taxa, Ophidia), Aves (1 taxa), Insectivora (Leptictis (=Ictops), other Insectivora or possibly Chiroptera), Lagomorpha (Paleolagus, cf. Megalagus), Rodentia (cf. Protosiurus, Ischyromys, Adjidaumo, cf. Paraadjidaumo, Eumys, cf. Heliscomys), Carnivora (Dinictis, Hesperocyon, Daphoenus), Perissodactyla (Mesohippus, Caenopus, cf. Hyracodon), and Artiodactyla (Bothriodon, Archaeotherium, Merycoidodon, other Oreodon, Poebrotherium, Leptomeryx). These findings corroborate the existence of a number of previously documented taxa from North Dakota and equivalent-age rocks in other areas of North America. The fauna of the Dickinson Mbr. is considered to be similar, if not equivalent, to the fauna of the Scenic Mbr. (Orellan Age) of the Brule Fm. exposed in the South Dakota Badlands. Representatives of certain important orders, known from rocks of the same age outside of North Dakota, for example marsupials and primates, have eluded discovery. Five gastropod species (three fresh-water and two terrestrial), fresh-water ostracods, beetle pupal cells, bee larval cells, coprolites, and plant fossils (hackberry endocarps, charophyte oogonia, root traces, and algal mats) were found associated with the vertebrate remains. These provide additional paleoenvironmental information.

Lithologies characterizing the Dickinson Mbr. represent deposition by a dynamic fluvial system in which sluggish, loosely sinuous aggrading streams, flanked by low-relief levees, transected a broad floodplain with small ponds and/or ephemeral swampy areas. A complex mosaic of habitats was available for occupancy by vertebrates and other organisms. At least three major habitats existed during deposition of the Dickinson Mbr. Open savanna plains were inhabited primarily by small animals such as rabbits (Paleolagus and cf. Megalagus), deerlike ruminants (Leptomeryx) and rodents (Ischyromys, Eumys etc.). Caenopus (rhinoceros), Poebrotherium (camel), Archeaotherium (giant pig), Bothriodon and probably other large mammals roamed the open plains but were also common in the near-stream woodlands. Gallery forests containing hackberry grew in the near-stream areas and supported a diverse mammal population, primarily medium-sized animals. Merycoidodon and other oreodons and the three-toed horse, Mesohippus, were probably the dominant animals in the riparian setting. Turtles (Stylemys and Testudo) and land snails were also common in the stream-marginal habitats. Carnivors and insectivors, although uncommon, were apparently ubiquitous. Shallow ponds or ephemeral swamps, indicated by the occurrence of algal crusts, charophyte oogonia, fish remains, ostracods and gastropods occasionally developed in inter-stream, open-plain areas. At the time, the climate of southwestern North Dakota was probably warm temperate and subhumid.

Episodic floodwaters deposited fine-grained sediments over the alluvial plain burying recently dead and decaying carcasses and partially disintegrated bones. Findings at the Fitterer Ranch excavation imply that some large mammals (e.g., Caenopus), were probably stranded on sand bars where they were dismembered by scavengers or their bones disassociated by decomposition before burial by lateral stream migration. Interludes of non-deposition of unknown duration occurred between the flooding events.

SYMPOSIUM

on

NEW DIRECTIONS IN ELECTRICAL ENGINEERING

Presiding: David A. Rogers
Department of Electrical and Electronics Engineering, NDSU
Fargo, ND

36. Modes in Inhomogeneous Optical Fibers
Paulo Sérgio da Motta Pires and David A. Rogers*
Department of Electrical Engineering, State University of Campinas, Brazil and Department of Electrical and Electronics Engineering, NDSU, Fargo, ND

37. Improving the Cycle-Slipping Performance of a Phased-Locked Loop
Anthony Massaquoi and Daniel J. Krause*
Onan Corporation, Bloomington, MN and Department of Electrical and Electronics Engineering, NDSU, Fargo, ND

38. Design of an X-Band Rectangular Microstrip Antenna
Banmali Rawat* and Hung Viet Hoang
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Grand Forks, ND

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A. Benjamin PremKumar* and P.K. Rajan
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40. Improving the Design of Tapered Transmission Lines
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Department of Electrical and Electronics Engineering, NDSU
Fargo, ND

41. The Inclined Wire Antenna
Gervásio Protásio S. Cavalcante and David A. Rogers*
Departamento de Engenharia Elétrica, Universidade Federal do Pará, Brazil and Department of Electrical and Electronics Engineering, NDSU, Fargo, ND

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MODES IN INHOMOGENEOUS OPTICAL FIBERS

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The mode cutoff frequencies in inhomogeneous optical fibers are important parameters that can be employed in the following ways: (i) the determination of the upper limit of the value of the single-mode fiber core radius, (ii) the characterization of fibers that permit the propagation of only two modes, and (iii) utilization as the initial value for iterative computations made for the purpose of analyzing propagation problems in multimode fibers.

Several methods have been proposed for calculating the mode cutoff frequencies in inhomogeneous fibers. Among them we will mention the following: variational analysis, matrix approaches, the WKBJ method, finite element analysis, direct integration, power series expansion techniques, and the method of transverse resonance.

Here we present an analysis based on the method of transverse resonance(1). This method is relatively simple, and it is easily implemented on a computer. Based on an initial approximation for the cutoff frequency for a given mode, the scalar wave equation is solved using the Runge-Kutta method. The resulting phase solution is subjected to the boundary conditions in order to yield the cutoff frequency using Muller's method. The procedure is repeated for all other modes of interest.

TABLE I. Some lower cutoff frequencies (dimensionless) for the LP_{m1} modes in optical fibers with various refractive index profiles.

Profile:	Power Law				Lorentzian		Gaussian Dip
Parameter:	1	2	4	10	0.2	0.4	
LP_{01}	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LP_{11}	4.382	3.613	3.000	2.649	2.468	2.587	3.698
LP_{02}	5.948	6.068	4.556	4.174	4.455	5.151	5.715
LP_{21}	7.218	5.744	4.850	4.243	3.904	4.053	5.987

Results for several different refractive index profiles are shown in Table I. Each cutoff frequency calculation requires about 25 seconds of central processor time on a mainframe computer. If we only require the LP_{11} mode cutoff frequency since it is the upper limit for single-mode operation (LP_{01}), the computation time is relatively small. Usually only this mode is required because, in all cases considered here, this mode was the next mode to be energized beyond the LP_{01} (or HE_{11}) mode. Additional modes can be analyzed if, for example, one is interested in making comparisons between a given inhomogeneous case and the step-index case.(2),(3)

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37 IMPROVING THE CYCLE-SLIPPING PERFORMANCE OF A PHASED-LOCKED LOOP

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The output phase of the voltage-controlled oscillator(VCO) in a PLL is considered a random process when additive noise is considered. With sufficiently low carrier-to-noise ratios, the VCO phase variance becomes large and slipping occurs which is inherent to the nonlinearity in the loop. The VCO phase variance increases to such an extent that the VCO slips one or several cycles with respect to the input phase. The slips are particularly destructive to operation in which every cycle counts, such as Doppler velocity measurements or recovery of digital clock timing.

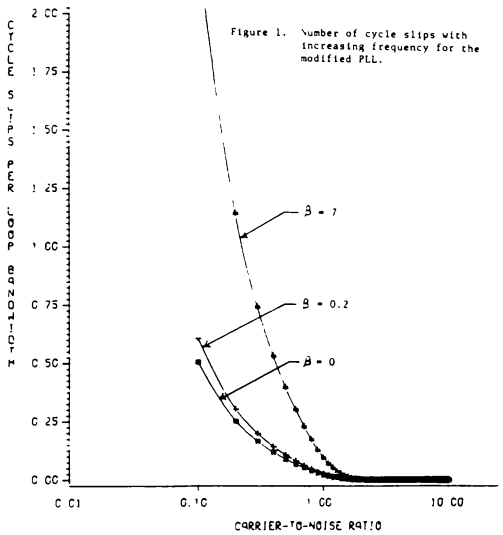

Figure 1. Number of cycle slips with increasing frequency for the modified PLL.

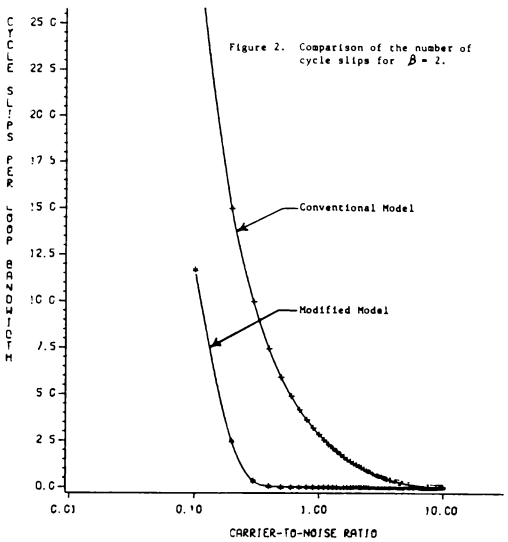

Figure 2. Comparison of the number of cycle slips for $\beta = 2$.

Rosenkranz(1) presented a new configuration of a PLL comprised of a phase detector with a limiter. The model for this PLL is an extension of the well known baseband mathematical model having the same structure which allows application of established linear or nonlinear methods for calculating the loop noise performance. An investigation(2) by computer simulation of this model was carried out by nonlinear analysis via the Fokker-Planck technique. For mathematical simplicity the loop filter is considered to have unity gain. The phase detector characteristic which depends on the input carrier-to-noise ratio is:

$$g(\phi) = \mu_1 \sin\phi$$

where: ϕ = phase error and μ_1 = signal suppression factor.
The number of cycle slips is then determined from:

$$S = W_L \cosh(\pi\beta)/\pi^2 \alpha I_o^2(\alpha\mu_1),$$

where: W_L = two-sided loop bandwidth
β = frequency detuning
α = effective carrier-to-noise ratio from linear theory
and $I_n(a)$ denotes the modified Bessel function of order n and argument a.

Figure 1 gives the number of cycle slips per loop bandwidth for increasing values of frequency detuning. As seen, the number of slips do increase with increasing frequency detuning. Figure 2 compares the number of cycle slips of the modified PLL with the conventional one. From the plot we can see that for the same frequency detuning, the number of slips is less for the modified PLL than the conventional one. Hence, in high noise environments the modified PLL with the limiter preceding the phase detector is superior in performance over the conventional PLL. The modified PLL provides greater synchronization reliability and accurate signal recovery.

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DESIGN OF AN X-BAND RECTANGULAR MICROSTRIP ANTENNA

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For conformal and low profile antennas, the microstrip configuration, Fig. 1, is the most suitable choice (1). This type of antenna also has the advantages of low cost, reproducibility, design flexibility and ease of installation. The radiating elements together with the feed lines are easily photoetched on a thin dielectric sheet on a ground plane.

A simple design technique of an X-band rectangular microstrip antenna has been developed. In order to simplify the problem, the radiating element is considered as two slots separated by a transmission line of low characteristic impedance. The slots are characterized by their radiation pattern, directivity and equivalent admittance. The design has been carried out with cross-link polystyrene/woven quartz as the substrate material (ε_r=2.65, thickness h=3.18mm) and mixture of copper and gold for patch conductor. The design center frequency f_o=10GHz.

The antenna element dimensions are obtained from width, $W = \frac{c}{2f_o}\left(\frac{\varepsilon_r+1}{2}\right)^{-\frac{1}{2}}$ ----------(1)

length, $L = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 2\Delta L$ ----------(2)

where c is the velocity of light, ε_{eff} is effective dielectric constant and ΔL is the length correction factor.

The Q-factor and antenna efficiency are determined from conductor and dielectric losses R_c and R_d respectively as

$$Q = \frac{c\sqrt{\varepsilon_{eff}}}{4f_o h} \quad \text{---------(3)}$$

$$R_c = 0.00027\sqrt{f_o}\,\frac{L}{W}\,Q^2 \qquad R_d = \frac{30\tan\delta}{\varepsilon_r}\,\frac{h\lambda_o}{LW}\,Q^2 \quad \text{----------(4)}$$

and radiation resistance, $R_r = 90\lambda^2_o/W^2$ ---(5)

Now the total quality factor $Q_T = \frac{Q}{R_r}(R_r+R_dR_c)$ -----(6)

and the antenna efficiency $\eta = \frac{R_r}{(R_r+R_d+R_c)}$ ------(7)

From eqn. (6), the bandwidth (BW) of the antenna for the feed line VSWR<2 is written as (2),

$$BW = \frac{VSWR-1}{Q_T\sqrt{2}} \quad \text{--------(8)}$$

Finally the directivity (D_W) and gain (G) of the antenna are obtained from

$D_W = \frac{2D}{1+g_{12}}$ --(9) $\quad G = \eta D_W$ -----(10)

The antenna designed here has an efficiency 99.98%, gain 8.20 dB, bandwidth 20%, size 11.1x7.13mm, and quite small beamwidth (θ_H=16.34°,θ_E=122.52°) suitable for long distance applications. The worst case design results in the variation of resonant frequency by 14 ppm.

Although the microstrip antennas have some disadvantages like lower power handling capability, lower gain, etc., they are certainly preferred in the applications where weight, volume, configuration and cost are critical constraints.

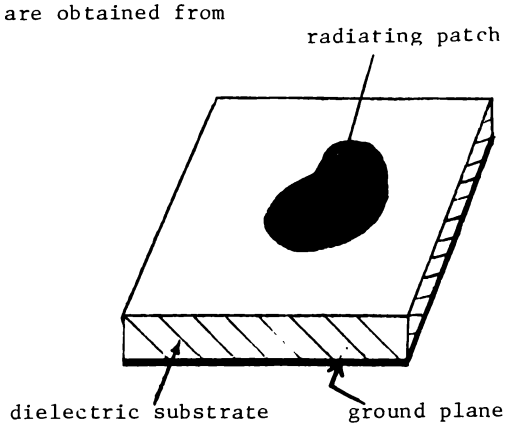

Fig. 1 Microstrip antenna configuration

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39 COMPUTER-AIDED ISOLATED WORD RECOGNIZER

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A requirement of an isolated word recognizer is that a set of measurements of certain speech parameters be made to enable identification of the words that are in the vocabulary. The parameters chosen should be capable of giving the general nature of the phonemes without being dependent on the speaker voice characteristics. Given a digital representation of a speech signal, various parametric representations can be derived in both the time and frequency domains. Among the various parametric representations, the parameters, zero-crossing rate, energy, linear predictive error and two-pole frequency are chosen to be in the recognition process for the following reasons. Speech data can be modelled as the output of a linear system excited by either glottal pulses or random noise. Since the linear prediction method provides a reliable and accurate method of estimating the coefficients of the system that uniquely specify the transfer function, a two-pole model is chosen. Energy in the speech signal is found to vary as a function of time. Sharp energy changes in different frequency regions often signify boundaries between voiced and unvoiced speech sounds. The zero-crossing rate is also a measure of the frequency content of the signal and gives important information as to the nature of the speech signal. This enables us to classify the speech as voiced or unvoiced.

The speech data acquired by digital hardware is subjected to the recognition algorithm which takes into account the steps described below.

1. The End Point Detection:
   The algorithm chosen is simple, efficient and uses the energy and zero-crossing rates applied suitably in the computational procedure. The end points are found by searching intervals at the beginning and at the end for certain thresholds set in the energy and zero-crossing rate features.

2. Feature Extraction Algorithm:
   Here the pole frequency and the LPC error are evaluated with the auto correlation coefficients from the speech segment. Since a two-pole model for speech is assumed, three correlation coefficients are computed. The LPC coefficients are then evaluated as mentioned in the next section.

$$a_1 = r_1(1 - r_2)/(1 - r_1^2)$$
$$a_2 = (r_2 - r_1^2)/(1 - r_1^2)$$

3. Preliminary and Final Decision Algorithm:
   Preliminary and final decisions are based on a set of comparison processes and therefore several thresholds are set. In setting thresholds, self-normalization techniques are used so that the comparison would become speaker independent.

Since the final decision is based on the sound classes, digits are broadly classified on the sound classes. Some of the digits can occur in more than one class. The recognition algorithm takes care of this by searching in each of the classes for these words.

Results:

The percentage accuracy obtained with a single speaker is about 75%. Errors are due to higher zero-crossing rates caused by the noise present in the room and in the system. The 8-bit analog-to-digital conversion also introduces noise due to truncation effects. The two-pole LPC analysis is less accurate and an eight-pole analysis would have yielded better results. The thresholds set for the comparison processes are based on one particular voice. The accuracy could be increased by making statistical measurements for several speakers and then setting the thresholds.

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(2) Rabiner, L. R., Sambur, M. R. (1975) Bell System Technical Journal, 54:2, 297-315.

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IMPROVING THE DESIGN OF TAPERED TRANSMISSION LINES

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In practical MIC (microwave integrated circuit) subsystems, a tapered, nonuniform section of stripline structure is frequently used to feed a microstrip antenna printed on the same substrate material, to modify the input impedance level of a solid-state device considered as a transmission line load, or to interconnect two other sections of uniform striplines with different characteristic impedances. In all these situations, impedance transformation and matching properties are of basic concern [1]. However, the performance of such structures seems to have been rigorously tackled so far only for special tapers or electrically long transmission line sections. In view of the increasing variety of short, nonuniform stripline patterns, which are extensively used in the micro-miniaturized integrated circuits, a more general treatment of this subject is needed. In this presentation, a new method will be shown for the improvement of the design of tapered transmission line sections.

As is well-known, a conventional way of treating tapered, nonuniform transmission lines is to start with the Riccati differential equation for the voltage reflection coefficient q(x):

$$q' - 2\gamma q + \tfrac{1}{2}(K'/K)(1-q^2) = 0 \qquad (1)$$

where K(x) is the local characteristic impedance of the transmission line, $\gamma(x)$ the local propagation factor. By assuming $|q^2| \ll 1$, the simplified differential equation can be solved and, with the help of Fourier transform interpretation, design procedures have been suggested [2-5]. However, this assumption means the ignoring of multiple reflections inside the electric taper. For nonuniform sections of more complicated contour occurring in practical MICs, it may lead to unsatisfactory results. To remove this difficulty, suitable equations will be introduced which can serve as different, often finer, tools for different purposes. For example, the differential equation for the normalized input impedance (or admittance) along the stripline is sometimes more handy for designing impedance transformers:

$$w' \pm (K'/K)\, w + \gamma(1-w^2) = 0 \qquad (2)$$

where w(x) designates normalized input impedance (or admittance) at position x along the line. As a second example of such tools, the following equation is found more convenient than (1) when treating tapered sections involving larger reflection coefficients:

$$y' + 2\gamma(1-y^2) - \tfrac{1}{4}(K'/K)\, y\,(1+y) = 0 \qquad (3)$$

where y(x) is a suitably chosen variable defined by $y = (1-q^2)/(1+q^2)$.

Thus, based on the purposive construction of Riccati and related equations for suitably chosen (or devised) variables, the design of more general, tapered transmission lines can be improved in a systematical way. Practical design examples will be illustrated using this method.

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THE INCLINED WIRE ANTENNA

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In this paper it is shown that the induced EMF method can be used to calculate the radiation resistance of an inclined dipole antenna in the presence of a plane conducting earth. Following the procedures of Schelhunoff and Friis(1) in conjunction with image theory, the radiation resistance as a function of antenna altitude, R(H), can be written as a 2N by N double summation involving the radiation influence coefficients, the element moments, and the phase differences between elements.

Simple geometric calculations allow R(H) to be found to reasonable accuracy for $N < 50$. The usual results for R(H) for vertical and horizontal polarizations are obtained using this method. Comparison of these results with those published, for example, by Balanis(2) shows agreement for both polarizations. Similar results for the inclined wire antenna for a fixed angle of inclination are also obtained (Fig. 1). For fixed antenna altitudes, this method allows the calculation of R(H) as a function of the inclination angle (Fig. 2). It can be seen that for an altitude-to-wavelength ratio of 0.25, R(H) decreases from about 100 ohms at vertical polarization to about 86 ohms for horizontal polarization. When the ratio is changed to 2.5, the radiation resistance is independent of the inclination angle.

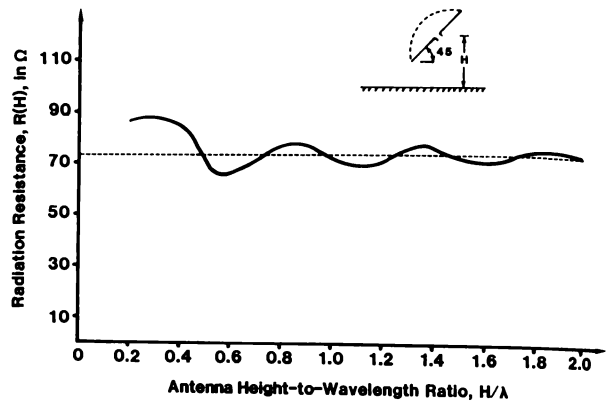

Fig. 1. R(H) as a function of altitude for a fixed inclination angle.

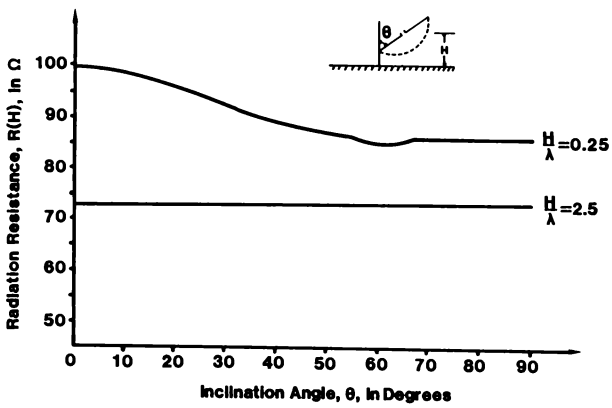

Fig. 2. R(H) as a function of inclination angle for fixed altitudes.

Using this procedure the ground proximity loss(3) is easily calculated for the traditional cases and similar values have been obtained for the inclined dipole. This elementary method shows itself to be quite beneficial due to its ease of utilization and to the low required computational time.

The method can be extended to any arrangement of thin wire radiators and is advantageous since the calculation is based on direct formula evaluation.

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FLUIDIZED BED REACTOR TREATMENT OF COAL GASIFICATION WASTEWATER

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The biological fluidized bed process has been demonstrated to be capable of treating high strength industrial wastewaters at relatively low hydraulic retention times without secondary clarification. This process provides higher surface areas and biological mass concentrations than conventional wastewater treatment processes. A coupled denitrification-nitrification bench scale fluidized bed reactor system was used to investigate its applicability in the treatment of solvent extracted and ammonia stripped coal gasification wastewater (SGL) from the Great Plains Gasification Plant near Beulah, North Dakota.

The bench scale fluidized bed system utilized in this study consisted of a 1.5 inch inside diameter plexiglass annoxic denitrification column and a 2.0 inch aerobic nitrification column. Both columns were 30 inches tall and contained 6.0 inches of quartz sand with an effective size of 0.013 inch and a uniformity coefficient of 1.23. The expanded bed surface areas were approximately 23, and 42 square feet for the denitrification and nitrification columns. Continuous upflow recycled nitrification effluent was mixed with the feed SGL to provide fluidization of the sand particles in the denitrification column. The recycle rate was 50 cycles for a total hydraulic retention time of 2.2 hours based on a once through retention time of 2.6 minutes. The denitrification effluent was oxygenated with compressed air and recycled through the nitrification column for fluidization. The recycle rate was 114 cycles for a total retention time of 3.8 hours based on a once through retention time of 2.0 minutes. Two inch support beds of spherical glass beads were used to uniformly distribute the flow over the cross-sectional area of each column. The recirculation flow rates were reduced by over 50% to approximately 260 ml/min for the denitrification column and 600 ml/min for the nitrification column, to eliminate sand washout at the top of each column, once microbiological coating had reduced sand particle specific gravities. The SGL feed rate was about 2 gallons/day. During startup both beds were expanded 2 times their original volume. Acclimated bacteria from existing bio-wastewater treatment systems, treating SGL, were added to the fluidized bed recycle water to speed microorganism attachment to the sand particles.

Table 1 summarizes analysis of the chemical constituents found in each stage of treatment after 1 week of operation. The feed water contained 2020 mg/L COD (chemical oxygen demand), 630 mg/L TOC (total organic carbon) , and 20 mg/L of phenol. Following denitrification and nitrification over 60% of the COD and 70% of the TOC were removed. Effluent concentrations were 790 mg/L and 180 mg/L, respectively. No phenol was detected in the effluent. Nitrification was indicated by a reduction in the ammonia concentrations from 560 mg/L to 340 mg/L. This represents approximately 40% reduction. The effluent alkalinity levels were also shown to decrease with a corresponding increase in nitrate.

Previous studies have shown the feasibility of using the combined nitrification-denitrification fluidized bed treatment of coke plant wastewaters (Nutt,et.al., 1982). The coupled denitrification- nitrification fluidized bed reactor system is expected to convert high concentrations of ammonia in coal gasification wastewater to nitrogen gas, while providing oxidation of biodegradable organics.

Table 1
Wastewater Chemical Analysis

	COD	TOC	PHENOL	AMMONIA	NITRATE	ALKALINITY
Feed	2020	630	20	560	0	1350
Denitr. effl.	830	190	0	380	50	560
Nitr. effl.	790	180	0	340	90	530

Concentrations in mg/L

Nutt, S.G., Melcer,H. Marvan,I.J., and Sutton,P.M. (1982) Treatment of coke plant wastewater in the coupled pre-denitrification-nitrification fluidized bed process. Presented at the 37th Ann. Purdue Indr. Waste Conf. West Layfayette, Indiana.

2 Biological Nitrification and Hydantoin Removal in Coal Gasification Wastewater

by
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The objective of this study was to determine the feasibility of ammonia and hydantoin removal using a complete mix second stage activated sludge bench scale unit.

The coal gasification wastewater used in this study was produced in the pilot scale gasifier at the University of North Dakota Energy Research Center. The pretreated wastewater typically contained ammonia concentrations of 500 mg/L and hydantoin concentrations of 630 mg/L. Complete mix activated sludge units optimized for carbonaceous removal do not remove high percentages of these compounds. A second stage activated sludge bench scale model was operated to study the oxidation of ammonia to nitrate and to determine if hydantoins in the pretreated wastewater were biodegradable.

The reactor was an aerated eight liter plexiglass tank. The effluent from the reactor was gravity feed to a 250 mL secondary clarifier. Settleable solids were recycled at two hour intervals from the clarifier back into the reactor by peristaltic pump. The reactor was continously mixed and feed by a Cole Parmer mixer and Masterflex peristaltic pump. The reactor pH was maintained by a Beckman pH monitor which pumped sodium carbonate into the reactor when the pH dropped below 7.9 and shut off when the pH reached 8.1.

A stable nitrification process was not established for the first 130 days of operation. Powered activated carbon (PAC) was then added to maintain a level of 600 mg/L in the reactor. Shortly after the PAC addition ammonia levels were reduced from 500 mg/L to 20 mg/L. In addition hydantoins, previously thought to be nonbiodegradable were successfully biooxidized in the reactor. The reactor was studied at three sludge ages of 20, 15, and 11 days while maintaining a hydraulic dentention time of 3 days. Table 1 lists the average removal obtained by the reactor at the specified sluge age. At a twenty day sludge age the reactor achieved a 96 percent removal of ammonia and a 89.4 percent removal of hydantoins. There was little change in the oxidation of ammonia to nitrate at the fifteen day sludge age but the hydantoin removal decreased to 77 percent. When the sludge age was lowered to 11 days the removal of ammonia decreased to 37.5 percent and the reduction of the hydantoins decreased to 50 percent.

The study indicates that nitrification will occur at a sludge age of 15 days but the process stability decreases below this. Hydantoins, once thought to be non-biodegradable[1], have been removed by this system.

TABLE 1

Sludge Age (days)	Ammonia (mg/L)		5-5 Dimethyl Hydantoin (mg/L)		Nitrate (mg/L)	
	Feed	Eff.	Feed	Eff.	Feed	Eff.
20	485	20	630	67	45	3673
15	555	16	633	146	30	3548
11	480	300	580	290	--	----

1. Wilson, W.G., Hendrikson, J.G., Mann, M.D., Mayer G.G. and Olsen. E.S., May (1983), "Pilot Plant Wastewater Treatment Project Status at the University of North Dakota Energy Research Center," Twelfth Biennial Lignite Symposium, University of North Dakota, Grand Forks, ND 58202.

BIOLOGICAL TREATMENT OF HIGH STRENGTH AMMONIA WASTEWATER USING A FOUR STAGE RBC

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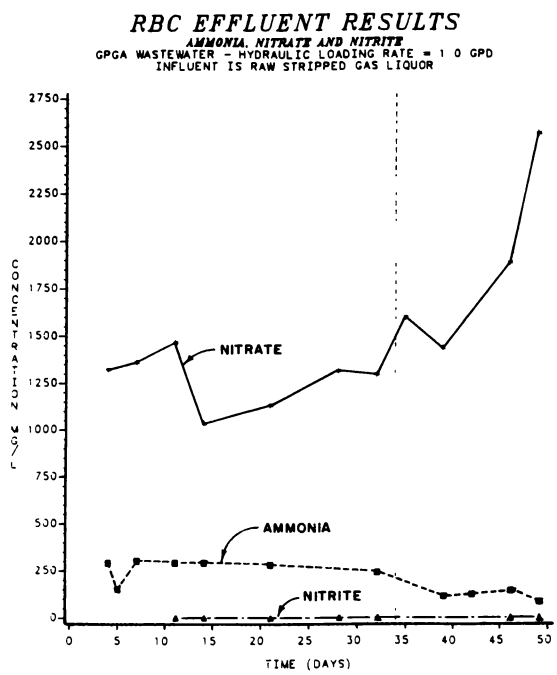
The objective of the research was to determine the treatability of lignite derived coal gasification wastewater using a four stage rotating biological contactor (RBC). Previous research successfully demonstrated the effectivness of using a single stage RBC for carbonaceous removal (1). The four stage RBC was operated to determine whether the additional stages would permit the conversion of ammonia to nitrate.

The bench scale RBC was assembled using plexiglass and PVC pipe. Each reactor contained 39-5 inch diameter equally spaced discs on a shaft that rotated in a rectangular tank with a concave bottom. Disc spacing in the first stage was 0.375 inches and each of the remaining stages used a 0.25 inch spacing. Each stage had a total disc area of 10 ft^2. The system operated at 40 percent disc submergence. The discs were rotated by a Cole-Parmer motor drive at an average peripheral velocity of 0.2 ft/s. The unit was fed continuously at three separate points located along the edge of the tank. Flow was normal to the axis of rotation. Flow between each stage was by gravity.

Feed wastewater was generated at the Great Plains Gasification Associates plant north of Beulah, North Dakota. The wastewater consists principally of gasifier condensate that has been solvent extracted and ammonia stripped (SGL). The SGL has the following characteristics: soluble five day biochemical oxygen demand (BOD_5), 1400 mg/L; ammonia, 740 mg/L; nitrate, 10 mg/L; chemical oxygen demand (COD), 3050 mg/L; total organic carbon (TOC), 900 mg/L; methanol, 300 mg/L. Ammonia toxicity became significant in the complete mix activated sludge bench scale units treating the same wastewater when the ammonia concentration exceeded 500 mg/l.

At a hydraulic loading of 0.1 gallons per day per square foot of disk area the units achieved a BOD_5 removal of 94% in the first stage and 99% removal after four stages. Total COD removal was 72%. TOC removal was 75% after the first stage and 80% after the fourth stage. Prior to adding sodium carbonate between the second and third stages, the effluent ammonia concentrations were consistently higher than 250 mg/L and the pH was less than 6.0. After sodium carbonate addition, the ammonia levels in the fourth stage effluent dropped to less than 100 mg/L and the pH stabilized at 7.0.



The four stage bench scale RBC system has demonstrated the feasibility of using the RBC process to reduce ammonia levels to less than 100 mg/L and BOD_5 to less than 30 mg/L. The resistance of the RBC process to upset by shock loading makes the system easier to control and provides a more consistent effluent.

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4 CORRELATION OF SOLVENT PARAMETERS TO DISSOLVABILITY OF COAL PREASPHALTENES

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Physical properties of coal derived liquids, such as high viscosity and limited solubility, are determined to a large degree by the nature of their intermolecular attractive forces. We have begun a study to distinguish between the types and extent of these forces, with the eventual goal of improving the aforementioned properties. We report herein preliminary results of the initial phase of the study -- the measurement of quantitative dissolvability of coal derived preasphaltenes (PA).

Nine PA samples were isolated from total coal liquefaction samples by solvent extraction. The quantitative dissolvabilities of the PA samples in twelve solvents were determined by mixing 30 mg PA with 3 ml solvent in a stoppered test tube for one minute in an ultrasonic bath. Vacuum filtration of the mixture yielded the insoluble residue.

Correlation of dissolvability of the PA samples in the solvents with various solvent parameters was carried out. The Hildebrand solubility parameter (δ) has been previously used to examine solvent effectiveness for extraction and swelling of coal and dissolvability of coal liquids (1,2). Plots of dissolvability of the PA samples vs. δ revealed maximum dissolvability in solvents with δ ca. 10.5-11.5 H, in good agreement with previous data. However, the maxima in the solubility parameter curves are quite broad; furthermore, the scatter of data in the plots suggests that the predominantly nonpolar Hildebrand solubility parameter cannot adequately account for the solubility of the PAs.

The net hydrogen bonding index (θ) is a solvent parameter which focuses on the formation and cleavage of hydrogen bonds. A general trend of increasing dissolvability of the PA samples with increasing θ was observed, indicating the importance of hydrogen bonding in the coal liquid. However, this parameter was not found to be a reliable predictor of individual solvent behavior, since considerable scatter existed in the plots.

Marzec and coworkers (3,4) have championed the use of donor number (DN) and acceptor number (AN) values of solvents to help explain results of extraction and swelling studies of coal. We found a general trend of increasing PA dissolvability with increasing DN or DN-AN values. Because of the scatter of data in either plot, neither parameter was judged acceptable for use as an absolute predictor of individual solvent behavior. Plots of the ratio DN/AN vs. dissolvability of PA yielded curves which were similar in appearance to the Hildebrand solubility parameter curves, but with narrower maxima and less scatter of data. Thus, the ratio was found to be a better predictor of solvent behavior than δ, θ, DN, or DN-AN.

The maximum dissolvability of the PA samples occurred in solvents with DN/AN values of ca. 2. Since the solvent must be able to replace the PA donor-acceptor interactions in order for dissolution to take place, these results suggest that donor sites (of all types) outweigh acceptor sites (of all types) in the preasphaltenes 2 to 1.

We are now attempting to identify and distinguish the types of donor and acceptor sites in the PA samples via relative viscosity measurements.

ACKNOWLEDGEMENTS: We thank the U.S. Department of Energy for financial support of this research (Grant No. DE-FG22-83PC60808), the University of North Dakota Energy Research Center for providing the total coal liquefaction samples, and Profs. R.J. Baltisberger, V.I. Stenberg, and N.F. Woolsey for helpful discussion.

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METAL SULFIDE CATALYST THERMODYNAMICS IN AQUEOUS H_2S COAL LIQUEFACTION

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New catalysts have been designed for use in aqueous-H_2S low rank coal liquefaction. The catalytic activities are now related to the thermodynamics of the H_2S interaction with the catalysts. In the liquefaction conditions, the surface of the metal sulfide catalysts, $M_{1-x}S$, actively interacts with H_2S and H_2. For the sake of simplicity, this interaction is represented by two simultaneous equations A and B.

$$MS_2 \underset{H_2S}{\overset{H_2}{\rightleftharpoons}} MS \qquad (A) \qquad\qquad MS \underset{H_2S}{\overset{H_2}{\rightleftharpoons}} M \qquad (B)$$

Active hydrogen is formed in the process of reverse of these reactions. The enthalpy change on the per mole basis in the reaction can be calculated using equations 1 and 2, respectively, where ΔH°_S is the heat of sublimation per mole of the metal. Table I lists these enthalpy changes for six

$$\Delta H_{f_1}^\circ = \Delta H^\circ_{MS_2} - (\Delta H^\circ_{MS} + \Delta H^\circ_{H_2S}) \qquad (1) \qquad\qquad \Delta H_{f_2}^\circ = \Delta H^\circ_{MS} - (\Delta H^\circ_{S} + \Delta H^\circ_{H_2S}) \qquad (2)$$

metal sulfides together with conversion data for Big Brown Texas lignite using these metal sulfides as additives to the reaction mixtures. There is a correlation between the heats of formation, the amount of light oil formed and the extent of heavy oil converted. The coal conversion data of Table 1 best correllate with the Δ values. Catalysts with intermediate values of Δ = 21-28 $KJmol^{-1}$ give the highest amounts of light oil. The net effect of the catalyst activity is the reduction of heavy oil yields and increased amounts of light oil yields.

The interpretation of the catalytic activity of these metal sulfides for active hydrogen-atom formation is based on a model involving localized electric field levels at the surface. The equilibrium distribution of unoccupied states with H_2(ads) to occupied states with 2 H• may be derived from the Fermi-Dirac equation 3, where E_t is the energy of hydrogen surface states due to weak adsorption and E_f is Fermi energy which for stoichiometric compounds represents the heat of formation, $-\Delta H^\circ_f$, of the bonds involved in the catalytic reaction. The conclusion derived from equation 3 is that the number of active hydrogens will be increased when $E_f = -\Delta H^\circ_f$ for the catalyst is lowered and it will be increased when the reaction temperature is raised.

$$H_2/2H^\bullet = 1 + \exp(E_t - E_F)/KT \qquad (3)$$

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Table 1 Thermodynamics, Product and Conversion Data for Various Metal Sulfides

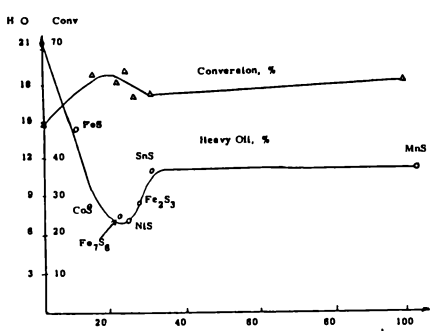
Compound	$-\Delta H_f^\circ$/equivalent, kJ mol^{-1}			Conversion to volatile products, %		Light Oil, %[c]	Heavy Oil, %[c]
	MS	MS_2	Δ[a]	BBI[b]	BBI[c]		
SnS_x	42 3	12 6	29.7	50.4	56.3	7.5	10.8
MnS_x	93 8	-5.0	98.8	52.7	62.0	27.2	11.4
CoS_x	34 1	18.2	15.9	48.8	61.8	30.2	8.3
FeS_x	35 9	25.4	10.5	49.8	53 - 1.4	20.1	14.0
Fe_7S_6		14 2	21.7	49.2	60.4	30.8	7.5
NiS_x	33 1	9.6	23.5	52.3	62.2	31.1	7.1
Fe			28.4	55.8	N.A.	N.A.	N.A.
no catalyst				35.0	49.5	7.5	23.9

a $\Delta = \Delta H_f^\circ(MS) - \Delta H_f^\circ(MS_2)$

b Experimental conditions for liquefaction; BBI lignite = 1g, water = 0.8g, catalyst = 0.15g Reaction temp = 420°C, reaction time = 20 min, pressure of gases: H_2S=250 psi, CO=500 psi, H_2=500 psi

c Experimental conditions for liquefaction; BBI lignite = 1g, water = 0.8g, catalyst = 0.15g Reaction temp = 400 - 500°C, reaction time = 20 min., pressure of gases: H_2S = 150 psi, CO = 250 psi, H_2 = 800 psi.

d Thermodynamic data were taken from reference 3.



6

BATCH ACTIVATED SLUDGE PROCESS FOR TREATING POTATO WASTEWATERS

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Activated sludge process has been used widely in the food processing wastewater treatment. For potato processing wastewater treatment, the activated sludge process is the most commonly used process as a secondary treatment method (1). Purposes of this study are to determine the effectiveness of using batch activated sludge process in treating potato processing wastewaters and to determine the removal efficiency of organic pollutants from the potato processing wastewaters.

The wastewaters used in the batch reactor study were the simulated potato processing wastewaters prepared by dilution of potato juice to desirable COD (chemical oxygen demand) concentrations. The potato juice was prepared from potato tubers, which were washed and cut into 1/2 inch cubic pieces, and blended with dechlorinated tap water. After removing pulp and starch, the juice was used as stock feed solution. A six-compartment batch activated sludge reactor was used in this study. To each unit (reactor) 2 liters of potato wastewaters of various COD concentrations and seed were added. The original bacterial seed was obtained from the activated sludge aeration tank of the Easterly Wastewater Treatment Plant, Cleveland, Ohio. The seed was acclimated to potato processing wastewaters for a period of two months by a fill-and-draw batch process. The acclimated microorganisms were then used in the bench scale completely mixed activated sludge batch reactors. Oxygen required for aerobic biological oxidation was supplied by diffused air, which also kept reactor contents well mixed. The reactor performance were determined periodically by measuring various pollutant levels in the reactors. The volume of potato wastewaters added to reactors 1, 2, 3, 4, 5, and 6 was 0, 0.06, 0.15, 0.3, 0.6, and 1.2 l, which corresponds to 0, 3, 7.5, 15, 30, and 60 % wastewater concentration. A 0.4 l of seed was added to all reactors. Reactor 1, which did not contain wastewater, served as control reactor. Dechlorinated tap water was added to reactors to bring the total liquid volume to 2 l in all reactors. Nitrogen and phosphorus nutrients were added to wastewaters to maintain a COD : N : P ratio of 100 : 5 : 1. Samples were taken from reactors at various time for determinations of mixed liquor suspended solids (MLSS), mixed liquor volatile suspended solids (MLVSS), COD and pH.

Table 1 shows the performance summary for the batch activated sludge reactor study. The initial COD was 52, 301, 564, 1183, 2571, and 4971 mg/l for reactors 1 to 6 respectively. The COD removal efficiency varied from 80.8 to 90 %. At the end of the reactor run, the reactor COD ranged from 30 to 326 mg/l. Reactor COD level decreased as the aeration time increased. Reactor 2 with the lowest potato wastewater concentration of 3 % had a 90 % COD removal with a final reactor COD of 30 mg/l, which was the same as the COD in the control reactor. All the reactors except reactor 6 had an increase in TSS as aeration time increased. At the end of 24 hours of aeration, the reactor TSS varied from 1883 to 2776 mg/l, while the reactor VSS ranged from 1730 to 2556 mg/l.

Based on the results of this study, the batch activated sludge process can be used to treat potato processing wastewaters with a COD removal efficiency of 80.8 to 90 % at a hydraulic detention time of 24 hours.

Table 1

Performance Summary of Activated Sludge Batch Reactors

Reactor	Parameter*	Values of Parameter at Time 0 hr	4 hr	12 hr	24 hr
1	COD	52	28	52	30
2	"	301	145	50	30
3	"	564	413	113	77
4	"	1183	949	498	227
5	"	2571	-	2203	326
6	"	4971	4076	4455	-
1	TSS	1656	1750	1695	1883
2	"	1764	1840	1817	1940
3	"	1904	1975	1970	2136
4	"	2050	1915	2110	2270
5	"	2290	1935	1970	2736
6	"	2930	2460	2325	2776

* COD (mg/l), TSS (mg/l).

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BATCH REACTOR TREATMENT OF POTATO WASTEWATERS USING ANAEROBIC DIGESTION

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Potato wastewater is the by-product of the potato processing industry, which produces potato chips, french fries and hash browns. Wastewaters from potato processing plants contain high concentration of organic pollutants and would require treatment prior to discharge to receiving waters (1). The objectives of this study are to determine the feasibility of using anaerobic digestion process in treating potato processing wastewaters and to determine the treatment efficiency for the organic pollutant removal.

Synthetic potato wastewaters were prepared in the laboratory and were used in this study. Three anaerobic digesters of 2.5 L volume each were used as batch reactor for treating potato wastewaters. Nitrogen and phosphorus nutrients were added to the wastewaters to maintain a chemical oxygen demand: N : P ratio of 100 : 5 : 1. Volume of potato wastewater added to reactors 1, 2 and 3 was 1.5, 0.75, and 0.375 L, respectively. All reactors had 0.5 L digested sludge as seed. Dechlorinated tap water was added to reactors so that the final liquid volume was 2 L for all reactors. The seed was originally obtained from the anaerobic digester in the Rocky River Wastewater Treatment Plant, Rocky River, Ohio, and had been acclimated to the potato processing wastewaters for several months. Reactors were operated at the mesophilic temperature at 24 to 26 C. The initial chemical oxygen demand (COD) was 5097, 2845, and 1206 mg/l, for reactors 1, 2, and 3, respectively. The batch reactor anaerobic study was conducted for a period of 35 days. During this period the volume of gas production and reactor COD were determined.

The performance data of the anaerobic reactors is summarized in Table 1. The initial total suspended solids (TSS), and volatile suspended solids (VSS) were 16,940 and 7825 mg/l for reactor 1; 21,005 and 8845 mg/l for reactor 2; and 20,330 and 8020 mg/l for reactor 3. The pH was 6.45, 6.68, and 7.0 for reactors 1, 2, and 3, respectively. After 35 days of reactor run, the reactor content COD was 2152, 254, and 164 mg/l for these three reactors. This corresponds to 57.8, 91.1, and 86.4 % COD removal efficiency. The corresponding COD removal was 2945, 2591, and 1042 mg/l. Cumulative gas production was 3.37, 1.855, and 0.805 L for reactors 1, 2, and 3, respectively, which was directly related to the initial COD concentration in the anaerobic reactors.

Based on the results obtained in this study, potato wastewaters can be treated effectively with an anaerobic digestion process with COD removal efficiencies exceeding 90 %. When feed COD concentration was increased, the total COD removal increased while percent COD removal decreased.

Table 1

Performance Summary of Anaerobic Reactors

Reactor	Parameter*	Values of Parameter at Time (days)					
		0	7	14	21	28	35
1	COD	5097	4588	-	3250	2621	2152
2	"	2845	2269	1988	1350	-	254
3	"	1206	1044	855	354	183	164
1	Cum Gas Prod	0	0.465	0.830	1.440	2.505	3.370
2	"	0	0.290	0.575	1.230	1.765	1.855
3	"	0	o.185	0.385	0.680	0.770	0.805

* COD (mg/l), cumulative gas production (l).

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8

COMPARISON OF TWICE OVER ROTATION GRAZING TO SEASONLONG GRAZING

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A study to compare cow-calf performance and forage production and utilization on a three pasture, twice-over rotation grazing system to seasonlong grazing was initiated in 1983. This study was conducted at the Central Grasslands Research Station (CGRS) which is located 11.3 kilometers northwest of Streeter, North Dakota. The study area is located in the glaciated region of the state known as the Missouri Coteau. Previous studies in North Dakota have involved steers rather than cow-calf pairs. (1, 2 and 3)

The rotation grazing system is replicated twice. Each replication consists of three pastures which range in size from 29.2 hectares (ha) to 35.3 ha. In 1983 each replication was stocked with 40 cow-calf pairs (2.4 ha/Animal Unit AU). This was increased to 45 cow-calf pairs (2.2 ha/AU) in 1984. Each pasture in a replication was grazed for 28 days and was then deferred for 56 days. Each pasture was grazed twice during the season. At the end of each grazing period the cows and calves were weighed before being rotated. Average weight gains are given in Table 1.

Seasonlong grazing was initiated on 130 ha at the CGRS in 1982. The pasture was stocked with 40 cow-calf pairs (3.25 ha/AU) in 1983 and 45 cow-calf pairs (2.9 ha/AU) in 1984. The weighing schedule for the cows and calves on the seasonlong pasture was the same as that for the cows and calves on the rotation system. Average weight gains are given in Table 1.

Grazing began on June 7 in 1983 and continued for 153 days ending November 8, 1983. In 1984 grazing began on June 5. The calves were weaned on October 9 while the cows remained on the pastures until November 5. This resulted in 126 days of grazing for the calves and 153 days of grazing for the cows.

With the assistance of personnel from the NDSU Soil Science Department it was determined that silty and overflow sites comprised 71% and 14% of the pastures respectively. While other range sites were present they did not occur in all pastures. Vegetation sampling was therefore limited to silty and overflow sites which represent approximately 85% of the study area. Production and utilization was determined by clipping quadrats on caged and uncaged paired plots. Production and utilization figures for 1983 and 1984 are given in Table 2.

Favorable livestock performance and proper utilization under higher stocking rates indicate that the rotation grazing system used in this study may lead to more efficient use of our forage resource.

Table 1. Average Kg gain/ha on Seasonlong and Rotation Grazing

	Rotation Grazing	Seasonlong Grazing
1983		
Cows	9.4	3.9
Calves	19.3	14.4
1984		
Cows	8.3	3.9
Calves	22.4	17.1

Table 2. Forage Production and Utilization on Seasonlong and Rotation Grazing

	Production (Kg/ha)	Utilization (%)
1983		
Seasonlong Grazing	3536	71
Rotation Grazing	2362	56
1984		
Seasonlong Grazing	2827	62
Rotation Grazing	2363	45

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9

MOTH COMMUNITIES OF THE NORTH UNIT OF THEODORE ROOSEVELT NATIONAL PARK

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The work reported here is part of a continuing study to confirm the presence of any lichen-associated moths, identify their host plants, and inventory the moth communities of Theodore Roosevelt National Park-North Unit (TRNP-NU). Some lichens are sensitive to air pollution. To assess the potential impacts of changing air quality on lichen-invertebrate associations baseline information is needed. The study was done in cooperation with the North Dakota Department of Agriculture (NDDA). The work also contributes to Gerald Fauske's dissertation research on the genus Copablepharon.

The North Unit, located in west-central North Dakota, is representative of the Missouri Plateau and the North Dakota Badlands sections of the Great Plains physiographic province. The climate is continental with a mean annual precipitation of 39.5cm. Precipitation for June through September 1984, was 15.5cm or 69% of normal(22.4cm).

In 1984 three light trap sites within the park were chosen. All sites were in the Little Missouri River valley, at approximately 613m elevation. Two sites were characterized by sagebrush flats and bottom grasslands. The third was at the edge of a cottonwood forest. June 12 through 17 September, one light trap was operated every two to four days as weather permitted and was rotated between the sites. Specimens were mailed to North Dakota State University for mounting and identification. All specimens of macrolepidoptera were identified when possible.

A total of 128 species were identified, representing 8 families, 20 subfamilies, and 88 genera. The classification used follows Hodges (1). Three lichen feeders were identified, and all occurred in abundance. They are Crambidia casta (Packard), Hypoprepia fucosa Hubner, and H. miniata (Kirby). Forty-eight species feed primarily on herbaceous plants, 26 on deciduous trees and woody shrubs, 9 on grasses, and 2 on sedges.

Significant new distribution records were recorded for Automeris io (Fabricius), Argyrostrotis anilis (Drury), and Lithacodia synochitis (Grote & Robinson). For Automeris io the closest records are SE Manitoba (2), Boulder, CO (3), and Hot Springs, SD (4). Records for Argyrostrotis anilis are from Lincoln, NB and Manhattan, KS (5), Brookings, SD (4), and Fargo, ND (6). Lithacodia synochitis is recorded from Fargo, ND (6) and Sioux Falls, SD (7). One new state record was identified. Euxoa catenula (Grote) has been previously recorded in Montana (8), Nebraska (5), and South Dakota (4).

The park samples included few economically important species, and those which did occur were found less frequently than on croplands and in low numbers. Of the 28 species considered economically important (or potentially so) by the NDDA only 12 were found in the park samples. Table 1 summarizes trap data for nine economically important species in terms of percentage of trap nights in which the species in question was found (number of nights species present divided by total number of trap nights). Data for comparison comes from light trapping done for the NDDA in 1984. More work in this area, as well as the collection of microlepidoptera and work on specific life histories, will be done in 1985.

Table 1. Number of nights present and presence percentage for nine economically important species at four North Dakota locations.

Species	TRNP-NU N=30		Williston N=34		Hettinger N=24		Bismarck N=15	
	no. nights	(%)	no. nights	(%)	no. nights	(%)	no. nights	(%)
Anagrapha falcifera (Kirby)	5	16.7	17	50.0	16	66.7	11	73.3
Caenurgina erechtea (Cramer)	13	43.3	15	44.1	11	45.8	10	66.7
Discestra trifolii (Hufnegal)	6	20.0	30	88.2	19	79.2	12	80.0
Faronata diffusa (Walker)	2	6.7	10	29.4	5	20.8	5	33.3
Leucania commoides Guenee	6	20.0	7	20.6	7	29.2	5	33.3
Loxostege sticticalis (Linnaeus)	9	30.0	24	70.6	17	70.8	10	66.7
Ostrinia nubilalis (Hubner)	5	16.7	2	5.9	3	12.5	1	6.7
Pseudaletia unipuncta (Haworth)	8	26.7	15	44.1	12	50.0	7	46.7
Xestia adela Franclemont	2	6.7	1	2.9	6	25.0	2	13.3

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10

OCCURRENCE AND HISTOPATHOLOGY OF LOXOGENES ARCANUM (TREMATODA) IN PYLORIC CYSTS OF RANA SEPTENTRIONALIS AND RANA PIPIENS

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Anyone doing frog dissections may occasionally find a cyst of variable size near the junction of the stomach and small intestine. Such objects contain small, egg-filled adult flukes. These were first described as Distomum arcanum (1), but later placed in a new genus, Loxogenes (2). Leopard frogs (Rana pipiens) and green frogs (R. clamitans) were experimentally infected with metacercariae taken from 9 species of dragonfly naiads in Minnesota (3). The cercaria and snail host remain unknown.

Despite the frequency with which frogs are used in parasitology and other biology courses, reports of L. arcanum are few. Necropsy records compiled from frogs collected in Itasca State Park, Minnesota, during the summers of 1964, 66, 68, 70-74, reveal only 7 cases of L. arcanum. Two of these have prompted this communication. During July 1974, a single L. arcanum was recovered from a small pyloric cyst in R. septentrionalis (UND Parasite Collection No. 1191). This appears to be the first report of this parasite in mink frogs. The other notable infection (August 1974) involved a leopard frog possessing an unusually large, ovate, multilobed pyloric cyst, approximately 8 x 12 mm in size (Fig. 1). The cyst was preserved in Bouins fixative, paraffin embedded, serially sectioned at 9 μm and stained with Mallory's triple connective tissue stain.

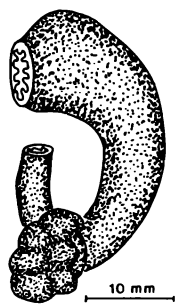

Figure 1. Freehand sketch of stomach, duodenum and pyloric cyst.

Although L. arcanum encysts in the duodenal wall (3), the size of the cyst reported here was so large that it surrounded the upper duodenum, pylorus and lower portion of the stomach. Within the lobate tissue mass were approximately 30 cystic chambers, variable in size and shape, each housing 1-6 adult flukes (Fig. 2). The total number present (100-120 worms) was similar to a heavy infection reported from a green frog in Michigan (4). Damage to the gut wall was extensive. The histologic integrity of the tunica muscularis was destroyed by the massive proliferation of fibrous tissue. This was especially obvious in the stomach wall where the muscle layer is thick and well developed. However, the gastric lining and rugae showed little change. In place of true villi, frogs possess branched mucosal folds. Such structures were greatly reduced in the duodenal region surrounded by the cyst. Leucocytic infiltration of the lamina propria was seen in the duodenum, but not in the stomach. Cystic chambers, where ever they occurred, usually contained large numbers of leucocytes. Only one chamber still retained a narrow connection with the duodenal lumen. Therefore, earlier assertions (1,5) appear to be correct that the eggs of L. arcanum are trapped within the cyst. It is difficult to postulate an evolutionary advantage for a fluke to require the death and disintegration of its host (naturally or by predation) in order for its eggs to enter the environment. Although such events are necessary for Capillaria hepatica, a common liver nematode of rodents, it remains an unusual situation for parasitic worms as a whole.

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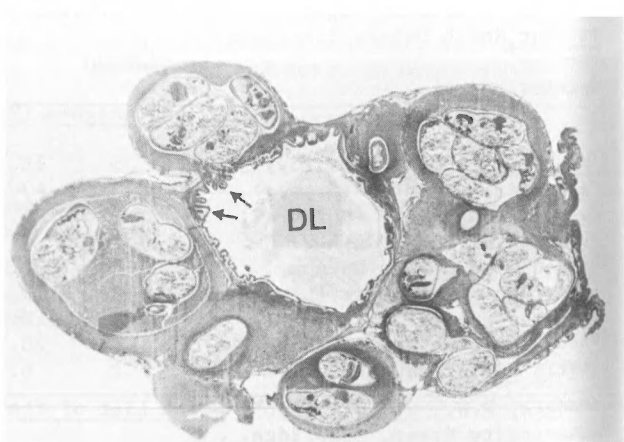

Figure 2. Cross section of duodenum and worm-filled cyst. Five well-defined chambers occur in this section. Note that mucosal folds (arrows) are few and reduced in height. x6.4
DL = duodenal lumen.

Appreciation is extended to Dr. Walter Wasdahl, Pathology Department, University of North Dakota, for examining sectioned material.

11

ECOLOGY OF SCLEROTINIA SCLEROTIORUM IN NORTH DAKOTA

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Sclerotinia sclerotiorum is a plant pathogenic fungus that is becoming a major problem on row crops in North Dakota (1). To understand the importance of this pathogen, its ecology was studied during 1980-1984. A state-wide survey was conducted to determine presence and importance of the pathogen in each county. Also, host range, production of apothecia, ascospore dispersal, soil inoculum densities and pathogen virulence were investigated.

Sclerotinia sclerotiorum was positively identified from 37 of the 53 counties in North Dakota. The counties where it was not observed were mostly in the southwestern part of the state. The pathogen was widespread and caused the greatest damage in eastern North Dakota, especially in and on the edges of the Red River Valley where infested fields are common. In the central counties it is becoming more common; however, serious damage to crops has generally been rare. The fungus is infrequent and not considered a problem in the western counties. Irrigated fields had a higher incidence and severity than dryland fields and were often "hot spots" within a county. The pathogen has destroyed fields of drybean, soybean and sunflower and has had a major impact on crop management decisions.

Crops commonly infected were sunflower, dry bean and soybean. Under dryland agriculture the pathogen was most frequently observed on sunflower. However, in irrigated crops it was most common on drybean and soybean. Other crops infected were Jerusalem artichoke, field pea, mustard, potato, rape and safflower. Artificial inoculations in the greenhouse showed that other crops grown in North Dakota, such as buckwheat, alfalfa, crambe, flax and lentils also were susceptible. Besides crops, the common weeds marsh elder, lambsquarters, pigweed, Canada thistle, sow thistle and wild mustard were found infected in and around crop fields.

Apothecia and ascospore puffing were routinely observed in infested fields during periods of high soil moisture. Usually, apothecia were produced after closing of the crop canopy. They were observed in barley, oats, wheat, sunflower, soybean, drybean, pea, corn, mustard, potato and Jerusalem artichoke fields and occasionally along the edges of fields in wild plant stands. Apothecia were more abundant and produced over a longer period in irrigated than in dryland fields. Ascospores were trapped above the canopy of a wheat field which had apothecia, indicating that non-host fields could be sources of ascospore inoculum.

Inoculum densities were measured in 32 naturally infested fields in eastern North Dakota, and ranged from 0.18 to 12.0 sclerotia/1,000 cc of soil (mean=2.6 sclerotia/1,000 cc soil). Fields with a history of S. sclerotiorum on drybean averaged higher inoculum densities than those with a history of the pathogen on sunflower. Inoculum densities less than 1 sclerotium/1,000 cc of soil were found to cause high disease incidence of Sclerotinia wilt of sunflower.

Inoculations of sunflower, drybean, soybean and potato with isolates of S. sclerotiorum from each of the same hosts indicated no evidence of host specialization in North Dakota. However, inoculations of sunflower with numerous isolates of S. sclerotiorum from a variety of sources confirmed there were differences in virulence among isolates.

Changing cropping patterns in North Dakota have promoted the spread of, and damage caused by, S. sclerotiorum. Row crop production is shifting westward and crop diversity is being encouraged throughout the state. The increased acreage of row crops such as sunflower has resulted in a large susceptible host population. This favors survival and increase of the pathogen population in the soil. There are no highly resistant host cultivars. Sunflower is an ideal host because infection occurs in the roots by myceliogenic germination of sclerotia, thereby eliminating the need for apothecia. Sunflower is the only crop where infection consistently occurs in the roots. All other crops are infected mainly by ascospores. Irrigation is providing ideal sites for ascospore production which can be inoculum sources for adjacent dryland fields of susceptible crops. Also important are low rainfall and prolonged low soil temperatures in North Dakota. They favor survival of sclerotia, the principal overwintering structures of the pathogen. This research strongly suggests that S. sclerotiorum will become a greater problem in the future, especially outside of the Red River Valley.

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12 A Semi-Selective Medium for *Phoma macdonaldii*

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Phoma macdonaldii Boerema causes black spot of sunflower (*Helianthus annuus* L.) (4) and stem girdling lesions that contributes to a problem called premature ripening of sunflowers (2). Premature ripening is now recognized as a general condition of senescence symptoms that do not have a common cause. The name describes sunflower plants which have small heads, low seed weight, low oil content and a low yield.

The fungus may be internally seed-borne (2,3) therefore seed is a possible source of inoculum. The fungus is relatively slow growing and other microorganisms present on seed, plant debris, and soil rapidly overgrow *P. macdonaldii*. In order to assay seeds and soil, a semi-selective medium is necessary.

Bugbee (1) developed a selective medium for *Phoma betae*. It contained: 4 g K_2HPO_4; 1.5 g KH_2PO_4; 25 ml soil extract (made by suspending 1 kg of soil in 1 liter of water and steaming the mixture at 104-110°C for 30 min in the autoclave); 200 mg boric acid; 100 mg each of streptomycin sulfate, chlorotetracycline, and benomyl; 10 g sucrose; and 17 g agar in 1 liter of distilled water. The medium was adjusted to pH 7.0 with HCl before autoclaving. Sucrose and the antibiotics were added to the molten agar (50°C) after autoclaving. This medium did not support the growth of *P. macdonaldii*. In preliminary studies, benomyl at 50-200 µg/mL in potato dextrose agar (PDA) inhibited *P. macdonaldii*.

Development of a useful selective medium involved growing *P. macdonaldii* for 14 days on PDA at 22°C. Adequate fluorescent light was provided to induce sporulation using a 12/24 hour photoperiod. Pycnidia bearing spores were present at 14 days. Mycelial plugs (3 mm^2) of *P. macdonaldii* containing pycnidia were aseptically transferred to Bugbee's basal medium (without chlorotetracycline or benomyl), modified by addition of one of six fungicides at 200 µg/mL. The fungicides tested were Thiram, Captan, Mertec, Topsin, Topsin M, and Terrachlor. Each test was replicated 10 times. After 15 days, fungi on medium containing Thiram, Topsin, and Topsin M showed no growth. Mertec allowed an average growth radius of 0.5 mm, Terrachlor 7.7 mm, and Captan 11.5 mm.

Selectivity was tested using *P. macdonaldii* and 8 fungal genera isolated from sunflower seed, all in pure culture. Terrachlor was chosen as the selective agent and the medium called *P. macdonaldii* agar (PMA). A mycelial plug of each fungus was transferred to PMA. Data shown in Table 1 compares growth on PMA and PDA. *P. macdonaldii* can easily be recovered from ground, dried sunflower stalks sprinkled over PMA. *P. macdonaldii* was also recovered from infected ground debris mixed with field soil.

In summary, a useful semi-selective medium (PMA) has been developed. This medium facilitates assay of soil, seed, and plant debris for the presence of *P. macdonaldii*.

Table 1. Growth of 9 fungi isolated from sunflower seeds on two media

Fungus	Media	
	PMA*	PDA
Doratomyces	6.3*	39
Chlamydomyces	6.7	5
Alternaria alternata	2.0	5
Diheterospora	3.3	5
Aureobasidium	2.7	7
Streptomyces	7.7	5
Rhizopus	1.7	11
Pseudobotrytis	1.0	6
Phoma macdonaldii	10.7	20

*Numbers represent the average radius in mm of mycelial growth on 3 plates after incubation at 22°C for 13 days.

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EFFECT OF NITROGEN FERTILIZERS AND FUNGICIDES ON WHITE MOLD DISEASE AND YIELD OF PINTO BEANS IN NORTH DAKOTA

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White mold, caused by Sclerotinia sclerotiorum (Lib.) de Bary, is a serious and sometimes devastating fungal disease of dry edible beans (Phaseolus vulgaris L.). Depending on weather and cultural practices, white mold can affect beans in some areas of North Dakota each year. The fungus causes a watery soft rot of bean plants by secreting cell wall-degrading enzymes and oxalic acid.

Plant nutrients may affect disease development. For example increased calcium content apparently increases the resistance of plant tissue to the action of pectolytic enzymes (1) and chloride-containing fertilizers have been related to suppression of certain plant diseases (2).

A study was designed to evaluate the influence of fertilizers and fungicides on development of white mold. A 30 acre experiment was made near Hamilton, ND on the Pinto cv. 'UI 111', planted June 1, 1984 in rows 22 in. apart and with a plant population of 70,000 plants/acre. Fertilizers (Table 1) were applied before planting in broad bands at 40 lbs N/acre in a N-S direction across the field, replicated twice. Fungicide (Table 1) application was made in 200 ft. wide bands in an E-W direction beginning July 17. Fungicides were applied at 1.5 lb/acre for benomyl and 4 pts/acre for Bravo, and applications were made at approximately 2 week intervals. Two applications of fungicide were made by ground, and a final application was made by aircraft. Untreated plots served as controls. White mold began developing about July 21. Severity of white mold was evaluated on 23 and 28 August. Within each plot, 20 randomly selected $1yd^2$ zones were classified by the following scale: 0 = no disease, 1 = 1-7%, 2 = 8-14%, 3 = 15-29%, 4 = 30-59%, 5 = 60-100% of the plants diseased. Class values of 0,5,10,20,40, and 80 were used for comparisons. Yield was calculated from mature beans collected from 20 ft. of row on September 11. Bean vines were air dried, threshed, cleaned, weighted, and tested for moisture content. Reported yields (Table 1) are adjusted to cwt/acre at 14% moisture.

Severe weed infestation caused loss of part of the experiment. Therefore, evaluations were made on one set of fungicides across two fertilizer replications (reported as fertilizer major effect, fungicide minor effect,) and one set of fertilizers across three fungicide replications (fungicide major effect, fertilizer minor effect). Yields are from pooled data.

Results indicate that the form of fertilizer had little effect on final yield. Clearly, benomyl fungicide significantly reduced the severity of white mold and increased yield by 2 cwt/acre. White mold control by Bravo was not significant. Ammonium forms of nitrogen apparently increased the amount of disease. This may have been due to increased plant growth with the heavy canopy retaining moisture for extended periods. Potentially higher yields were negated by increased disease. Neither calcium nor chloride forms of fertilizer significantly reduced the amount of white mold. Plants with calcium nitrate fertilizer did have less disease, and more studies relating calcium to reduced white mold seem warranted.

Table 1. Effect of fungicides and fertilizers on white mold and yield of pinto beans near Hamilton, ND, 1984

Fungicide	% Disease Major Effect		% Disease Minor Effect		Yield Cwt/A	
Bravo	13.4[1]/	a[5]/	11.8[2]/	a	12.1	b
Benomyl	9.4	b	2.9	b	14.1	a
Control	18.8	a	9.1	a	12.2	b

Fertilizer	% Disease Major Effect		% Disease Minor Effect		Yield Cwt/A	
Anhyd Am	18.1[3]/	a	40.0[4]/	a	13.6	a
Am Chloride	8.7	b	17.6	b	13.3	a
Am Nitrate	12.0	ab	13.1	bc	13.0	a
Urea	6.7	b	8.1	bc	12.6	a
18-30-12-4	3.7	b	5.5	c	12.6	a
Ca Nitrate	2.9	b	2.5	c	12.2	a
Control	3.4	b	6.0	c	12.2	a

1/ Mean % 420 ratings
2/ Mean % 280 ratings
3/ Mean % of 120 ratings
4/ Mean % of 180 ratings
5/ Numbers followed by the same letter within groups are not significantly different (ANOVA + Duncans Multiple Range Test $\alpha = 0.1$).

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14 A laboratory technique to evaluate infection of green ash by Gloeosporium aridum.

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Anthracnose caused by the parasitic fungus Gloeosporium aridum Ell. & Holw. is a foliar disease that may cause extensive defoliation on green ash (Fraxinus pennsylvanica Marsh.) (1). Observations suggest susceptibility to anthracnose varies among individual trees (2). A technique of screening for resistance is needed. Several infection techniques used for other tree diseases have been inconsistent or slow to produce infections when attempted with G. aridum on green ash (2). An excised leaf disc technique may be a suitable tool for resistance screening (3).

Leaf discs, 18 mm in diameter, were cut from expanded healthy leaves of 2 to 3-year-old green ash grown in the greenhouse. Leaf discs were surface disinfested in 0.25% NaOCl for 30 seconds, then rinsed and dried. Plastic petri dishes (9 cm diam) were prepared with 20 ml of 2.0% water agar. In each dish eight wells were cut and one leaf disc was placed in each well. G. aridum conidial suspensions were prepared by washing conidia from 60-day-old cultures grown on potato dextrose agar (PDA) in petri dishes at 20 ± 2°C under a 14 hour photoperiod. Conidial concentrations were determined by haemocytometer. Treatments applied to leaf discs included cutting with the point of a sharp scalpel and burning with the end of a heated 4 mm diameter aluminum rod. A 10 µl droplet of conidial suspension was placed on leaf discs receiving inoculum. Non-inoculated controls included wounding treatments and the application of a 10 µl droplet of sterile distilled water.

In the first experiment (Table 1A) leaf discs were subjected to different wounding treatments. All inoculations were done at a concentration of 1.3×10^6 conidia/ml. In the second experiment only burning was used as the wounding treatment and different concentrations of conidia were used (Table 1B). Petri dishes containing leaf discs were incubated at 20 ± 2°C under a 14 hour photoperiod. Nine days after inoculation, the leaf discs were examined with a dissecting microscope (20X) to assess amount of lesion development. Lesion width was measured across the cuts and as the average of two diameters for the burns. Burn treatment produced a 5-6 mm diam. necrotic spot. Preliminary studies, not reported here, indicated that burning combined with moderately high concentrations of G. aridum inoculum could produce infection in the excised leaf discs within 7 to 14 days.

Table 1. INFECTION OF GREEN ASH BY GLOEOSPORIUM ARIDUM

A. EFFECT OF WOUNDING.

TREATMENT	INOCULUM[a]	DISEASE INCIDENCE[b]	LESION WIDTH[c]
1. None	None	0/6	0
2. Burn	None	0/6	5.3 ±0.24
3. Cut	None	0/6	0.2 ±0.21
4. Burn	Sterile distilled water	0/6	6.1 ±0.15
5. None	13,050 Conidia	0/6	0
6. Burn	13,050 Conidia	6/6	9.4 ±0.85
7. Cut	13,050 Conidia	0/6	0.2 ±0.17

B. EFFECT OF INOCULUM CONCENTRATION

TREATMENT	INOCULUM[a]	DISEASE INCIDENCE[b]	LESION WIDTH[c]
1. Unwounded	None	0/6	0
2. Unwounded	13,500 Conidia	0/6	0
3. Burned	None	0/6	5.5 ±0.26
4. Burned	Sterile distilled water	0/6	5.6 ±0.23
5. Burned	123,500 Conidia	6/6	8.9 ±1.52
6. Burned	13,050 Conidia	6/6	12.3 ±1.43
7. Burned	5,250 Conidia	6/6	10.0 ±0.98
8. Burned	625 Conidia	0/6	5.9 ±0.20

[a]Inoculum or sterile distilled water applied as a 10 µl droplet.
[b]Number of discs with symptoms at 9 days.
[c]Lesion width (mm) (± s.e.). Burn treatment produced a 5-6 mm diam. necrotic spot.

After 9 days the burn treatment had the highest rate of infection and the largest lesions (Table 1A). The cut and the non-wounded discs receiving inoculum showed no lesion development. The non-inoculated controls remained free of infection. Of the four spore concentrations applied to the burned tissue, an intermediate concentration produced the greatest lesion development (Table 1B). In all cases where infection occurred, lesions appeared as darkened collapsed tissue beyond the burn margin. This tissue gradually became necrotic. Necrosis of leaf discs was not due to the preparation or incubation of discs because non-inoculated discs, whether wounded or unwounded, remained healthy for the duration of the experiment.

These results indicate that the excised leaf disc inoculation method can successfuly be applied to study the infection of green ash by G. aridum. The optimum environmental conditions (such as temperature and photoperiod) and developmental parameters (such as leaf and leaflet position, leaf age, etc.) remain to be defined, and will be the subject of further experiments. It appears this method will be useful to explore inherent differences in susceptibility among clones, cultivars, or seed sources. Large numbers of individual trees could be screened rapidly and in a limited space.

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COLLEGE BACKGROUND OF NORTH DAKOTA SCIENCE TEACHERS 1983-84

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In light of increasing national concern regarding the quality of secondary science education, the Science Education Committee of the North Dakota Academy of Science and the North Dakota Science Teachers Association expressed interest in assessing the status of North Dakota science education with regard to the college background of junior and senior high school science teachers. A questionnaire was designed and mailed to all science teachers. The main objectives were to:

1) Identify the highest degree attained.
2) Identify major fields of study compared to subjects taught.
3) Identify the number of semester hours attained in various science areas compared to subjects taught.
4) Identify areas in which teachers would be most interested in taking college extension courses.

The data obtained are reflective of the 279 (56%) returned.

It was found that all the respondents have Bachelor's degrees and 81 (29%) hold Master's degrees. Of those teachers with Master's degrees, 53% teach in schools with an enrollment of 351 or more students, and 48% have been teaching for more than 19 years.

There were 119 (43%) respondents with a Bachelor's degree major in Biology. The next most frequently cited majors were Composite Science, Chemistry, Math, and Physical Education. Biology was also the most frequently cited Master's degree major.

A comparison was made between each teacher's major and the subject(s) he/she taught. To keep data readable, the subjects of life science and biology were compared to majors in the biological sciences. The subjects of earth science, physical science, chemistry, and physics were compared to majors in the physical sciences. It was found that the subjects of life science and biology had a larger percentage of teachers with majors in fields related to those subjects than the teachers of the physical sciences. The percentage of science teachers without a science major does not exceed 12% in any one subject area.

The specific college course work completed by each science teacher was also compared to the subject(s) he/she taught. In this case, the subjects of earth and physical science had a larger percentage of teachers with more than 16 semester hours in science courses related to those subjects than the biology and life science teachers. There were 41.9% of the physics teachers teaching with 8 semester hours or less in Physics, and 20.4% of the chemistry teachers teaching with 8 semester hours or less in Chemistry. The North Dakota Department of Public Instruction requires that a teacher complete a minimum of 8 semester hours in the subject he/she will be teaching for qualification to teach that subject(1).

In the questionnaire, the teachers were asked to choose from a list of science areas, the three they would be most interested in taking for college credit through extension courses. Computer Science was the most frequently cited interest area followed by Physics and Chemistry. Nearly 60% of the respondents indicated that there was a "great need" in their locale for college extension courses.

In reviewing the above data, concern arises because of the percentage of chemistry and physics teachers teaching with semester hour preparation at, or below the minimum required for qualification to teach those subjects. It is interesting to note that it is those subjects of chemistry and physics (along with computer science) that the teachers are most interested in taking through extension courses. Overall, results from this survey indicate that, with regard to their major(s) and specific course work, the majority of North Dakota science teachers are teaching subjects within their college fields of study.

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A REPORT ON THE COLLEGE BACKGROUND OF NORTH DAKOTA MATHEMATICS TEACHERS IN 1983-84

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The work reported here is part of a joint study conducted in 1983-84 to assess the educational background of junior and senior high school science and mathematics teachers in North Dakota. The main objectives were to identify the highest degree attained and the subject area of the degree. Respondents also identified their interest areas for college credit through extension courses, and their opportunity to meet state recertification requirements through college credit extension courses.

Recent national studies have shown a shortage of mathematics teachers to staff our nation's schools (1). The shortage has resulted in personnel being hired who are poorly qualified, not qualified, and in some cases, not even certified (2). The study was, in part, an attempt to find out if the effects of the mathematics teacher shortage are being felt in North Dakota.

A questionnaire was developed and initially distributed to the mathematics teachers attending the 1983 North Dakota State Teacher's Convention. Then questionnaires were mailed to the remaining mathematics teachers throughout the state. A total of 397 surveys were distributed with a return of 250 (63%).

Of the 250 junior and senior high school mathematics teachers in North Dakota, 195 held a bachelor's degree, 54 a master's degree and 1 held a PhD. Most of these had a degree in mathematics (174 held a bachelor's degree, 22 held a master's degree), followed by a degree in physical education (36). These, in turn, were followed by biological sciences (24), composite sciences (22), physics (14), and then chemistry (13).

The average number of class hours of college preparation per subject taught increased with school size. Of the mathematics courses being taught, 81.7% of the classes were by instructors with a degree in mathematics and 11.1% had a mathematics minor. The percentage of teachers teaching with a mathematics degree rose steadily with years of experience, as did the level of the degree.

North Dakota mathematics teachers indicated a need for greater opportunity to meet state recertification requirements through college credit extension courses. Computer science/programming was the subject in greatest demand (209) followed by math concepts (99). The need for and increased emphasis on basic mathematics courses for teachers was the consensus of those responding.

On the basis of the returned surveys, it would appear that we have, statewide, a well prepared, competent staff of mathematics teachers. The results may have been different with a 100% return. It appears likely that teachers with out-of-field majors would have been less likely to return a study of this nature.

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INTERACTIONS AMONG NICKEL, METHIONINE, AND PYRIDOXINE IN RATS: LIVER CONTENT OF SELECTED TRACE ELEMENTS

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Among animals, plants, and microorganisms, nickel interacts, either directly or indirectly, with at least 13 other elements (1). Many of these interactions are manifested by changes in tissue trace element content. In microorganisms nickel apparently influences methyl group metabolism (2), and affects some enzyme reactions involving pyridoxine. Thus, we decided to ascertain whether pyridoxine and methionine interact with nickel in the growing rat. The work reported here was done to determine if any possible interaction affected liver trace element content.

Male weanling Sprague-Dawley rats were assigned to groups of six in a fully-crossed, three way, 2x2x2 design. A basal diet (3,4) without added pyridoxine was supplemented as follows in order to obtain various treatments: nickel at 0 and 1 µg/g, pyridoxine•HCl at 0 and 7.5 µg/g, and methionine at 0 and 10 mg/g. Environmental conditions have been described (3). The rats were fed their respective diets for eight weeks, weighed and decapitated subsequent to cardiac exsanguination with a heparin-coated needle and syringe. The livers were removed, weighed, and quickly frozen for later trace element analysis by our usual atomic absorption method (3-5). Selected findings are shown in the following table.

Effects in Rats of Nickel, Pyridoxine and Methionine on Liver Trace Element Content

Treatment, µg/g diet			Mean weight, g	µg of element/g dry liver				
Ni	Pyr	Met	at 8 weeks	Cu	Fe	Mn	Ni	Zn
0	0	0	196	18.9	853	9.2	38	92
0	0	10,000	172	17.2	706	10.6	77	89
0	7.5	0	188	22.6	950	7.6	106	101
0	7.5	10,000	165	19.4	879	8.9	46	106
1	0	0	190	22.2	871	8.2	88	100
1	0	10,000	180	18.3	923	10.3	125	104
1	7.5	0	195	21.4	859	7.7	212	101
1	7.5	10,000	187	21.6	878	7.8	66	110
			Analysis of Variance - P Values					
Nickel effect			0.03	NS	NS	NS	0.004	0.01
Pyridoxine effect			NS	0.05	NS	0.0001	NS	0.004
Nickel x pyridoxine			0.06	NS	0.03	NS	NS	NS
Methionine effect			0.0001	0.04	NS	0.001	NS	NS
Nickel x methionine			0.03	NS	0.05	NS	NS	NS
Pyridoxine x methionine			NS	NS	NS	NS	0.0004	NS
Nickel x pyridoxine x methionine			NS	NS	NS	NS	NS	NS

All dietary treatments affected the hepatic mineral profile. Both pyridoxine deprivation and methionine supplementation resulted in depressed copper and in elevated manganese concentrations in liver. Liver iron was affected by interactions between nickel and pyridoxine, and nickel and methionine. Pyridoxine deprivation and methionine supplementation increased liver iron in nickel-supplemented rats and decreased liver iron in nickel-deprived rats. Both nickel and pyridoxine deprivation decreased liver zinc. Liver nickel was lower in nickel-deprived than nickel-supplemented rats. In pyridoxine-deprived rats, methionine supplementation increased liver nickel; the reverse was true in pyridoxine-supplemented rats. The findings show a relationship between nickel and pyridoxine, and between nickel and methionine. This suggests that nickel may have a biological role that can affect pyridoxine and/or methionine metabolism.

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43 **EFFECTS OF CADMIUM ON THE RADIATION RESPONSE OF THE YOUNG ADULT RAT**

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Despite recognition of the serious nature of two or more agents interacting in the environment, data on mammalian systems remain scarce. Recently, we introduced hematological and biochemical data in the young adult Sprague-Dawley (S-D) rat showing the effects of cadmium on the radiation response (1). The experimental design was established by conducting dose-response experiments (2,3).

Two hundred and sixteen male S-D rats, 80 ± 5 days old, were injected with 0, 1.0, or 2.5 mg Cd/kg body weight every 3 days for 29 days. Total cumulative doses were 0, 9.0, or 22 mg Cd/kg body weight. Twenty-four hours after the last Cd injection (day 30), each rat was subjected to an acute whole-body exposure of 0, 3.62, or 5.43 Gray (Gy) of ^{60}Co gamma irradiation.

Blood samples were collected via cardiac exsanguination under sodium pentobarbital (4.0 mg/100 g^{-1} body weight) anesthesia on post-irradiation day 1, 7, or 21. Serum parameters were analyzed on the Technicon Multichannel Autoanalyzer and whole blood parameters on the Coulter Electronics Particle Counter. The statistical model was a 3 X 3 X 3 factorial arrangement with eight replicates. The analysis of variance (ANOVA) was used to test the significance of this data. The Student-Newman-Keuls test was applied where appropriate.

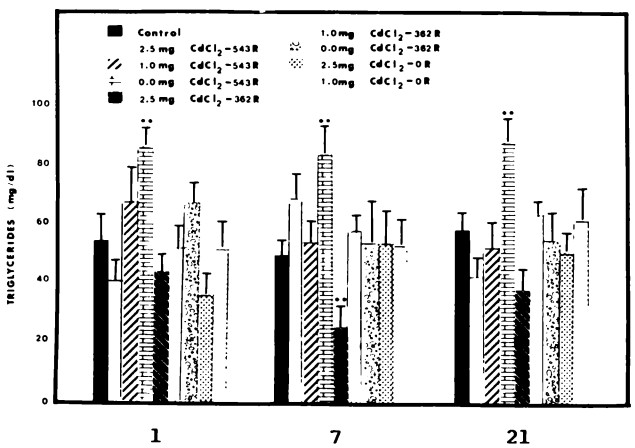

Figure 1. Co-insult Effects on Serum Triglycerides (Triacylglycerols).

In general, Cd acted as a debilitator which enhanced the overall effect of ionizing radiation when applied as the second insult. On the other hand, Cd protected against radiation; that is, some parameters such as serum triacylglycerols (triglycerides) shown in figure 1 were not adversely affected by the co-insult as when radiation only was used. The nature of this protective mechanism of Cd against radiation in the intact animal is not known. However, based on our findings and the work of others (4) we speculate that the Cd anomaly might be dependent upon different conformations of Cd-induced metallothionein cysteine clusters.

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REPRODUCTION IN THE MALE RAT DEFICIENT IN VITAMIN E

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Fat soluble alpha tocopherol is the active form of vitamin E. Human deficiency is found in malabsorption syndromes and in premature infants. Deficient experimental animals cannot reproduce; female rats lose their conceptuses while males cannot fertilize. Vitamin E physiology has been extensively reviewed (Machlin, L.J. (ed.) (1980) Vitamin E, A Comprehensive Treatise, Marcel Dekker, Inc., New York and Basel). Marginally deficient males sometimes retain low level fertility which is the subject of these studies.

Male Long-Evans rats were weaned to a purified diet containing 0.5 ppm alpha tocopherol and maintained on this diet plus distilled water permanently. Commencing at 90 days of age these males were mated to pro-estrus females which had been maintained on commercial diet. On the day following mating with the E-deficient males, these females were examined for insemination and then observed daily for evidence of pregnancy, e.g. weight gain and mid-pregnancy vaginal bleeding. Those females which were able to retain their litters were permitted to deliver on bedding with free access to their pups and to commercial diet and observed several times per day for viability.

As indicated in the table below, the expected failures of insemination were encountered but also a variable degree of pup viability ranging from intrauterine death and resorption at one end of the spectrum to normal survival and weaning weight at the other. Between these two extremes were found neonatal death of entire litters and litters in which some pups survived and some did not. Some litters sired by E-deficient males were small (5 or less pups vs. control of 9) or neonatal death was excessive (50% or more of litter vs. control value of 16%) or both.

Fertility of Male Rats Deficient in Vitamin E

MATING #	1	2	3	4	5	6
Rat Number						
00	NEG	NEG	NEG	POS NO PUPS	POS	
16	NEG	NEG	NEG	POS NO PUPS		
19	POS	POS 8/4 PUPS	POS	POS	POS	POS 6/4 PUPS
21	POS PUPS DIED	POS 5/4 PUPS	POS RESORBED	POS		
22	NEG	NEG	POS PUPS DIED	POS	POS	
23	NEG	NEG	POS PUPS DIED	POS RESORBED	NEG	
25	NEG	NEG	NEG	NEG		
26	POS 12/6 PUPS	POS	NEG	POS	NEG	
28	NEG	NEG	NEG	NEG		

Control males fertilized identical females in 89% of 44 matings which produced a mean of 9 young and a pup loss of <1.

Males on severely deficient diet; normal proestrus females presented to males overnight. "NEG" = no vaginal sperm or plug following day; "POS" = vaginal sperm on following day; X/Y = pups at delivery/pups at weaning. 9 rats; 42 matings; 12 normal litters = 29%.

Histological sections of reproductive organs in the E-deficient males revealed a variety of conditions which paralleled reproductive performance. Thus, those males which were unable to inseminate had suffered extensive tubular degeneration. In less severely damaged testes tubules appeared to be filled with sloughed off germinal epithelial cells which occasionally could be traced into the tubules of the epididymis. Epididymis also revealed frequent round cells, which appear to be macrophages among the spermatozoa. These cells are rarely found in the lumina of normal epididymides suggesting that there might be abnormal or damaged sperm present which would support the hypothesis that the marginal fertility of the E-deficient male rat might be expressed as poor fetal and neonatal viability when mated to normal females.

Although vitamin E deficiency is not a widespread human clinical problem, there is strong evidence that this vitamin is involved in important physiological functions. We should, therefore, pursue further studies which might aid in understanding its role in normal animal physiology.

45 SPATIAL VARIATION OF MULTIPLE SCLEROSIS

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Certain geographic spatial dimensions of multiple sclerosis (MS) in the United States seem to be focused upon latitude, and particular climatological parameters. On January 1, 1976 prevalence rates for high- (states north of latitude 41° N), medium- (latitudes 37°-41° N), and low-risk areas (states south of 37° N) were reported as 74, 65, and 36 per 100,000 population respectively.[1] Age-adjusted death rates for MS per 100,000 persons in the U.S. between 1959 and 1961 have also been shown to vary.[2] In that study, North Dakota (latitudes 46°-49° N) was identified as recording the highest MS mortality rate, namely, 1.4 per 100,000 persons. (Graphic representation of MS mortality for the U.S. is shown in Figure 1.). Although high MS mortality rates for North Dakota have been documented, the extent of this disease throughout the state in terms of variability in its distribution has not been graphically presented.

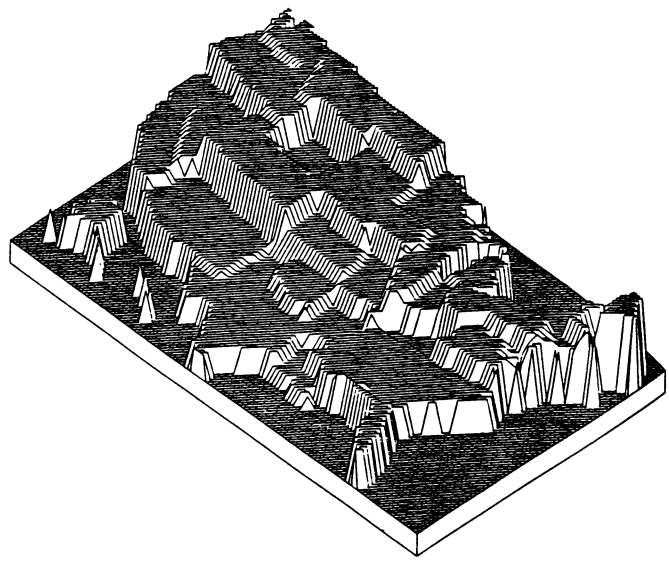

Figure 1. Age-Adjusted Death Rates for MS per 100,000 Population in the U.S. from 1959 to 1961.

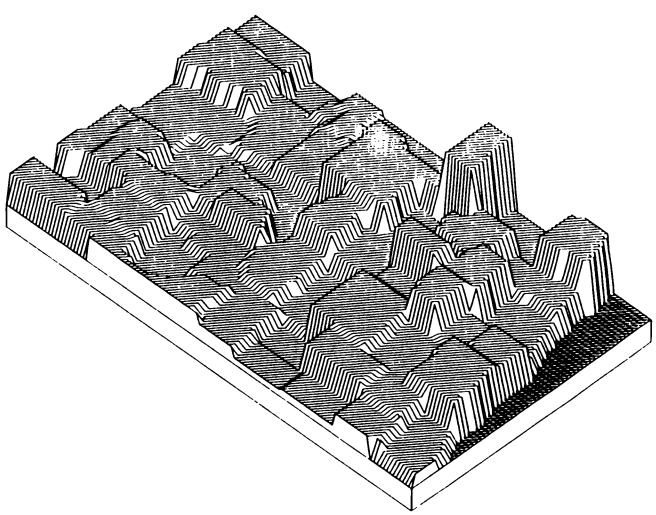

Figure 2. MS in North Dakota from 1977 through 1981

To determine the extent of MS distribution in North Dakota, zipcodes of patients admitted to all the acute care hospitals in the state from 1977 through 1981 were plotted using the SYMVU computer program. Distribution of MS in North Dakota appears to be concentrated in the northeastern section focused upon the Devil's Lake watershed (Figure 2). Further discrimination in the distribution of this disease reveals that MS prevalence in the north and northeastern quadrant of the state is considerably higher than in the west and southwest areas of the state. The single deviation from this pattern is Cass County and might be explained by the major medical complex located in the area that attracts individuals with MS in seeking treatment for their illness. As noted by Laborde,[3] in North Dakota, the area east of the 100th meridian has a subhumid climate, whereas the area to the west is semi-arid. Variability of MS distribution as indicated in this study may be climate-related.

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46

PULMONARY RESPONSIVENESS AND ANTIBODY IN GUINEA PIGS SENSITIZED TO TOLUENE 2,4-DIISOCYANATE (TDI)

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TDI is a widely used chemical in the plastics industry. For over 25 years reports of its toxicity have been accumulating. Effects include asthma in about 10% of workers, dermatitis, chronic pneumonitis and bronchitis (1). A role for antibody mediated allergic reactions (IgE) has often been suggested as an explanation of these symptoms (2).

In the present study serum from guinea pigs sensitized to TDI by an inhalation route was examined for the presence of TDI specific IgG_1 and IgG_2 antibody. Two groups of 8 female English guinea pigs were exposed in an inhalation chamber to TDI vapor in Montreal in the following way: Controls, air for 180 min. on day 1; 0.423 µgTDI vapor for 75 min. on day 18; solubilized GPSA for 20 min. and then 0.02 mg/L TDI-GPSA aerosol on day 25 for 20 min.; subcutaneous injection of 0.01% TDI in saline/PBS on day 28; Sensitized, 4.23 ug/l TDI vapor for 180 min. on day 1, exposures on day 18, 25 and 28 were identical to control. Prior to exposure and on days 15, 22 and 30 blood was drawn and serum prepared and shipped in dry ice to Louisville. An ELISA assay was utilized to determine the presence of antibody.

The results indicated the presence of IgG_1 and IgG_2 antibody in response to inhalation exposure to TDI vapor. The titer increased with subsequent challenge. The values for the sensitized group were significantly different from controls at the 0.05 level. The titer of IgG_1 was greater than IgG_2. This is an important finding, since IgG_1, in the guinea pig is equivalent in activity to human IgE, causing basophil degranulation with release of histamine. The results indicate that antibody is found in response to TDI by inhalation challenge and supports the hypothesis that antibody mediated mechanisms may be involved in adverse reactions to TDI in industrial settings, since inhalation is the major route by which workers are exposed.

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47 CHANGES IN INFERIOR VENA CAVA WALL PROPERTIES WITH POSITIVE PRESSURE VENTILATION AS MEASURED BY INDUCTION ANGIOMETRY IN THE RABBIT

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INTRODUCTION: Extrinsic autonomic influence on large conducting veins has not been shown (1,4). Yet smooth muscle adrenergic α and β receptors in canine inferior vena cava have been histologically demonstrated (3). We hypothesized that extrinsic as well as intrinsic regulatory mechanisms inflence segment properties of the inferior vena cava. In vivo rabbit inferior vena cava segments were chosen as a model for study based on our studies of cardiovascular reflex mechanisms in this species (5).

METHODS: In 14 anesthetized rabbits, we measured inferior vena cava segment diameter (D) and transmural pressure (P_T) by induction angiometry and appropriate pressure catheters placed inside and outside the vessel. Briefly, induction angiometry (4) involved measurements of diameter signals from a single loop wire probe placed in contact with the vena cava inside walls, via femoral vein cannulation. For components of P_T, inside pressure (P_{sv}) was determined using probe cannula and outside abdominal pressure (P_a) was estimated from a partially fluid filled balloon tipped cannula, placed along outside of the vein. Following additional surgical procedures each rabbit was placed on positive pressure inspiration with spontaneous expiration. In the protocol, measurements were made in nine animals before and during 0.1-0.2 ml bolus in situ injection of epinephrine (0.05 mg/ml). Measurements were also made before and during increases in positive end expiratory pressure (PEEP) of 2.5, 5.0 and 7.5 cm H_2O. In nine rabbits procedures were repeated following injection (iv) of 1 mg/kg phentolamine and 1 mg/kg DL-propranolal HCl respective adrenergic α and β receptor blockers (1). In five other rabbits procedures were repeated following bilateral section of the cervical vagi. Permanent records were simultaneously made on a polygraph recorder and magnetic tape. All values are reported as mean ± SEM. Statistical evaluation used Model 1 ANOVA, regression analysis and student t-test for paired comparisons; significance (*) was set at $p < 0.05$. To quantify dynamic responses, characteristic of altered properties of a wall segment, we obtained derivatives of diameter, P_{sv} and P_a from magnetic tape recordings. A mathematical relationship was developed utilizing these derivatives to produce an index of compliance (CI) of the vein segment as: $CI = 1.0 \text{ mm} \cdot \pi \cdot D/2 \cdot (dD/dt)/(dP_{sv}/dt - dP_a/dt)$.

RESULTS AND DISCUSSION: Prior to epinephrine injection, mean diameter ($\bar{D}$) was 7.07 ± .31 mm, VP_T was 1.57 ± .15 mm Hg and CI was 6.27 ± 0.96 mm^3/mm Hg. 10 to 15 sec post injection $\bar{D}$ was 6.82 ± .34 mm* and CI was 4.22 ± 1.44 mm^3/mm Hg* while P_T was unaltered. $\bar{D}$ and CI responses to epinephrine were abolished following use of α and β blockers. These results indicate a potential for reactivity of this vein to circulating vasoactive agents. In 11 rabbits PEEP was used to: (1) alter vena cava transmural pressure by increasing resistance to venous return to the heart and (2) stimulate cardiopulmonary mechanoreceptors (2,5); results are in Table 1.

TABLE 1
Vena cava responses for 11 rabbits before and during PEEP

Parameter					Significance	
					F > A	R
PEEP (cm H_2O)	0.0	2.5	5.0	7.5		
$\bar{D}$ (mm)	7.08 ± .29	7.19 ± .29	7.23 ± .32	7.27 ± .32	No	-
P_T (mm_3Hg)	1.40 ± .18	1.97 ± .16	2.78 ± .16	3.51 ± .16	Yes	Yes
CI (mm^3/mm Hg)	4.52 ± .68	3.69 ± .63	2.92 ± .54	2.17 ± .40	Yes	Yes

critical value (A) ANOVA $F_{.05(3,40)} = 2.84$; (R) linear regression $F_{.05(1,2)} = 18.5$

In 8 of these animals responses to PEEP were altered following use of α and β blockers; now as P_T increased so did $\bar{D}$, while CI was relatively unchanged. These results demonstrated a functional role for both α and β antonomic receptors in regulation of vena cava wall tone. As to afferent portions of reflex influences, comparison of results before and after vagotomy and then use of α and β blockers indicated involvement of both vagally and non vagally mediated mechanoreceptors.

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BANK RECESSION MAGNITUDES AND FACTORS, LAKE SAKAKAWEA, ND

48

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Garrison Dam was completed in 1953, creating Lake Sakakawea. The reservoir continued to fill until 1969 when maximum normal pool level of 564.3m (1850 ft.) was first reached. Since then, shoreline erosion has been a significant problem (Reid and Millsop, 1984). Land is lost, water quality is adversely affected, and reservoir storage capacity is decreased as sediment accumulates in the lake. Previous work at Orwell Lake, MN (Reid, 1984) provided the foundation for similar research at Lake Sakakawea.

This study was begun in the spring of 1983 to determine the magnitudes and causes of erosion along the eastern end of the lake. Twenty stations were selected for instrumentation. Erosion pins were set normal to the bank faces to measure erosion by rainsplash and runoff. Both bank recession pins, set 3m back from the edge of the bank top and repetitive profile measurements (Figure 1) were used to determine wave erosion and thaw failure. Measurements were made regularly from the time of thaw to freeze-up. Volumes of colluvium from thaw failure were calculated from trench excavations. In addition, other data related to erosion processes were gathered: pool level fluctuations; wind velocity, direction, and duration; precipitation; soil moisture; frost penetration; freeze-thaw cycles; and geology (texture, clay mineralogy and structure).

The study has demonstrated that the magnitude of erosion is highly variable. For the interval of May 1983 through Aug. 1984 the banks receded between 0.6 and 5.9m (0.5 to 4.6 m/yr). Measurement of aerial photographs for 1966 to 1976 yielded similar average recession (0 to 4.3 m/yr).

The predominant activating cause of bank recession at Lake Sakakawea is wave erosion, responsible for about 87% of total bank recession. The passive factors include: pool level; bank lithology, structure, geometry, orientation, and vegetation; natural rip-rap; offshore bathymetry, and the presence of offshore islands. Results indicate that banks shorter than 5m, which face northeast, and are of well-jointed till or mudstone, have the highest recession rates, especially during high pool levels. Because the wave-cut banks are typically almost vertical, rain erosion is minor. Most of the 2-52mm of recorded rain erosion occurred on the colluvium along the base of the banks.

The colluvium, from winter sublimation and spring thaw failure, varied from 0.13 to 3.3m for each metre of shoreline. Thaw failure accounted for about 13% of total bank recession and was greatest for those banks facing west and northwest and which were in well-jointed till or mudstone.

A typical sequence for erosion at Lake Sakakawea begins in late winter as frost, binding the sediment, undergoes sublimation. The loosened aggregates accumulate as a thin apron at the foot of steep banks. Spring thaw results in slab failures, followed by earthflows and mudflows. As summer approaches, the lake rises from snowmelt influx. The maximum pool level is reached sometime in mid-summer. Waves, generated by strong winds preceding and following low pressure cells easily erode the loose colluvium along the base of the banks. Not all of the colluvium is eroded every year. Sometimes the pool level does not reach the base of the banks; other times, duration of high pool level is too brief for the removal of all the colluvium. However, if all the colluvium is eroded (as was the case this past summer), the waves can remove the primary sediment or bedrock, effectively undercutting the banks. At the top of such banks, extensional cracks are initiated. The cracks expand until bank failure releases the stresses. The blocks tumble into the water if the pool level is still high enough. Otherwise, they accumulate along the base even after the pool level has dropped. Bank failure continues until a relatively stable profile has formed. Late summer to late winter is an extended period of relative quiescence, after which time release of aggregates by sublimation again occurs.

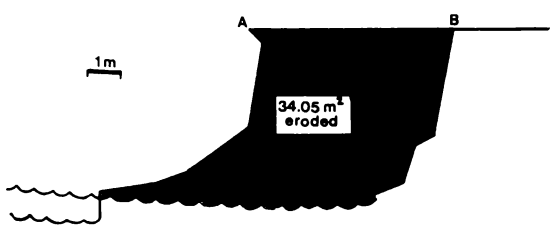

Figure 1. Cumulative bank erosion, Site #61, Lake Sakakawea, ND. Position A = 6/23/83; B = 6/20/84. Note higher pool level in 1984.

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49 Significance of Free-Standing Glacial Erratics South and West of the Missouri River, North and South Dakota

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West and south of the Missouri River trench in South and North Dakota free-standing glacial erratics, with little or no inclosing matrix or fine-grained drift of any kind, are used to mark the position of maximum ice advance (1). Flint (2) hypothesized the glaciation which deposited the boulders postdated the present topography. He suggested the Missouri River and accompanying breaks served as a baffle which trapped the flow of basal ice, while the upper part of the glacier, which contained little drift material, was permitted to flow freely beyond the Missouri trench.

White (3) and Clausen (4) have proposed deep dissection of the Great Plains associated with glacial advances. The hypothesis of deep glacial erosion suggests an alternate hypothesis for the presence of the free-standing glacial erratics. The boulders may represent the residual concentrate of the coarsest element of extensive glacially deposited sediments which had covered a topographic surface now largely removed.

To consider the hypothesis that free-standing erratics, south and west of the Missouri River, might be residual concentrates of once extensive glacial sediments, glacial deposits in the Minot, North Dakota, area were studied to determine what type of residual deposits could be expected after deep erosion. The study area selected was bounded on the north by U.S. highway 2 and on the south by the Souris River between Minot and Towner. The area was selected due to a variety of sediments related to glacial activity and due to the presence of a river valley cutting through tills producing residual concentrates.

The study was done by systematically traversing most section lines in the study area, noting the presence of glacial erratics and recording the sizes of the largest boulders found. Many of the glacial erratics found showed evidence of being moved by human activity and were found in rock piles. Rock piles were studied and sizes of largest erratics in them were also noted.

Most free-standing boulders found outside the Souris River Valley showed evidence of human movement. Within the Souris Valley, between Velva and Verendrye, free-standing boulders were observed which did not appear to have been moved. The largest such boulder exceeded 4 meters in length and 3 meters in width. The presence of free-standing boulders in the Souris Valley appears to be explained as a residual concentrate left after the erosion of an end moraine by the Souris River.

The size and concentration of the free-standing boulders in the Souris River study area were compared with the concentration and size of boulders between Mandan and New Salem in Morton County, North Dakota. The largest boulder observed in Morton County was 6 meters in length and 4 meters in width. The boulders in Morton County appear similar in size and concention to those found along the Souris River between Velva and Verendrye. The geographic area covered by free-standing boulders in Morton County is more extensive than is present in the Souris River study area. The Morton County boulders appear to be the residual concentrate left after the dissection of a topographic surface on which a major end moraine had been deposited.

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50

NEW DISCOVERY OF A TOPOTYPE OF PROCAMELUS GRANDIS GREGORY FROM THE MIOCENE (CLARENDONIAN) BIG SPRING CANYON LOCALITY IN SOUTH DAKOTA

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Introduction: Investigation of the local fauna preserved at Big Spring Canyon in Bennett County, South Dakota, from which this remarkably preserved camel was derived, began in 1902-03 by J.W. Gidley, W.D. Matthew, and H.F. Osborn. However, these investigators described no camelids from the locality. In 1933-37, expeditions from the University of California under the direction of R.A. Stirton made extensive collections from Big Spring Canyon (University of California Museum of Paleontology (UCMP) locality, V-3322; South Dakota School of Mines, Museum of Geology (SDSM) locality, V-512). Gregory (1939, 1942) described the local fauna which included four genera of camelids, including the description of a new camel, Procamelus grandis. This species is based on two skulls (UCMP 32864, 32301), a rostrum (UCMP 33449), partial dentaries (UCMP 32589), and postcranial elements. Although later investigators such as P.O. McGrew and researchers from the Museum of Geology have collected camels from the locality, none have been described. During the summer of 1984, an almost complete cranium and atlas of P. grandis were found in a well rounded and sorted, medium-grained quartz sandstone characterized by numerous calcareous root casts. The protruding occipital portion of the upside down cranium was found by Ms. Diane McCain, who was a student in the field paleontology course offerred by the Black Hills Natural Sciences Field Station. The atlas was found disarticulated from the cranium about 20 cm away.

Description: Procamelus grandis Gregory, 1939

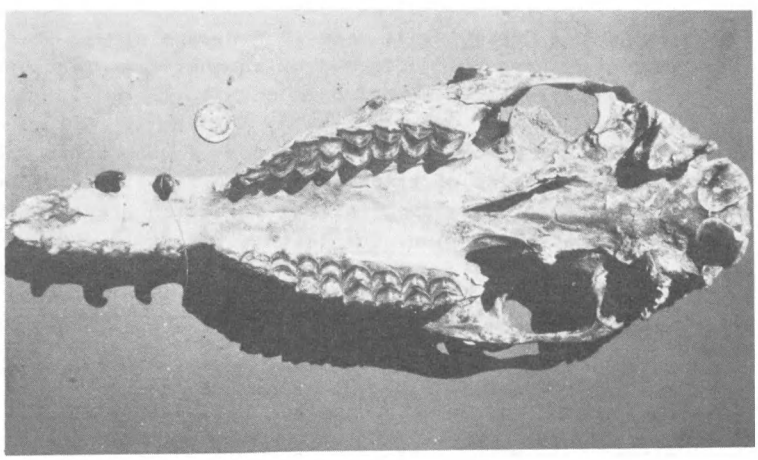
Topotype: SDSM 12135, atlas and cranium. Cranium complete except for left I^3 and P^2.

This cranium rivals the type, UCMP 32864, and the paratype, UCMP 32301, in complete preservation. In fact, the rostrum, caniniform teeth, and pterygoid processes are better preserved, and SDSM 12135 is uncrushed. The preservation is remarkable as demonstrated by the presence of the delicate pterygoid and paraoccipital processes.

Compared to the specimens described by Gregory, SDSM 12135 is very similar. Dorsally, SDSM 12135 compares well with the descriptions of Gregory except for a slightly longer supraorbital notch (20 mm), and the posterior sutures of the nasals are indistinct. Ventrally, the posterior palatine foramina are opposite the posterior margin of P^4 as described for one of the three UCMP specimens by Gregory. Unlike the previously described specimens, the pterygoid processes are well preserved. The processes arise opposite the posterior border of M^3, extend posteriorly to form an articular facet which is in dorsoventral line with the postorbital process, and descend to fade into the basicranium anterior to the auditory bullae. The processes are composed of thin sheets of bone which are even slightly broken on this very well preserved specimen, and the articular facets are triangular and deflected laterally.

The dentition is moderately worn. The canines are the largest of the caniniform teeth and are recurved similar to the P^1. Both teeth have wear on their tips. Conversely, the I^3 curves anteriorly, and the wear facet is on the tip but slopes anteriorly to near the enamel-cementum contact. Therefore, the C and P^1 appear to have functioned separately as a unit. As is characteristic of the taxon, the P^2 consists of a single blade, the internal crescent of the P^3 is incomplete, and that of the P^4 is complete.

Figure 1. Procamelus grandis, SDSM 12135



Cranium length	442 mm
Premaxilla to condyle length	385 mm
Width across postorbitals	163 mm
Width between auditory meati	98 mm
P^2-P^4 length	35 mm
P^4-M^3 length	99 mm
M^1-M^3 length	83 mm

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51 **MODE AND TEMPO OF EVOLUTION: A MODEL FROM EARLY EOCENE MAMMALS OF COLORADO**

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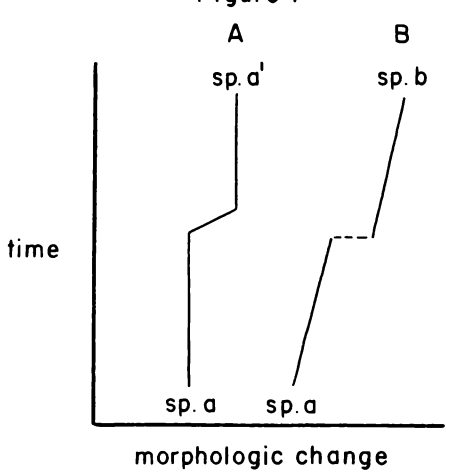
Recent publication of a new model of evolution has added "punctuated gradualism" to phyletic terminology (1). This model involves rapid, but not geologically instantaneous, morphologic change between much longer periods of stability (Figure 1a). As described, this model does not involve a speciation event nor is the gradual change punctuated. Instead it is morphologic stasis interrupted by gradual change.

Figure 1



Fossil mammals from the DeBeque Formation (latest Paleocene to middle Eocene, approximately 55-49 ma) of the Piceance Creek Basin, northwestern Colorado, represent more than 120 species. One genus, Hyopsodus, is relatively common and demonstrates a new evolutionary model. The oldest species in the formation is Hyopsodus, sp.,nr. H. latidens which is primitively small, but shows a gradual increase in size from the early to middle Wasatchian faunas. It is recognized by its size and by the presence of small paraconid on the first lower molar (M/1).

Within the middle Wasatchian fauna there is an immigration event marked by the appearance of species from three families of condylarths (Hyopsodontidae, Phenacodontidae, and Meniscotheriidae) and two of perissodactyls (Equidae and Helaletidae). At the level of this event, H. sp.,nr. H. latidens becomes extinct with two new species appearing. Hyopsodus cf. wortmani is smaller (approximately 12%) and differs morphologically in not having a paraconid on M/1. Hyopsodus cf. miticulus is larger (approximately 15-17%) but retains the M/1 paraconid. The possible explanations are: 1) both H. cf. wortmani and H. cf. miticulus are immigrants into the basin, 2) H. sp.,nr. H. latidens splits into two lineages represented by the new larger and smaller species, 3) H. cf. wortmani is an immigrant and H. cf. miticulus is derived from H. sp.,nr. H. latidens, or 4) H. cf. miticulus is the immigrant and H. cf. wortmani is derived from H. sp.,nr. H. latidens. Of these, the third hypothesis is preferred over the fourth because deriving H. cf. wortmani from the native population requires a reversal in the trend of increasing size and because of the different M/1 condition displayed by H. cf. wortmani. The first and second hypotheses are both more complex than the third.

Hyopsodus cf. miticulus is seen to increase slowly in size during the middle Wasatchian. Its rate of increase may have been affected by another immigrant species, Hyopsodus powellianus which is larger and notably lacks a paraconid on M/1.

The evolutionary model proposed is one of an endemic species undergoing gradual change over a relatively long period of time. This trend is altered by an immigration event involving a smaller, more advanced species causing intense selection pressure for larger individuals of the native species and resulting in speciation. Thereafter, the newly evolved species shows a gradual trend toward larger size. This model suggests gradual change punctuated by geologically instantaneous change followed by a return to gradual change (Figure 1b). Semantically, "punctuated gradualism" is more aptly applied to this model than it is to the previously described one.

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52 THE INFLUENCE OF HOMESTEAD/GRASSLAND VEGETATION ON SOIL PHYSICAL, CHEMICAL AND MORPHOLOGICAL PROPERTIES OF A NEBISH SOIL FORMED UNDER MAPLE FOREST VEGETATION

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Two sites were selected in Tamarack National Wildlife Refuge in western Minnesota. Both sites studied were located on a sandy loam moraine. Two soil profiles of the Nebish series with opposite aspects and similar landscape positions were chosen for evaluation: homestead/grassland (HP) and forest (HT) sites. The HP site was cleared and plowed circa 1900 with plowing continuing into the late 1950's. This area remains in grass as the forest has not yet reinvaded the cleared lands. Present plant community at the HP site includes western wheatgrass (Agropyron smithii), yarrow (Achillea millefolium), smooth brome (Bromus inermis) and bluegrass (Poa spp.). Grass was dense with a thick litter cover. The forested sites (HT) consisted of red maple (Acer rubrum) age 50 years, paper birch (Betula papyrifera) age 35 years, with basswood (Tilia americana) and red oak (Quercus rubra). This study demonstrates the influence of vegetation after tree removal, plowing and cropping on selected morphological, physical and chemical properties of some forest soils.

Since no major aspect influence was noted, the average morphological, physical and chemical properties for each of the sites are reported in Table 1. The morphological features: texture, horizon depth and color were similar for both sites. Soil moisture contents were similar for all horizons, except for the A horizon; the HT site had nearly twice the moisture content as did the HP site. Greater soil moisture content is attributed to the greater water holding capacity of the organic matter (TOC). The HT site had a higher TOC content in the A horizon than the HP site. The lower TOC content at the HP site is thought to be due to the mixing of the A and E horizons during plowing, with subsequent oxidation of organic matter, and accelerated erosion. The elements P, K, Ca, and Mg had similar trends for all sites, so only Ca is discussed here. The Ca distribution between the two sites were similar for the E and Bt horizons, while the A horizon differed greatly. The HP site had a lower Ca value in the A horizon as compared to the HT site. The E horizon for both sites had the lowest Ca value. These sites show evidence of nutrient pumping or biocycling, but subsequent leaching after forest removal has altered the elemental distribution (1, 3). Therefore, the HP site demonstrates Ca removal since the forest cycle was broken. Leaching of bases is occurring at a more rapid rate than loss of these elements by erosion.

Vegetative changes from forest to homestead/grassland influenced some physical and chemical soil properties but the morphological influence imparted by the original forest vegetation remains.

Table 1. Average morphological, physical and chemical properties of the Nebish soil studied.[2]

Horizon	Thickness (cm)	Moist Color	Texture	Moisture (%) (θm)	TOC (%)	[P	K	Ca	Mg] (ppm)
				HP (Grass)					
Ap	0-19	10YR 2/1	sl	18.6	1.37	4.7	92	1063	104
E	19-36	10YR 4/2	sl	12.6	0.20	5.5	68	751	90
Bt	36-51	10YR 5/2	scl	15.8	0.18	18.0	122	1844	242
				HT (Forest)					
A	0-13	10YR 2/1	sl	38.7	4.39	14.5	128	3095	226
E	13-35	10YR 5/3	sl	12.8	0.37	5.5	51	844	90
Bt	35+	10YR 4/4	scl	16.4	0.16	16.5	117	1719	262

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53 INFLUENCE OF JACK PINE AND DECIDUOUS VEGETATION ON SOIL CHEMICAL AND MORPHOLOGICAL PROPERTIES

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Sites were selected along the Ogemash Trail south of the Sioux burial mounds in the Tamarac National Wildlife Refuge, western Minnesota (SE 1/4, Sec. 28, T 141 N, R 39 W). The areas studied have similar landscape position and sandy-loam parent material but differ in predominant vegetation. Two soil profiles were sampled in each of a jack pine (Pinus banksiana) stand and an adjacent stand of bur oak (Quercus macrocarpa) and aspen (Populus tremuloides). The age of both stands is approximately 60 years. Previous observations indicated a difference in soil morphology between the sites which was hypothesized to be the result of greater iron movement in the jack-pine soils. To test this hypothesis, soils of the adjacent sites were compared with respect to soil morphological and chemical properties. Of particular interest were the content of soil lipids and fulvic acids which were thought to be involved in the process of iron translocation.

Morphological and chemical data for two of the four profiles are listed in Table 1. The profiles are similar with respect to texture, pH, fulvic acids, organic carbon, and extractable calcium. Calcium values show the effect of nutrient pumping, a common feature of forest soils. The high value for organic carbon in the A horizon of the jack pine site is most likely due to inclusion of a small amount of Oa material. Although the fulvic acid contents of the soils appear similar, the Oe horizons of the jack-pine sites are thicker than those of the deciduous sites, suggesting a higher total amount of fulvic acids in the former.

The main difference between profiles is the presence of a thick, light-colored E horizon in the jack-pine soil which is absent in the deciduous site. Translocation of iron is evidenced by the small amounts of free iron oxides in the E horizon, and much larger amounts in the underlying B horizon. High lipid and water-repellency values in the jack-pine soils suggest a possible mechanism for iron translocation. A high content of lipids makes the soil increasingly water repellent, thereby reducing its infiltration capacity and giving the soil a droughty tendency. Only when large amounts of water have accumulated at the soil surface would much leaching occur. Under these conditions the soil would be flushed with a relatively large volume of water containing fulvic acids, which would complex and translocate soil iron. Soils under deciduous vegetation do not have this tendency because leaching tends to be less episodic and therefore less intense.

While a detailed vegetational history of the two sites is not available, we can be fairly certain that the present vegetation type has influenced soil development during the last 60 years. The striking differences in soil morphology can be attributed primarily to recent vegetational differences.

Table 1. Morphological and chemical data for soils formed under jack pine and deciduous vegetation.

Site	Depth	Horizon	Texture	Color Munsell	pH	Ca^{+2}	Org. C	Free Iron Oxides[1]	Fulvic Acids[3]	Lipids[3]	Water Repellency[2]
	cm					mg kg^{-1}			%		s
FJ2	9-5	Oe							0.42	2.90	67
Jack	5-0	Oa								0.62	253
Pine	0-6	A	s.l.	7.5YR 2/0	5.7	1940	4.70	0.34	0.33	0.22	
	6-11	AE	s.l.	10YR 2/2	6.0	1130	0.81	0.31			
	11-47	E	s.l.	10YR 5/4	6.2	560	20	0.26			
	47-107	B	s.l.	10YR 4/4	7.3	810	0.12	0.51			
	107-127	C	s.l.	10YR 4/6	7.9	810	0.08	0.28			
FN2	4-2	Oe							0.25	0.17	1
Decid-	2-0	Oa								0.16	3
uous	0-9	A	s.l.	10YR 2/1	5.4	1500	2.15	0.41	0.49	0.07	
	9-19	AB	s.l.	10YR 3/3	7.0	810	0.18	0.41			
	19-37	BW	s.l.	10YR 4/3	6.6	940	0.35	0.41			
	37-	C	s.l.	10YR 4/6	6.5	440	0.20	0.33			

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54

PEDOLOGIC STUDY OF ARCHAEOLOGICAL SITES ALONG THE RED RIVER

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Soils were examined at two archaeological sites (21 NR 9 and 21 NR 29 -- hereafter, sites 1 and 2) in Norman County, MN. Both of these contain stratified cultural deposits dating to the Middle Archaic and Late Woodland periods. The earlier materials in site 1 were found at 90-110 cm below surface, while in site 2 they were buried at about 160 cm. Late Woodland artifacts and culturally generated debris at both sites were from 0-50 cm. The Archaic component at site 1 is dated by 14 C to 4300-3300 b.p. (all dates are uncorrected radiometric years). At site 2 they are more precisely dated to 3400 b.p. Late Woodland pottery from site 2 is dated to 940 b.p. by means of three thermoluminescence assays.

The 2 sites are along the Red River on terracettes below the lacustrine plain but over 3 m above the stream. The sediments are mostly fluvial, but site 1 may have received minor slope wash material. The soils are members of the Cashel and Wahpeton soil series. Descriptions were by standard techniques. Particle size was by sand sieving and clay hydrometer (site 1) and pipette (site 2). Soil pH was by 1:1 soil-water ratio with a Beckman pH meter. Extractable P and K contents were determined by NDSU Soil Test Lab methods[1].

Numerous buried soil horizons are observed in both sites (Fig. 1) which indicate stability periods and flooding episodes. Time was sufficient to develop at least four distinct A-horizons at both sites. At site 1 the base of 4AB contained charcoal dated to 2710 b.p.± 110 (Beta 1536). At site 2 dates of 3420 b.p.± 60 and 3400 b.p.± 50 (Beta 7335 and 7336) were obtained on charcoal from a depth of 160 cm at the base of 3AB. These horizons often have $CaCO_3$, abundant organic matter, high K, and lack evidence of translocated clay which indicate a climate at least as dry as the present climate. The correlations given below are based on observed organic matter, color, and structure. Evidence that the profiles have similar histories even though site 2 is nearly twice as deep is the fact that both soils contain 2.8 g of organic carbon.

The cultural horizons were expected to be high in extractable P. These horizons contained only modest amounts -- hardly more than overlying horizons. Site 2 had been fertilized with a phosphatic fertilizer. The buried A-horizons in site 2 were higher in extractable K than other horizons, but in site 1, K contents were similar in every horizon. The textures were silty clays and clays. The pH reflected carbonate presence and little leaching. The carbonates are in concretions and on macropore walls in the buried A-horizons which indicate removal from above and reprecipitation in the lower horizons.

We wish to emphasize the principal point of this presentation is that 4 well defined A-horizons were formed in deposits containing dateable archaeological materials along the Red River. At one site, 3 A-horizons formed during the past 3500 years, and the two most recent of these formed during the last 940 years. At the other site, 4 A-horizons formed during the last 2700 years.

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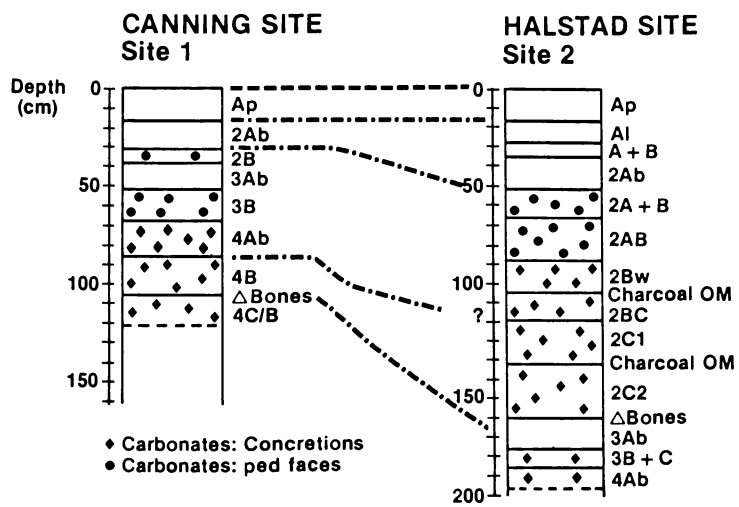

Fig. 1

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Charles John Brydges' Observations on an American Railway Connection for Winnipeg

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Winnipeg is a major Canadian transportation center. Its development as a gateway city resulted from people's manipulation of its hinge position between the prairies and the Canadian Shield. Yet, it is business entrepreneurs, consumers, and government officials who influence regional central place hierarchy changes. Charles John Brydges, Hudson's Bay Company Land Commissioner from 1879-1889, was a key decision-maker during Winnipeg's initial development in the Prairie Provinces' urban system. Studying excerpts of Brydges' correspondence that emphasized Winnipeg's hinterland expansion reveals the importance of using historical geography evidence when attempting to understand that modern city's functional evolution and role in Canada's system of cities.

While Winnipeg became the "Bull's Eye of the Dominion," it also benefitted from railway access to the United States. The Pembina Branch, a Canadian Pacific Railway line from St. Boniface (Manitoba) that joined with the St. Paul, Minneapolis and Manitoba Railway at Noyes (Minnesota) in 1878, provided the first connection southward. Indeed, until the completion of the eastern portion of the Canadian Pacific Railway, railroad movements from Montreal to Winnipeg had to pass over that route. Furthermore, the monopolies of these two railways stimulated efforts in Winnipeg to secure additional railroad services during the 1880's.

Correspondence by Brydges provides insights into the struggles of Winnipeg's citizens to gain more diversified railway service. Efforts to break existing transportation monopolies included attempts to build a Winnipeg-Hudson Bay connection and a Winnipeg-Grand Forks-Minneapolis route. Brydges was an advocate of such schemes as illustrated by his letter to another executive on February 2, 1887 (1: 250):

> "The Northern Pacific has reached Grand Forks, only about 80 miles from Pembina & they are stated to have made arrangements to build to the boundary this year. They will unquestionably try to get into Winnipeg, and would certainly join the Hudsons Bay railway wherever their station was established."
>
> "I think there is no doubt but that the construction of the Hudsons Bay railway will go on, and that it will reach the northern boundary of Manitoba at least, thus opening up a large area of country between Lakes Winnipeg and Manitoba which would otherwise be inaccessible to settlers. I think it is equally clear that a line of railway from the south will get in here, and that its natural objective will be where the H.B. [Hudsons Bay] railway has established itself."
>
> "...I fail to see how the entry of a line from the south is to be stopped. And I do not believe it would be injurious to the C.P.R. [Canadian Pacific Railway]. Facilities create trade, and the experience all over the United States & Canada has been that the opening of apparently competing lines, has resulted in increasing trade and has not injured existing lines."

Winnipeg's development as a railway-oriented gateway city was contingent upon people's manipulation of its hinge position location. Analyzing Brydges' correspondence is valuable in that it introduces researchers to what Harley (2) cites as a theme of historical geography: studying evidence itself. Reading the current human landscape requires an understanding of its historical geography. Winnipeg's present transportation functions are best understood using many sources, but one significant aspect of its development is to be found in studying the late nineteenth century spatial relationship of hinges, gateways, and Brydges.

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56 INVERSE MODELING OF SOLUTE TRANSPORT IN SHALLOW GROUND WATER:
WITH AN EXAMPLE OF SULFATE MOVEMENT AROUND A LIGNITE MINE IN SOUTHWESTERN NORTH DAKOTA

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Numerical modeling of solute transport in ground-water systems is still in its infancy. Even ignoring uncertainty in modeling ground-water flow, simulation of solute transport is subject to enormous uncertainty because of our present inability to model many of the complex chemical reactions that occur in nature. To date, solute-transport models only have been successful in simulating movement of a few conservative constituents or, at best, a few constituents that react independent of any other constituents present in the system. Because of the complexity of the mathematical formulations necessary to simulate the chemical reactions, such models have been able to simulate transport of no more than three constituents at a time. Few potentially hazardous constituents are conservative. Most constituents undergo multiple complex chemical reactions during their migration through a ground-water system. Accordingly, most numerical formulations of solute transport have not been able to address environmental problems.

By comparison, equilibrium geochemical models explaining the instantaneous chemical composition of natural waters have improved substantially in recent years. These models commonly can simulate simultaneous, multiple-component, complex chemical reactions, including precipitation-dissolution reactions, cation- and anion-exchange reactions, reduction-oxidation reactions, and mixing of two end-member waters. The ability of these models to simulate natural conditions is limited only by the availability of thermodynamic data and the approach of the system to equilibrium. However, equilibrium geochemical models do not simulate transport.

An approach that holds promise for simulating the transport of multiple, nonconservative chemical constituents in ground water is inverse solute-transport modeling. In this approach, ground-water flow is simulated first using a traditional ground-water flow model, such as the U.S. Geological Survey's modular, three-dimensional, finite-difference, ground-water flow model (1). Next, chemical analyses from several wells along a single ground-water flow path are selected for equilibrium geochemical modeling. Analyses of ground water from an upgradient and a downgradient well are compared using a mass-balance geochemical model such as BALANCE (2). The mass-balance model defines and quantifies a set of chemical reactions that would have to occur along the flow path from the upgradient well to produce water with a chemistry identical to that found in the downgradient well. Quantities are calculated solely on mass-balance constraints, independent of kinetics. Because the combination of reactions that might be considered to result in this composition change is not unique, the modeler needs to be capable of identifying the most probable and reasonable chemical reactions to be included in simulations using a mass-balance model. Implicit in the approach is the assumption that ground-water movement is slow compared with the speed of chemical reactions, so that the water is assumed to be at equilibrium at each point on the flow path. Once the most probable chemical reactions that might account for the compositional change have been identified and quantified, these reactions need to be simulated using an ion-pairing aqueous equilibrium model to confirm that equilibrium kinetics would permit the compositional change to occur during the time of transport. Geochemical models such as PHREEQE (3) permit rapid calculation of the water composition that would result from exposing the initial (upgradient) ground water to the proportion of chemical reactions identified by the mass-balance model. If the resultant modeled compositional change still matches the actual changes, the simulation is assumed to be representative of chemical reactions occurring along the modeled ground-water flow path, provided no hydrologic or geologic conditions affecting the modeled flow change. The resultant ground-water geochemical model may be calibrated by comparing results along the flow path with determinations of water quality at an intermediate site between the upgradient and downgradient sites used to develop the model. Assuming the calibration check agrees with the ground-water composition at the intermediate site, solute transport may be predicted by projecting the model down the flow path beyond the original downgradient site.

Use of this approach in a ground-water geochemistry investigation in the vicinity of the Gascoyne open-pit lignite mine in southwestern North Dakota was attempted to simulate transport of sulfate from disturbed aquifers in the mine area downgradient toward undisturbed-aquifer discharge areas along Buffalo Creek. For the major constituents modeled, agreement with measured concentrations 2 miles downgradient was within 20 percent.

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57 WINTER EFFECTS ON THE SALT BALANCE OF SALINE PONDS IN NORTH DAKOTA

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Fall and winter water samples and a selection of winter ice samples were collected from two saline ponds in Nelson Co., ND to determine the seasonal dynamics of dissolved solids in saline wetlands. All samples were analyzed for electrical conductivity (EC) and major dissolved ions (Table 1). During winter sampling, the presence of wind-blown salt drifts up to 10 cm deep were noted in the emergent vegetation rimming these ponds. Samples of this salt were collected and analyzed for major chemical constituents and solid phase minerals (Table 1).

In all cases pondwater salinity, measured as EC, increased 2-3 times from fall to winter. Winter ice was much less saline than the associated pondwater, but its salt load was still considerable. These results are similar to those of Ficken (1). Pondwater freezes from the surface downward. Since ice crystallizes out of solution in a pure state, dissolved constituents are concentrated in the adjacent water. These constituents then diffuse downward to less concentrated solution, resulting in progressively more saline pondwater as the ice thickens. The salts left behind in the ice are present as entrapped crystals and either redissolve upon ice-melt or remain when the ice sublimes. The presence of wind-blown salt indicates that sublimation releases a considerable amount of ice-entrapped salt.

The chemical composition of ice and pondwater indicates that sulfates of magnesium and sodium are dominant, with lesser amounts of calcium, bicarbonate, and chloride. A comparison of the ionic composition of ice and underlying pond water suggests that the proportions of anions are similar in both; however, the pondwater is enriched in Mg^{+2} at the expense of Ca^{+2} and Na^{+}. This is most likely a result of the relatively low solubility of gypsum ($CaSO_4$) and mirabilite ($Na_2SO_4 \cdot 10H_2O$). Mirabilite in particular exhibits a temperature dependent decrease in solubility (500 g/l at 32°C to 50 g/l at 0°C). In a solution undergoing concentration through freezing, these salts would reach saturation and precipitate earlier than the more soluble Mg-sulfates, thus allowing the solution to become Mg^{+2} enriched.

The selective precipitation on freezing hypothesis is further supported by an examination of the wind-drifted salt mineralogy. An x-ray diffraction analysis indicated the presence of several sulfate salts, specifically gypsum, mirabilite, thenardite (Na_2SO_4), and epsomite ($Na_2SO_4 \cdot 7H_2O$). The double salt konyaite ($Na_2Mg(SO_4)_2 \cdot 5H_2O$) was expected but not observed. Total analysis of salt confirms the presence of larger relative amounts of Ca^{+2} and Na^{+} than was found in the associated pondwater. The relative amounts of cations and anions more closely resemble the composition of the ice but are even more enriched in Ca and Na, possibly due to the fact that Ca and Na-sulfates precipitate out of freezing solutions earlier and are more likely to be ice-entrapped.

Winter freeze-over has a profound effect on the salt balance of saline ponds. Dissolved solids accumulate in unfrozen pondwater to such high levels that saturation equilibria of soluble minerals determines pondwater chemistry. Sublimation of ice releases ice-entrapped salt and acts as a mechanism to remove soluble salts from pondwater.

Table 1. Conductivity and relative ionic composition of unfrozen water, ice, and aeolian salt from two wetlands in Nelson Co., ND.

Wetland	Sample	EC	$SO_4^{=}$	Cl^{-}	$CO_3^{=}$	HCO_3^{-}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
		mho/cm	% anions				% cations			
1	Fall*	18,300	96.3	2.3	-	1.2	4.6	42.5	50.9	2.1
	Winter 1**	43,970	94.7	1.7	-	3.5	2.1	54.5	42.3	1.1
	Ice 1**	11,090	95.8	1.5	.05	2.5	6.8	40.5	51.4	1.3
	Winter 2**	61,890	95.4	2.0	-	2.5	1.5	59.7	37.3	1.6
	Ice 2**	13,680	95.1	2.0	-	2.9	3.5	47.0	46.3	1.7
	Winter 3**	40,600	93.2	1.8	-	5.0	2.7	53.9	42.3	1.0
	Ice 3**	8,030	93.5	1.9	.07	4.6	4.4	46.3	47.7	1.6
	Aeolian** Salt	--	96.5	0.9	1.2	1.4	8.6	26.1	64.5	0.7
2	Fall*	14,310	91.5	7.1	-	1.5	5.5	39.3	53.3	2.1
	Winter**	50,810	91.4	6.3	-	2.3	2.2	50.8	45.2	1.7

* = Sampled 7/84; ** = Sampled 11/84.

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58

RELATIONSHIP BETWEEN STREAM FLOW AND SALINITY OF NORTH DAKOTA RIVERS

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The mean total salinity of the water in 83 North Dakota rivers is 1,160 µmhos/cm (Maianu, 1985). Individual values of the water salinity vary considerably depending upon the particular river, season, and stream flow. The extreme individual values ranged from 6.70 µmhos/cm to 9,490 µmhos/cm. Previously the rivers had been classified in eight salinity groups according to their salt composition change as total salinity increases (Maianu, 1985).

Figure 1 shows the chemical composition of four rivers, each one in a different group. The total salinity is different for each river and the water chemical composition varies dramatically. For example, Park River - North Branch (group two) has a low total salinity and exhibits little variation in salinity with stream flow rate. Tobacco Garden Creek (group seven) has a very high total salinity, which varies greatly as stream flow rate changes. Wild Rice River (group four) is intermediate. A special situation exists with large rivers, such as the Missouri River, the fourth example in Fig. 1. The total salinity and chemical composition of Missouri River water are relatively constant in all seasons.

The highest values of total salinity are found in rivers that drain saline aquifers, cross salty deposits, and/or have a low stream flow. Low values of total salinity are characteristic of rivers which drain acquifers or cross geologic deposits with low salinity and have high stream flow. For example, the rivers in group one, which drain aquifers with high salinity and cross saline soil areas, have some of the highest values of total salinity. The rivers of group seven, which drain aquifers with a low salinity, have some of the lowest total salinity values.

Stream flow is the dominant natural factor influencing the variation of water salinity. The curves in Fig. 2 show that salinity and stream flow are inversely related for all eight river groups. Generally, the salinity of river water increases from 500 µmhos/cm to very high values as the flow decreases from 10,000 ft^3/s to less than 25 ft^3/s. In this interval there are differences between the river groups according to both the minimum values of total salinity, and the maximum values of the stream flow (Fig. 2).

At salinity values higher than 1,500 µmhos/cm, there is a rapid salinity increase for stream flows less than 25 ft^3/cm. For example, as stream flow decreases from 10,000 ft^3/s to 25 ft^3/s there is a salinity increase of 1,000 µmhos/cm; as stream flow decreases from 25 ft^3/s down to 10 ft^3/s, the salinity increases 8,000 µmhos/cm (from 1,500 to 9,500 µmhos/cm). For this reason the maximum variation of river water salinity takes place in streams with moderate to low stream flow. Streams with a moderate stream flow are primarily in groups six, seven and eight and are located in the Missouri Basin. These streams have extreme variations in salinity (50 - 9,500 µmhos/cm) at low stream flow values (10 - 18,000 ft^3/s).

The rivers with high flow are in group two and three (10 - 95,000 ft^3/s) and generally do not have salinity values over 2,000 - 3,000 µmhos/cm at their lowest flow. A special situation exists in group one, in which rivers have very high salinity (2,000 - 7,400 µmhos/cm) but very low flows (100 - 9,500 ft^3/s).

*Maianu, A. (1985). J. Environmental Quality, No. 2, Salt Accumulation in the Rivers of North Dakota. (In press).

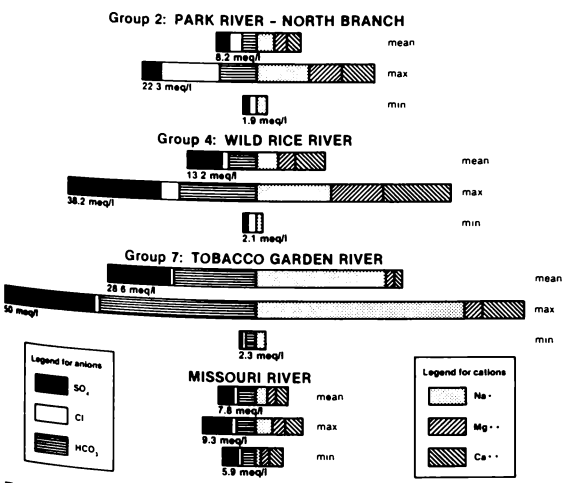

Fig. 1. Chemical composition of representative river waters.

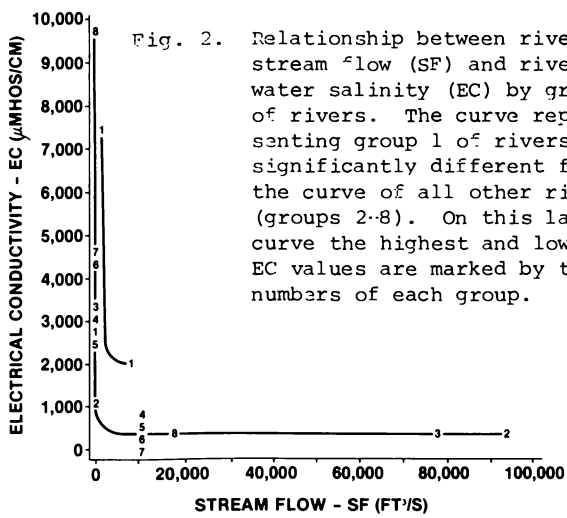

Fig. 2. Relationship between river stream flow (SF) and river water salinity (EC) by groups of rivers. The curve representing group 1 of rivers is significantly different from the curve of all other rivers (groups 2-8). On this last curve the highest and lowest EC values are marked by the numbers of each group.

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INDUCED CHROMOSOME BREAKAGE AND MUTAGENICITY BY THE HERBICIDE 2,4,5-T IN MAMMALIAN CELLS

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Herbicides sprayed in an ecosystem contact not only the targeted plants but also the animals living in that environment, including humans. The hormonic herbicide 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) was in wide use in the U.S. until 1979 when its use was restricted and its extremely toxic contaminant 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin) was severely limited to 0.1 ppm. Research on essentially 'pure' 2,4,5-T in mammalian systems remains few and inconclusive (1). The object of this study was to determine the chromosomal and genetic damage of this compound, analyzed by the E.P.A. to be free from dioxin at 39 ppt, to mammalian cells.

Chromosome breakage is an important indicator of damage induced by a compound, while the rates of sister chromatid exchanges are a sensitive measure of induced genetic effects. Cells exposed for a 4-hr versus 24-hr period allow for the assessment of the direct effect of the compound compared to the indirect effects of its metabolites produced in mammalian systems or side effects from inhibition of mammalian enzymes. In this study 50 cells were analyzed for each treatment and controls from mouse bone marrow cells exposed *in vivo* and human lymphocytes exposed *in vitro*. Ten DBA mice from 2 litters of 5 or more siblings at about 3 weeks of age were exposed to three treatments (5, 50 and 65 mg/kg) and two controls (no treatment and DMSO). These experiments were conducted for 4-hr and 24-hr exposures and the bone marrow was processed by standard techniques.

The whole blood cultures from three normal donors were subjected to five treatments (5, 20, 50, 100 and 200 µg/ml) and two controls (no treatment and DMSO). These levels of exposure are being conducted at 4-hr and 24-hr periods. The cultures are being harvested by the standard technique and the data are taken on a Zeiss photomicroscope III. The protocol used is in close agreement with the recommendations of the Genetox report (2).

The results indicate that the damage to the chromosomes occured primarily as gaps, particularly in the secondary constriction regions, though deletions, pycnosis, depressed mitotic indices, and mild G banding were also observed. The ANOVA indicated a lack of significant difference [$p(0.05)=2.09$] between the DMSO-treated control and the control receiving no treatment. The Dunnett's test indicated a highly significant increase [$p(0.01)=2.68$] in total aberrations in both the 4-hr and 24-hr treatments at the 5 mg/kg dosage in mouse bone marrow and a significant increase [$p(0.05)=2.29$] at the 5 and 20 µg/ml dosage in human lymphocytes. Total aberrations at the higher dosages decreased, though remained above the controls. This decrease may be due to selective mitotic inhibition from the enhanced toxicity of these concentrations. The results of sister chromatid exchanges are being analyzed.

Since 2,4,5-T and related herbicides readily biodegrade in soil or water within a few weeks (3), the concern is not so much to entirely ban them but rather to advise caution in their use. One study reported field hands being exposed to herbicide solutions of 2% phenoxy acids in kerosene. The average amount of 2,4,5-T found in the urine of these workers following a day of exposure was 4.5 µg/ml with a range of 1-11 µg/ml 2,4,5-T (4). Because of the potential for genetic damage, more concerted efforts should be directed to test the effects of 2,4,5-T in mammalian systems. The results of this study indicate that direct and repeated exposure to this compound must be looked at with concern since exposure to 5 ppm or higher dosages may well be genotoxic.

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18 ESTIMATION OF THE NESTING POPULATIONS OF PRAIRIE FALCONS AND GOLDEN EAGLES IN NORTH DAKOTA

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In North Dakota increasing resource development has led to a greater need for information about raptors, particularly species of special interest to management agencies. An extensive summary of information about all bird species in North Dakota was published in 1975 (1), and an intensive survey for raptors in a portion of Dunn County was completed in 1979 (2). In addition, unpublished raptor nesting data have been compiled in two locations (3,4), although much of the site-specific information about sensitive species is not available to the public. Other than these sources, information about nesting populations of raptors in the western part of the state is limited.

From 1982 through 1984 I conducted a study to determine the nesting populations of Prairie Falcons *(Falco mexicanus)* and Golden Eagles *(Aquila chrysaetos)* in western North Dakota. I began surveys on 1 May each season to minimize early season disturbances of Prairie Falcons. To minimize survey biases due to nesting failures and fledging of young, I ended surveys each season by 10 June. Three field assistants each year aided in the surveys. Working in pairs, we spent as much time as necessary to check every location in each survey unit that we believed might contain a nest. For preliminary surveys in 1982 I used clustered random sampling, drawing townships at random in the study area and then selecting sections at random in each township. This surveying system was unsatisfactory because the probability of locating a nest of either species in a quadrat was small and because it was inefficient to travel between numerous small quadrats.

To increase sampling efficiency for 1983 and 1984 I changed to quadrats of 9 square miles. Using all available information on nest site locations of both species, I established a stratified random sampling scheme comprised of three strata: (1) quadrats with reported nests of either species, (2) quadrats which had not been systematically surveyed and in which there were no reported nests, and (3) quadrats which had been surveyed by U.S. Fish and Wildlife Service personnel in 1982 and in which they had found no Prairie Falcon or Golden Eagle nests. Poor weather, difficult terrain in many quadrats, and time necessary for travel between quadrats limited sample sizes; we surveyed 15 quadrats each year. The time necessary to survey a quadrat ranged from a few minutes to three days.

The differences between the 1983 and 1984 survey results (Table) reflect the difficulty in obtaining large sample sizes for nesting Prairie Falcons and Golden Eagles in North Dakota. However, a composite of the results of 1983 and 1984 samples (based on the 1984 study area) indicates nesting populations of 95±63 and 95±62 pairs of Prairie Falcons and Golden Eagles, respectively (α=0.10).

1983 and 1984 Survey Results

Year	Number of Quadrats (Number Sampled)				Nests Located		Population Estimates (α=0.10)	
	High Priority Stratum	Medium Priority Stratum	Low Priority Stratum	Total	Prairie Falcons	Golden Eagles	Prairie Falcons	Golden Eagles
1983	148(7)	322(5)	214(3)	684(15)	5	2	149±146	21±40
1984	148(7)	212(5)	115(3)	475(15)	2	5	64±91	169±112

Because the effectiveness of searches for Prairie Falcons depends to a great extent on adults responding to intrusions near their aeries, in 1984 I attempted to assess biases in ground surveys for nesting pairs. Factors I evaluated were number of adults present, distance between observers and responding adults (if any), and whether the aerie would be likely to be found in a normal ground survey. There was no apparent trend in the number of adults present when we visited the aeries or in responses to observers by adult falcons at successful aeries during the season. However, it was apparent that nesting failures and failures of adult falcons to respond to observers reduced survey accuracy. Approximately 37% of active Prairie Falcon aeries probably would not be seen during a single ground survey. In apparent contrast to what is seen in most other areas where Prairie Falcons nest, many aeries in North Dakota erode quickly. Therefore, surveys of known aeries are likely to be only moderately effective for gathering nesting population data. Extensive ground surveys are necessary to determine the Prairie Falcon nesting population, but aerial surveys should be much more effective for gathering Golden Eagle nesting data.

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19

The Bromination of Dibenzofuran

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Dibenzofuran (DBF, 1) has been observed to produce amorphous, infusible polymers when reacted with chloromethylating agents under Friedel-Crafts conditions.[1] These materials are of interest because of their thermal stability and their potential as conductive polymers. A general structure based on IR and cross polarization-magic angle spinning (CP/MAS) ^{13}C NMR spectral data has been proposed for these polymers,[2] but further verification by model compound syntheses and characterization is still in progress (Scheme I). As can be seen, the key reagent for the preparations of the model compounds is 2-bromodibenzofuran (2-BrDBF). Two methods of preparation of 2-BrDBF have been reported in literature-bromination of DBF with Br_2[3] or by conversion of 2-dibenzofuran-sulfonic acid (2-DBF-SO_3H).[4] In our laboratory the isolated yield of pure product from the bromination of DBF with Br_2 in CS_2 was less than that reported; the major difficulty was the removal of unreacted DBF and 2,8-dibromodibenzofuran (2,8-diBrDBF) from the crude reaction product. The conversion of 2-DBF-SO_3H to 2-BrDBF is a multistep process with a reported overall yield of only 33% and thus was not attempted. In order to effect a more efficient synthesis of 2-BrDBF three other methods of brominating aromatics in high yields were examined: 1) Br_2 in refluxing glacial acetic acid,[5] 2) N-bromosuccinimide (NBS) in N,N-dimethylformamide (DMF) solvent,[6] and 3) anhydrous cupric bromide in refluxing chlorobenzene.[7] The reactions were analyzed by gas chromatograhpy (G.C.) and the results are shown in Table I.

Scheme I

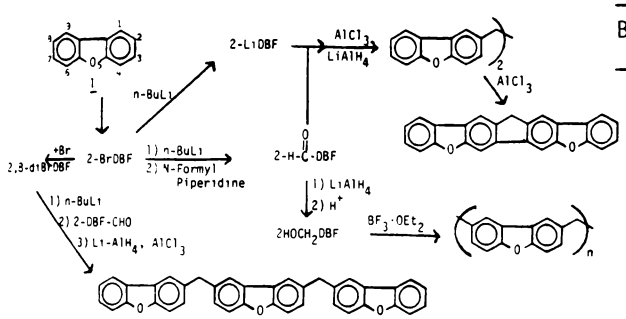

Table I. Results of Bromination of DBF

Brominating Agent	Solvent	Reaction Temp (°C)	Reaction Time (h)	2-BrDBF[a] / DBF
Br_2	CS_2	40	24	3.4
Br_2	AcOH	110	5	10.0
NBS	DMF	RT	84	4.5
$CuBr_2$	C_6H_5Cl	135	10	6.3

[a]Ratio determined by G.C. area percentages

From the ratios of the G.C. area percentages, the yields of 2-BrDBP are greatest from the Br_2/AcOH reaction followed by the $CuBr_2/C_6H_5Cl$ and the NBS/DMF reactions, respectively. The $CuBr_2/C_6H_5Cl$ bromination is very clean, i.e. no side products are observed other than small amounts of 2,8-diBrDBF. The reaction with Br_2/AcOH and especially with NBS/DMF afford unidentified side products and slightly more 2,8-diBrDBF than the aforementioned reaction. Bromination times for both the Br_2/AcOH and $CuBr_2/C_6H_5Cl$ reactions are short relative to the NBS/DMF and Br_2/CS_2 reactions. One possible advantage of using the $CuBr_2/C_6H_5Cl$ in place of the Br_2/AcOH for this bromination, despite the decreased yield, is that $CuBr_2$ is more convenient and safer to handle than Br_2.

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20

A NEW TECHNIQUE FOR CONSTRUCTING ARTIFICIAL AERIES FOR PRAIRIE FALCONS IN WESTERN NORTH DAKOTA

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Stewart (6) considered the prairie falcon (*Falco mexicanus*) to be uncommon and local in the badlands and on adjacent plains along the Little Missouri and Missouri Rivers in North Dakota. Allen (1) estimated the population at 95 nesting pairs. This low nesting density means that management of prairie falcons has become more important because of increased energy development in western North Dakota. Olendorff and Stoddart (5) stated that "nest site availability (not prey) limits raptor in many grasslands". Fyfe and Armbruster (4) found an increase in the numbers of nesting prairie falcons after excavating artificial aeries. I believe that nest sites are a limiting factor in western North Dakota, so construction of artificial aeries is one possible management tool. Three of 12 artificial aeries built in Dunn County in the 1970's (3) are known to have been used by prairie falcons (2). All were excavated in clay substrate and are subject to rapid erosion. In light of this problem, I devised a technique intended to alleviate excessive erosion and increase aerie longevity.

I chose sites for construction of artificial aeries by subjectively evaluating characteristics of natural aeries. I rappelled to the selected locations and excavated the cavities with hammers and chisels. I constructed 1 aerie in 1982, 5 in 1983, and 5 in 1984. To increase aerie longevity, 8 of the 11 excavated cavities were fitted with internal frames cubical in shape or with an arched roof, similar to mailboxes in appearance (Table 1). The "mailbox" design simplified construction and strengthened the structure of metal frames. Three of the "mailbox" aeries were designed so the entrance height was less than the height at the rear, in an attempt to prevent use of the cavities by great horned owls (*Bubo virginianus*). A 10cm front lip was added to each frame to contain a layer of sand on the floor for a nest scrape. I placed frames in the excavated cavities flush with the cliff faces and filled the space surrounding each frame with mortar to reduce the possibility of erosion around the aeries. The insides of the frames were painted, and exposed mortar was shaped to resemble substrate color and texture. In 3 instances the substrate was too hard to excavate cavities large enough to accomodate a prefrabricated frame. Four of the artificial aeries (2 metal and 2 without frames) were constructed near historically active natural aeries that had been destroyed by erosion. One metal frame was placed in a badly eroded natural aerie in 1984 after a clutch had been destroyed by erosion debris. None of the aeries constructed in 1982 or 1983 was active in 1984. Artificial aeries containing frames were stable and showed no significant erosion in 1984. Use of the aeries and their physical condition will be checked in 1985.

Artificial aeries may be an important management tool for prairie falcons in western North Dakota, with implications for peregrine falcon (*Falco peregrinus*) reintroduction. It remains to be seen if prairie falcons will nest in man-made structures or if the frames increase aerie longevity. Should the technique prove successful, however, I believe this management tool should be considered in areas where nest sites are limiting and substrate conditions are not conducive to aerie longevity.

I gratefully acknowledge assistance of George Allen, Mari Smaby, John Loegering, Chris Paige, Sharon Chase, and Bill Blunt in this project.

Table 1. Internal frame characteristics

Contruction	Dimensions (in cm) Width	Depth	Height at entrance	Height at rear
One plywood and 1 fiberglass "cubical"	51	51	51	51
Three sheetmetal "mailbox"	61	61	61	61
Three sheetmetal "mailbox"	51	56	46	58

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A STUDY OF THE MECHANISM OF HYDANTOIN FORMATION

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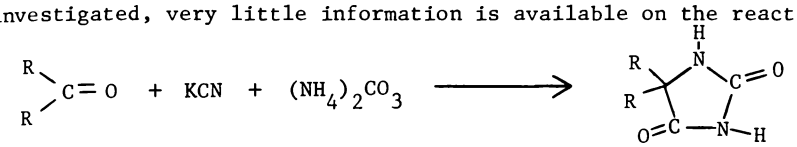
Hydantoins have been known for over one hundred years. They occur in nature, and are commonly found in sugar beets, butterfly wings, and other plants. Recently, hydantoin derivatives have been widely used for germicides, anti-convulsant drugs, stabilizers in photographic film, and in the preparation of amino acids.[1] Hydantoins are generally white, crystalline solids which are very polar and therefore highly soluble in water and other polar solvents.

Hydantoin itself (R=H,I) was first isolated by Baeyer in 1861 by the reduction or the hydrogenation of allantoin,[1] hence the name hydantoin. Strecker determined the structure of hydantoin a few years later in 1870.[1]

The most general synthesis of hydantoins today is the Bucherer-Berg reaction. It involves the addition of potassium cyanide and ammonium carbonate to compounds containing the carbonyl group. Berg first proposed this synthesis in 1929 and by 1934, Bucherer had improved on it.[2] Many reactions for the preparation of hydantoins have been studied, but this method is the most generally used and is applicable for most ketones and aldehydes. Even though much of the chemistry of hydantoins has been investigated, very little information is available on the reaction mechanism.



(I) R=H Hydantoin

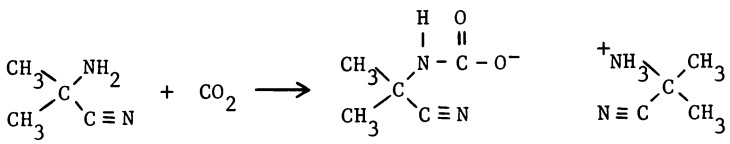
(II) R=CH_3 DMH

5,5-dimethylhydantoin (DMH,II) has recently been detected in the condensate water from a slagging gasifier, along with several other hydantoins. The DMH is formed in the exit stream when the lignite coal is being burned.[3] The reactants, acetone, cyanide, ammonia, and carbonate, are similar to those used in the Bucherer-Berg synthesis and are present in the condensate water. Control of hydantoin formation is necessary in the condensate water due to environmental concerns and this prompted an investigation into the kinetics and mechanism of the reaction.

Until recently, methods for quantitative identification of hydantoins were not reliable. However, in 1983, Olson developed a method of analysis using gas chromotography and glass capillary columns.[4] Using this method kinetic studies have shown that the formation of DMH is first order in each reactant.[5]

$$\frac{d\ DMH}{dt} = k\ [Acetone][Cyanide][Ammonia][Carbonate]$$

A complex mechanism will be presented which is consistent with the kinetic data. Prior to this work, very few intermediates in the mechanistic pathway have been isolated because of the lack of instrumentation available to detect reactive intermediates. Experimental evidence supports the structures of several intermediates, particularly those of the aminonitrile, (III), and the carbamic acid salt (IV).



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22 SUCCESSFUL TRANSPLANTATION OF POLE CELLS BETWEEN THE WILD TYPE (FW_2) AND A MUTANT STRAIN (M_2) OF THE HOUSEFLY

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Currently, laboratory strains of insects can be maintained only through mass rearing. Such rearing procedures are generally costly, time consuming, subject to cross contamination between strains, and prone to catastrophic loss. In addition, laboratory colonies bred over hundreds of generations are subjected to selection pressures. The ability to store insect germplasm would greatly reduce these problems and provide an opportunity to store genetic stocks which might otherwise be lost. The storage of dipteran germplasm might be achieved through the isolation, cryopreservation, storage and reimplantation of pole cells (primordial germ cells). However, before this can be accomplished, it will be necessary to adapt existing techniques for isolation and transplantation, as well as develop new techniques for culture cryopreservation and storage of these cells. As part of this ongoing study, we have performed reciprocal transplants between two laboratory strains of the housefly, Musca domestica.

The Fargo wildtype (FW_2) and mutant (M_2) stock strains of houseflies used in this study were reared and maintained as previously described by Leopold (1). Adult females are induced to oviposit by crowding in vials containing black cloth soaked with a solution of 2.5% $(NH_4)_2CO_3$. They are allowed to oviposit for one hr. following the initial observation of eggs. The adults are removed and the eggs are incubated for an additional 30 min. After this 90 min. development period the eggs are dechorionated using a solution of sodium hypochloride (commercial bleach diluted 1:2 with distilled water) for 3 min. Following dechorionation, the embryos are washed 5 times with distilled water and placed on moist black filter paper. In preparation for transplantation the embryos are then mounted onto a cover slip with double stick tape as described by Van Deusen (2). They are dehydrated for 10-12 min. and then covered with a halocarbon oil to prevent further dessication. Using a siliconized glass micropipette with a 10-12 μm tip, and an inverted microscope, the pole cells are removed from the donor and inserted into the recipient embryo. The embryos are then placed on Monroe's medium to continue their development (3).

Dipteran pole cells segregate at the posterior pole of the embryo early during development and migrate inward during gastrulation, eventually being incorporated into the gonads. In Drosophila, pole cells which are transplanted from genetically different donors migrate along with the host's cells and form gonads that are mosaic for germ line (4). Thus, successfully transplanted embryos give rise to adults which have viable germ cells containing the genetic material of the donor and produce phenotypically identifiable offspring. In our research, when wild type pole cells are transplanted into embryos of the mutant strain, 66% of the resulting fertile adults carry the donor genotype. In the reciprocal experiment, 33% of the fertile adults produced contain germ cells with the donor genotype. In both of the above cases the adults were backcrossed to M_2 stocks and produced phenotypically normal, fertile offspring. To our knowledge this is the first time pole cells have been successfully transplanted in any fly other than Drosophila. This indicates that pole cell transplantation techniques might be adapted to other diptera and has opened the way for storage of housefly germplasm through the preservation and reimplantation of pole cells.

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PAUL CONRAD SANDAL
(March 14, 1914 - August 6, 1984)

Paul Sandal was born and grew up in Midland, South Dakota and received the B.S. in agronomy from South Dakota State College in 1941. He began graduate work at Iowa State College in the fall of 1941 and completed one year before he entered the Army, where he served in the Medical Corps until 1945, spending 22 months overseas in England, France, Belgium, and Germany. He was awarded the Bronze Star Medal for valor under fire.

He received the M.S. in agronomy from Iowa State in 1946 and then was appointed Assistant Agronomist at the University of Arkansas. After receiving the Ph.D. from Iowa State College in agronomy in 1951, specializing in crop breeding and genetics, he was appointed to the NDSU faculty in 1954 as Associate Professor and Associate Agronomist where he served continuously until he retired as Professor Emeritus in 1981.

His research specialties pertained mainly to forage crops. His main interests were sudangrass improvement, looking toward hybrid sudan varieties, and improvement of sweetclover. His interests also turned to new crop possibilities for North Dakota, and he was particularly successful in the development of germplasm in dry edible beans. He was recognized with the Alpha Zeta Outstanding Teacher Award in 1962.

Dr. Sandal possessed a strong sense of public service, which was much enhanced by his fairminded approach to achieving workable solutions. He held responsible positions in his church, was Chairman of the F-M United Fund Campaign in 1973, and was President of the Cass County Mental Health Association. He was especially prominent in Kiwanis International, including its campus aspect, Circle K.

He was a member of the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America, and served as President of the NDSU Sigma Xi Club in 1956-57. He became a member of the North Dakota Academy of Science upon coming to NDSU in 1954 and served as President in 1965-66.

FREDERICK HJALMER SANDS
(July 25, 1901 - February 19, 1985)

"Fred Sands cared a lot about teaching undergraduate students. He was good at it. Because of that, he drew those big sections of freshman chemistry, which gave others time for research. We never heard him complain about that. He liked students. He was a bit of a showman. One of his favorite things to do was to bring a group of bright high schoolers to the campus and put on a sort of half-chemistry, half-magic show for them to capture their imagination. Students liked Fred, too. They showed their respect and affection by awarding him the Blue Key Doctor of Service. That took him completely by surprise...But Fred was deeply honored." So reads part of the sketch on Dr. Sands in Bison Briefs for March 1985.

Sands was born in Alvarado, Minnesota, completed high school there in 1928, and entered Concordia College that same year, majoring in chemistry. In 1930, he transferred to the University of North Dakota and received the B.S. with a major in natural science in 1932. He taught chemistry, physics, biology, and music (he was active in music as a singer and choral director for most of his adult life) at Leeds High School (1932-34) and at International Falls High School (1934-46).

Pursuing graduate work as opportunity afforded during summer sessions, he earned the M.S.Ed. at UND in 1945 and the Ed.D. in 1961. A direct outcome of his doctoral dissertation was publication of the North Dakota High School Chemistry Course of Study, which was mailed to all chemistry teachers in the state in 1963.

He was appointed Instructor in Chemistry at North Dakota Agricultural College in 1946, and he served continuously until his retirement as Professor Emeritus at NDSU in 1972.

Dr. Sands became a member of the North Dakota Academy of Science in 1946 and served as President in 1963-64. He was very active in the Science Education Committee, leading the High School Visitation and Talent Search programs, and interacting closely with high schools and students throughout the state.

THEODORE ELLINGSON STOA
(January 30, 1890 - August 10, 1984)

Theodore Stoa was born into a family of Traill County pioneers at Buxton, North Dakota. He began his scientific career with enrollment at North Dakota Agricultural College in 1911 and graduated in 1915 with the B.S. in agronomy. He served as Scientific Assistant, Office of Cereal Crops and Diseases, USDA, from 1915 to 1920, working particularly on flax investigations. In 1920, he began his graduate program at NDAC, and he received the M.S. in agronomy in 1921, his thesis being an analysis of all spring wheat trials at the Agricultural Experiment Station and its Branches to that time. In 1929-30, he did advanced graduate work at the University of Minnesota.

He was appointed Assistant Agronomist at NDAC in 1921 and served in that capacity until 1934, in which year he became Agronomist and Chairman of the Department of Agronomy. After twenty-six years in this position of leadership, which also included a term as Chief of the Division of Plant Science, he retired in 1960 as Professor Emeritus. In that year he was also granted the D.Sc. *honoris causa* in recognition of his long and distinguished service.

Dr. Stoa's contributions to plant science in North Dakota and the region are summarized by William C. Hunter in the following words: "His work...has been in the fields of breeding and crop production, and the coordination of plant research as related to crop improvement, including evaluation of new lines to determine their relative suitability for this area. Along with this research he has been influential in the creation and administration of a system of increase and distribution of new seeds in order to make the program of plant improvement most effective." (*Beacon Across the Prairie*, Fargo, 1961, p. 233).

He became a member of the American Society of Agronomy in 1915, was elected Fellow in 1954, and served as President of the North Central Branch in 1956-57. He received ten other awards of recognition from county, state, regional, and national crop improvement associations, and his contribution to the campus community was recognized by the Blue Key Doctor of Service award in 1958. Membership in honorary societies included Alpha Zeta and Phi Kappa Phi. He became a member of the North Dakota Academy of Science in 1915, his graduation year.

WILLIAM WIIDAKAS
(January 27, 1901 - November 7, 1980)

William Wiidakas birthplace was Tallinn, Estonia. As a young man in 1919-20, he traveled as a war refugee in Russia, Turkey, Austria, and other European countries and then via England emigrated to the United States in 1922 and came to live with an uncle in New England, North Dakota. He completed his American high school education at the Model High School of Dickinson State Teachers College and then attended the college from 1928-30. Transferring to North Dakota Agricultural College in 1930, he attained the B.S. in agronomy in 1932. He received the M.S. in plant breeding from the University of Minnesota in 1940.

He was appointed Field Assistant in Agronomy at NDAC in 1934, became Assistant Agronomist in Charge of Corn Improvement in 1937, and served continuously until he retired as Associate Professor at NDSU in 1970. His consistent aim was to make corn a viable field crop throughout North Dakota, and he succeeded in this mission. His master's thesis, *Cold Resistance in Inbred Lines of Corn*, indicated one aspect of the problem. Coping with low rainfall was the other main aspect. The most feasible solution to the problem lay in using hybrid varieties with early maturing characteristics; in fact, his inbred variety, ND 203, was widely used, including in the Corn Belt, as a source of early maturing characteristics.

In 1972, he received the Outstanding Achievement Award from Dickinson State College. The Corn Seed House at NDSU, which had been his headquarters from 1950 and now houses mainly experimental activity, has been renamed Wiidakas Laboratory.

Mr. Wiidakas was a long-time member of the AAAS and the American Society of Agronomy, and he served as chairman on early maturing corn with the North Central Corn Breeding Research Committee. He became a member of the North Dakota Academy of Science in 1946. He also held membership in Alpha Zeta and Sigma Xi.

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BALTISBERGER, RICHARD	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
BANASIK, ORVILLE J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
BARES, RICHARD	1510 UNIVERSITY AVENUE	GRAND FORKS	ND 58201
BARKER, WILLIAM T.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
BARMAN, SCOTT	1901 24TH AVENUE SOUTH, #17	GRAND FORKS	ND 58201
BARNEY, WILLIAM G.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
BARRON, GEORGE	JAMESTOWN HIGH SCHOOL	JAMESTOWN	ND 58401
BASSINGTHWAITE, DAVID	615 NORTH 39TH STREET, 307C	GRAND FORKS	ND 58201
BAUER, ARTHUR J.	GREAT PLAINS GASIFIC. ASSOC.	BEULAH	ND 58523
BEHM, MARLA	PURDUE UNIVERSITY	WEST LAFAYETTE	IN 47907
BEHRINGER, MARJORIE	1613 CRIPPLE DRIVE	AUSTIN	TX 78758
BENTZ, KEN	3401 NORTHEAST MAPLE	FARGO	ND 58102
BENZ, LEO C.	1407 NORTH 23RD STREET	BISMARCK	ND 58501
BERGSTROM, DONALD E.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
BERKEY, GORDON B.	MINOT STATE COLLEGE	MINOT	ND 58701
BERRYHILL, DAVID L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
BITZAN, EDWARD F.	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
BLEIER, WILLIAM J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
BLISS, HARALD N.	MAYVILLE STATE COLLEGE	MAYVILLE	ND 58257
BLUEMLE, JOHN P.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
BOLEY, CHARLES	1827 QUAIL STREET #2	LAKEWOOD	CO 80215
BOLIN, F.M.	1505 SIXTH STREET SOUTH	FARGO	ND 58102
BOLONCHUK, WILLIAM W.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
BORHO, ALAN	4812 SIXTH AVENUE NORTH #11	GRAND FORKS	ND 58201
BOUDJOUK, PHILIP R.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
BRAMMER, J.D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
BRAND, MICHAEL	1116 SOUTH THIRD STREET, #2	BISMARCK	ND 58501
BREKKE, DAVID	NORTH DAKOTA GEOLOGICAL SURVEY	GRAND FORKS	ND 58202
BROPHY, JOHN A.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
BROSCHAT, MYRON D.	203 EAST CHANNING AVENUE	FERGUS FALLS	MN 56537
BROWN, RALPH C.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
BRUMLEVE, STANLEY	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
BUKOWIEC, TRUDY	MINOT STATE COLLEGE	MINOT	ND 58701
BURTON, MIKE	81 PRAIRIEWOOD DRIVE	FARGO	ND 58103
CALLENBACH, JOHN A.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
CAMARA, MICHAEL	11723 CLEARGLEN AVENUE	WHITTIER	CA 90604
CAMPBELL, LARRY G.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
CARLSON, EDWARD C.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
CARLSON, KENNETH T.	320 SECOND AVENUE NORTHWEST	MAYVILLE	ND 58257
CARMICHAEL, VIRGIL W.	1013 NORTH ANDERSON STREET	BISMARCK	ND 58501
CARTER, JACK F.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
CASSEL, J. FRANK	U.S. AIR FORCE ACADEMY	COLORADO SPRINGS	CO 80840
CHERIAN, SEBASTIAN K.	JAMESTOWN COLLEGE	JAMESTOWN	ND 58401
CHIASSON, BRUCE J.	502 WALNUT STREET	GRAND FORKS	ND 58201

CHRISTOFERSON, LEE A.	700 FIRST AVENUE SOUTH	FARGO	ND 58102
CLAMBEY, GARY K.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
CLARK, JOHN S.	BOX 7252, UNIVERSITY STATION	GRAND FORKS	ND 58202
CLAUSEN, ERIC N.	MINOT STATE COLLEGE	MINOT	ND 58701
COCKRUM, FRANCES E.	10 FIRST STREET SW, #10	MINOT	ND 58701
COLLINS, CHARLES C.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
COMITA, GABRIEL W.	89 NORTH 21ST AVENUE	FARGO	ND 58102
CONNELL, MARVIN D.	2606 FIFTH AVENUE NORTH	GRAND FORKS	ND 58201
COOK, DEBORAH A.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
CORNATZER, WILLIAM E.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
COWARDIN, LEWIS M.	310 16TH AVENUE NORTHEAST	JAMESTOWN	ND 58401
CVANCARA, ALAN M.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
D'APPOLONIA, BERT L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
DAFOE, ARTHUR W.	551 THIRD STREET NORTHEAST	VALLEY CITY	ND 58072
DANDO, WILLIAM A.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
DAVIS, DAVID G.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
DEBOER, BENJAMIN	312 ALPHA	GRAND FORKS	ND 58201
DIEPOLDER, PAULA RENEE	3719 UNIVERSITY, #11	GRAND FORKS	ND 58201
DINGA, GUSTAV P.	CONCORDIA COLLEGE	MOORHEAD	MN 56560
DINUSSON, WILLIAM E.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58102
DISRUD, DENNIS T.	413 HILLCREST DRIVE	MINOT	ND 58701
DOERING, EUGENE J.	2206 LAFOREST AVENUE	BISMARCK	ND 58501
DOGGER, JAMES R.	BUILDING 264, BARC E	BELTSVILLE	MD 20705
DONALD, PATRICIA A.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
DOUBLY, JOHN A.	306 23RD AVENUE NORTH	FARGO	ND 58102
DRAPER, MARTIN A.	STATE UNIVERSITY STATION	FARGO	ND 58105
DUERRE, JOHN A.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
DUGAN, MURRAY	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
DUNHAM, DAVID	RURAL ROUTE 2, BOX 308	COOPERSTOWN	ND 58425
DUXBURY, ALEXIS	ND PARKS AND RECREATION DEPT.	BISMARCK	ND 58501
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
EL-NASHAAR, HOSSIEN	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
ELLIS, LEE	MINOT STATE COLLEGE	MINOT	ND 58701
ERICKSON, DUANE	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58102
ERICKSON, J. MARK	ST. LAWRENCE UNIVERSITY	CANTON	NY 13617
ETCHINGHAM, MICHAEL J.	1601 SIXTH AVENUE EAST	BEULAH	ND 58523
EVANS, HAROLD W.	2624 OLSON DRIVE	GRAND FORKS	ND 58201
FACEY, VERA	801 BOYD 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
FEGLEY, MELVIN M.	1402 GRAFTON STREET	LARAMIE	WY 82070
FEIL, VERNON J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
FETTERS, HAZEL	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
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
FLAKOLL, TIMOTHY J.		FORBES	ND 58439
FLEETWOOD, CHARLES W.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
FLETCHER, ALAN G.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
FOSS, JOHN E.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
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.	1141 NORTH UNIVERSITY DRIVE	FARGO	ND 58102
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
GALITZ, DONALD S.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GALLAHER, DANIEL D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GARVEY, ROY	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105

GASSNER, GEORGE	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GIESE, PATSY A.	715 N. 40TH STREET, APT. 203H	GRAND FORKS	ND 58201
GIRARD, MICHELE M.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GLASS, THOMAS L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GOETTLER, HANS J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GOETZ, HAROLD	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
GREENWALD, STEPHEN	253 COLLEGE STREET, SW	VALLEY CITY	ND 58072
GRENDA, JAMES C.	ANGELO STATE UNIVERSITY	SAN ANGELO	TX 76909
GRIFFIN, DAVE	1218 THIRD STREET NORTHEAST #4	MANDAN	ND 58554
GROENEWOLD, GERALD	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
GULLICKSON, KIMBERLY K.		CENTER	ND 58530
GUSE, PAUL A.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
HALVORSON, GARY A.	BOX 459	MANDAN	ND 58554
HAMILTON, ROBERT G.	CROSS RANCH	HENSLER	ND 58547
HANSON, DAVID D.	RURAL ROUTE 1, BOX 48	TURTLE LAKE	ND 58575
HARRISON, STEPHEN	11008 KIRKLAND WAY, 201	KIRKLAND	WA 98033
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
HAUNZ, EDGAR A.	1029 LINCOLN DRIVE	GRAND FORKS	ND 58201
HEIDEL, BONNIE	BOX 700, PARKS AND RECREATION	BISMARCK	ND 58502
HELENBOLT, KENNETH S.	3563 LONGFELLOW ROAD	FARGO	ND 58102
HENDERSON, WILLIAM	3014 NORTH ELM STREET	FARGO	ND 58102
HERTSGAARD, DORIS	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
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
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
HOWARD, DALE B.	ONE IRMA COURT	MINOT	ND 58701
HOWELL, FRANCIS L.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HUESERS, LLOYD B.	1900 HIGHLAND DRIVE	MINOT	ND 58701
HUNG, YUNG-TSE	27906 LINCOLN ROAD	BAY VILLAGE	OH 44140
HUNT, CURTISS D.	1510 FIRST AVENUE NORTH	GRAND FORKS	ND 58201
HUSAIN, SYED	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
HYDER, DON E.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
JACKSON, JON A.	UND SCHOOL OF MEDICINE	GRAND FORKS	ND 58202
JACOBS, FRANCIS A.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JENKINS, DENNIS R.	493 MCMULLIN DRIVE	GRAND JUNCTION	CO 81504
JENSEN, GORDON	ROUTE 1, BOX 59K	MANDAN	ND 58554
JOHANSEN, ROBERT H.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
JOHNSON, A. WILLIAM	416 TERRACE DRIVE	GRAND FORKS	ND 58201
JOHNSON, ARNOLD R.	MINOT STATE COLLEGE	MINOT	ND 58701
JOHNSON, DOUGLAS H.	BOX 1747	JAMESTOWN	ND 58401
JOHNSON, LESTER E.	RURAL ROUTE 2, BOX 92	BOTTINEAU	ND 58318
JOHNSON, LYNDON L.	RURAL ROUTE	ALAMO	ND 58830
JOHNSON, PHYLLIS E.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JONES, MARTIN B.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
JONES, MICHAEL L.	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
JORDAN, DAN R.	1325 THIRD AVENUE EAST, #13	HIBBING	MN 55746
JORDAN, JULIE	1325 THIRD AVENUE EAST, #13	HIBBING	MN 55746
JORDE, DENNIS	UNIVERSITY OF MAINE	ORONO	ME 04469
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
KEHEW, ALAN E.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KELLEHER, JAMES J.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KEMP, JUDY	748 VIKING DRIVE	VALLEY CITY	ND 58072
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	BOX 63	ELDRIDGE	ND 58435
KNUDSON, CURTIS L.	711 NORTH 25TH STREET	GRAND FORKS	ND 58201
KOENKER, WILLIAM E.	6403 GARRET ROAD	DURHAM	NC 27707
KOEPSEL, KIRK T.	P.O. BOX 5548	FARGO	ND 58105
KOHANOWSKI, N.	3532 TENTH AVENUE NORTH	GRAND FORKS	ND 58201
KOLSTOE, RALPH H.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KONTZ, BRADLEY	824 SOUTH 25TH STREET, #46	GRAND FORKS	ND 58201
KONZAK, KRISTIN E.	2520 17TH AVENUE SOUTH, APT. 2	GRAND FORKS	ND 58201
KOPONEN, MARK A.	CHATEAU 304, 815 DUKE DRIVE	GRAND FORKS	ND 58201
KOTCH, ALEX	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KRAFT, DONALD J.	BEMIDJI STATE UNIVERSITY	BEMIDJI	MN 56601
KRAUSE, DANIEL	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
KRESS, WARREN D.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58102
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
KUBE, WAYNE R.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KUCERA, HENRY L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58102
KUEHN, DAVID	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
KUIPERS, GILBERT	VALLEY CITY STATE COLLEGE	VALLEY CITY	ND 58072
KUKLA, JEFF L.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
LABORDE, JOYCE M.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
LAIRD, WILSON M.	101 SPANISH OAK LANE	KERRVILLE	TX 78028
LAMBETH, DAVID	1909 20TH AVENUE SOUTH	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
LEAGUE, LARRY	DICKINSON STATE COLLEGE	DICKINSON	ND 58601
LEHR, EUGENE R.	BOX 724	LINTON	ND 58552
LEITE, DAVID	RURAL ROUTE 2, BOX 161	MINOT	ND 58701
LEITE, MICHAEL B.	RURAL ROUTE 2, BOX 161	MINOT	ND 58701
LENO, GREGORY H.	1645 N. WOODMERE DRIVE, A-27	CHARLESTON	SC 29407
LENZEN, THOMAS W.	2114 'UNIVERSITY AVENUE	GRAND FORKS	ND 58201
LI KAM, W.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58102
LINDLEY, JAMES A.	1421 NORTH UNIVERSITY DRIVE	FARGO	ND 58102
LIPP, GARY	BOX 1229	DICKINSON	ND 58601
LIPP, WILLIAM V.	3024 NORTH 10TH STREET, #19	FARGO	ND 58102
LIU, BING H.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
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
LORENZ, RUSSELL J.	1924 NORTH GRANDVIEW LANE	BISMARCK	ND 58501
LOW, FRANK N.	2511 ST. CHARLES AVENUE	NEW ORLEANS	LA 70301
LUNN, ERIC R.	503 SPINDRIFT LANE	COLUMBIA	SC 29209
LURA, CHARLES L.	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
MAGNUSSON, ADELYNN M.	1703 SOUTH 20TH STREET	GRAND FORKS	ND 58201
MAHALKO, JANET	1513 BARON BOULEVARD	GRAND FORKS	ND 58201
MAIANU, ALEXANDRU	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MAJIDIAN, MAJID	P.O. BOX 5162	FARGO	ND 58105
MANZ, OSCAR	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
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.	P.O. BOX 1174	RATON	NM 87740
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
MCMAHON, KENNETH J.	NORTH DAKOTA STATE UNIVERSITY	FARGO	ND 58105
MEARTZ, PAUL D.	MAYVILLE STATE COLLEGE	MAYVILLE	ND 58257
MEDHAUG, CARRIE L.	1802 1/2 FIFTH AVENUE SOUTH	MOORHEAD	MN 56560
MELDRUM, ALAN	512 COLUMBIA ROAD	GRAND FORKS	ND 58201
MERRILL, STEPHEN D.	NO. GREAT PLAINS RESEARCH CTR.	MANDAN	ND 58554
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 B.	SOUTH DAKOTA STATE UNIVERSITY	BROOKINGS	SD 57007
MITCHELL, E.N.	220 GLENHILL LANE	CHAPEL HILL	NC 27514
MITCHELL, MARTHA J.	UND ENERGY RESEARCH CENTER	GRAND FORKS	ND 58202
MOE, WAYNE L.	934 NORTH 32ND STREET	BISMARCK	ND 58501
MOLLAND, GIBBS	1205 NORTH 22ND STREET	BISMARCK	ND 58501
MORGAN, ROSE M.	823 SIXTH STREET SOUTHWEST	MINOT	ND 58701
MOWER, ROLAND D.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MOWERY, GARRY B.	334 FOREST AVENUE NORTH	FARGO	ND 58102
MUNSKI, DOUGLAS	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
MURDOCK, LEE E.	2914 SOUTH TENTH STREET	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, L. S.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
NELSON, ROBERT M.	614 NINTH AVENUE NORTH, APT. 2	FARGO	ND 58102
NELSON, WALLACE T.	ROUTE 1, BOX 350	PARSHALL	ND 58770
NIELSEN, FORREST H.	UNIVERSITY OF NORTH DAKOTA	GRAND FORKS	ND 58202
NIESAR, SHERRY L.	209 14TH AVENUE SOUTHEAST	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
NUTI, RAO N.	815 THAYER AVENUE, #1104	SILVER SPRING	MD 20910
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PEKOWSKY, ROBERT	1419 FOURTH AVENUE NORTH	GRAND FORKS	ND 58201
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