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The Relative Abundance of the Brown-Headed Cowbird (*Molothrus ater*) in Relation to Exterior and Interior Edges in Forests of Missouri

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Abstract: Forest fragmentation may be detrimental to many bird species in part because it increases contact with a brood parasite, the brown-headed cowbird (*Molothrus ater*). Using censuses at different distances from the forest edge, we found a significant decrease in the relative abundance of cowbirds as the distance from the forest edge increased. Censuses from edges that surround interior openings showed that the abundance of cowbirds also decreased as the distance from the edge increased. The density of cowbirds within these cuts was positively correlated with the size of the opening.

Key Words: Brown-headed cowbird, forest fragmentation, clearcutting, relative abundance

Introduction

The brown-headed cowbird (*Molothrus ater*) is an obligate brood parasite that occurs throughout North America (Friedmann 1929). It is believed that before European settlement, the cowbird was primarily a bird of the grasslands and prairie/forest ecotone of the central United States, where it was associated with herds of native grazers (Erlich *et al.* 1988). As settlers opened forests and brought in domestic cattle, the range of the cowbird expanded into the eastern and western United States. In more recent years, the cowbird population has risen dramatically in numbers (Bystrak and Robbins 1977), possibly due to an increase in their winter food supply, waste grain in southern rice fields (Meanley 1971). Although the cowbird will parasitize both grassland and forest species, it is generally considered an edge species (Rothstein *et al.* 1980), perhaps because edge often provides the greatest density of potential hosts (Gates and Gysel 1978).

Forest fragmentation occurs when human land use patterns create small forest fragments where there was once a large, continuous forest. Fragmentation of a forest increases the amount of exterior edge relative to forest area in the fragments. Because the cowbird is an edge species, this increase in edge may increase the amount of cowbird parasitism in forest fragments. Brittingham and Temple (1983) found the greatest density of cowbirds near the forest edge, although they noted that cowbirds may travel as far as 400 m. into a 1,000 ha forest. In contrast, Robinson (Robinson *et al.* in press) detected consistently high cowbird densities throughout his 1000 ha. forest tracts in southern Illinois with high parasitism rates at distances greater than 300 m. from the forest edge. These results suggest that there may be regional variation in how far into the

forest cowbirds effectively penetrate.

Additionally, cowbirds frequent the edges of interior openings with snags and other exposed perches where they conduct breeding displays and observe their surroundings, with females presumably looking for nests (Mayfield 1965, Robbins 1979). Therefore, forest harvest in the form of interior clearcuts may increase cowbird parasitism in otherwise large forested areas because they provide edges for entry into the interior of the forest and exposed perches for cowbird breeding.

Many studies have documented the decrease in the numbers of bird species occurring in small forest fragments (Bond 1957, Galli *et al.* 1976, Forman *et al.* 1976, Robbins 1979, Whitcomb *et al.* 1981, Ambuel and Temple 1983, Blake and Karr 1984, Lynch and Whigham 1984, Hayden *et al.* 1985). Neotropical migrants, bird species that spend most of the year in the neotropics and breed in the summer in North America, seem especially vulnerable to forest fragmentation. Many of these migrants require a large minimum area to be successful, hence they are called "area sensitive" species (Galli *et al.* 1976, Whitcomb *et al.* 1981, Hayden *et al.* 1985). This sensitivity may be due in part to cowbird parasitism. These migrants are forest-interior specialists that produce a single brood of small clutch size during the breeding season, therefore, the loss of a brood through the fledging of a cowbird often destroys the total reproductive output for a pair for that year.

It is possible that the increase in the cowbird population, the range expansion of the cowbird, fragmentation of forests, and creation of interior openings has brought the cowbird into contact with more birds than ever before. Here we examine the extent to which cowbird parasitism extends into forests from exterior and interior edges by censusing cowbirds in a highly fragmented region of central Missouri. This information may help to explain the decrease of forest-interior neotropical migrants in central Missouri, a decrease that seems to be a consequence of forest fragmentation.

Study Areas

Three study areas were chosen using topographic maps and aerial photographs. Study areas were selected that were larger than 900 ha, had similar vegetative cover (mature oak-hickory forest), contained both interior and exterior edges, and were public access lands. These were: the University of Missouri's Thomas Baskett Wildlife and Education Center (Boone County, 900 ha), the Missouri Department of Conservation's Rudolph Bennitt Wildlife Area (Randolph and Howard counties, 900 ha) and Daniel Boone State Forest (Warren County, 1100 ha). Hereafter the study areas will be referred to as Baskett, Bennitt, and Boone.

Each study area contained from two to eight study sites. Study sites were delineated so that they bordered a pasture or cropfield. Each site was at least 400 meters from any interior opening, (clearcuts that were cut since 1985 or old fields), to reduce the possibility that cowbirds were entering the site from interior edges. Each study site measured 400 m into the forest and 500 m along the edge. In a study site, five points were randomly chosen going into the forest from the edge at the following distances: a point at the edge, 100 m, 200 m, 300 m, and 400 m. Along the edge, the entry into the forest for each point was 100 m apart.

The forests of each study area were dominated by mature oak (*Quercus* spp.) and hickory (*Carya* spp.) stands with relatively open understories. Exterior edges were found at the borders between the contiguous forest and pastures or cropfields. Interior edges surrounded clearcuts that had been cut between 1985 and 1988.

Methods

All censusing took place between sunrise and 10:30 a.m. between the dates of 7 May and 30 June 1989 and 1990. In 1989 each site was visited once. In 1990 each site was visited three times.

I. Exterior Edge Experiments

In 1989, 15 study sites were chosen for cowbird censusing from within the three study areas (five sites from Baskett, two from Bennitt, and eight from Boone). A cowbird census was completed at each site. In 1990, three study sites from Boone forest were dropped from the project because of time constraints. Therefore, 12 of the original 15 sites remained for the 1990 field season census.

The fixed-radius point count method was used (Hutto *et al.* 1986) to estimate cowbird numbers. We used eight minutes for the time period at the point and 50 m as the fixed radius around the point. We chose these parameters to ensure optimal detection of cowbirds. Both male and female cowbirds were counted. We completed a census of cowbirds in each study site using the random points already described. This census determined the relative abundance of cowbirds at each point.

For the 1989 census data, relative abundance of cowbirds for each distance interval in a study site was the number of birds counted in the single census period. For the 1990 census data, relative abundance of cowbirds for each distance interval in a study site was the mean of the number of birds counted during the three census periods.

Data from the 1989 and 1990 study sites were analyzed separately using linear regressions. The variables used were relative abundance *vs.* distance from edge. Regression coefficients were recorded for each study site for each year. A positive regression coefficient (slope) would signify that the relative abundance of cowbirds was increasing with distance from the edge, a negative regression coefficient signifies a decrease in abundance *vs.* distance from edge, and a slope of zero signifies no change in abundance.

If cowbird densities are not related to edge, we would expect, by chance, to have a 0.5 binomial distribution of positive and negative regression coefficients. Deviations from this assumption were analyzed, using a table of the upper tail probabilities for binomial distributions, to determine if the trend was significant.

II. Interior Edge Experiments

In 1990, six clearcuts were selected for the interior edge experiments, with two from each study area. Each clearcut was cut between 1985 and 1988 and each had between five and fifteen exposed perches per hectare, (*i.e.*, snags or living trees). A range of clearcut sizes (0.7-13.0 ha) was chosen for comparison purposes that will be discussed later.

The Hutto *et al.* (1986) census method, with the eight-minute time period

and 50 m radius parameters, also was used to determine the relative abundance of cowbirds in the interior edge experiments. A straight-line transect entered the forest from the clearcut edge. A count was made at five points along the transect: the edge of the clearcut, and 100 m, 200 m, 300 m, and 400 m from the clearcut edge.

In order to determine the densities of cowbirds within a clearcut, the Hutto *et al.* (1986) census method was used but modified to decrease the possibility of counting the same cowbird twice: the radius around the point was decreased to 25 m and the time spent at the point was decreased to four minutes. Points were placed randomly within clearcuts. The number of points depended on the size of the clearcut. The range was from two points in the smallest clearcut to 10 points in the largest. A census was completed at each point and these results were used to determine the density of cowbirds within that clearcut. The density of cowbirds within a clearcut was calculated by determining the mean number of cowbirds per point over the three census periods. The mean then was multiplied by five to estimate the number of birds per hectare, as each point had a 25 m radius (0.2 ha).

Results

Exterior Edge Experiments

Thirteen of the 15 study sites that were censused in 1989 had negative regression coefficients; this was significantly different from the 0.5 distribution expected by chance ($p < 0.01$, Table 1). Ten of the 12 study sites that were surveyed in 1990 had negative regression coefficients ($p < 0.05$, Table 1).

Combined data from all 15 1989 study sites reveal the overall trend of a negative slope (Fig. 1). A similar trend is apparent when the 1990 data from 12 study sites are combined (Fig. 1). Therefore, a decrease in cowbird abundance with an increase in distance from the exterior edge is supported through two years of censuses at the same study sites.

Interior Edge Experiments

Linear regressions also were completed using the relative abundance data *vs.* distance from edge for the six interior edge study sites. All six of the regression coefficients were negative ($p < 0.05$, Table 2). It appears that cowbirds are entering the forest from interior clearcuts, but as the distance from the clearcut edge increases the abundance of cowbirds decreases.

A Spearman rank correlation test (Snedecor and Cochran 1980) showed a positive correlation between the size of a clearcut and the density of cowbirds within it ($r_s = 0.771$, $p < 0.10$). This implies that smaller clearcuts will have fewer cowbirds and as the size of the clearcut increases the density of cowbirds could rise (Fig. 2).

The size of the clearcut also was positively correlated with the slope of the linear regression for the relationship of distance into the forest *vs.* relative abundance of cowbirds ($p < 0.05$). Larger clearcuts have greater slopes because of the higher number of cowbirds at the clearcut edge. Higher numbers of cowbirds at the clearcut edge are presumably due to higher densities within the clearcut. The pattern suggests that parasitism will be greatest at the clearcut edge and will then extend into the forest. Because there appeared to be no

Table 1. Regression coefficients for relative abundance vs. distance from edge for the fifteen 1989 and twelve 1990 exterior edge study sites.

Study site	Regression coefficient	
	1989	1990
BASKETT		
#1	-0.20	-0.03
#2	-0.10	+0.03
#3	0	0
#4	+0.20	-0.09
#5	-0.60	-0.34
BENNITT		
#1	-0.50	-0.56
#2	-0.10	-0.59
BOONE		
#1	-1.30	-0.37
#2	-0.40	-0.63
#4	-0.60	_____
#5	-0.20	_____
#6	-0.20	-0.69
#8	-0.20	-0.44
#9	-0.70	-0.40
#10	-1.00	_____

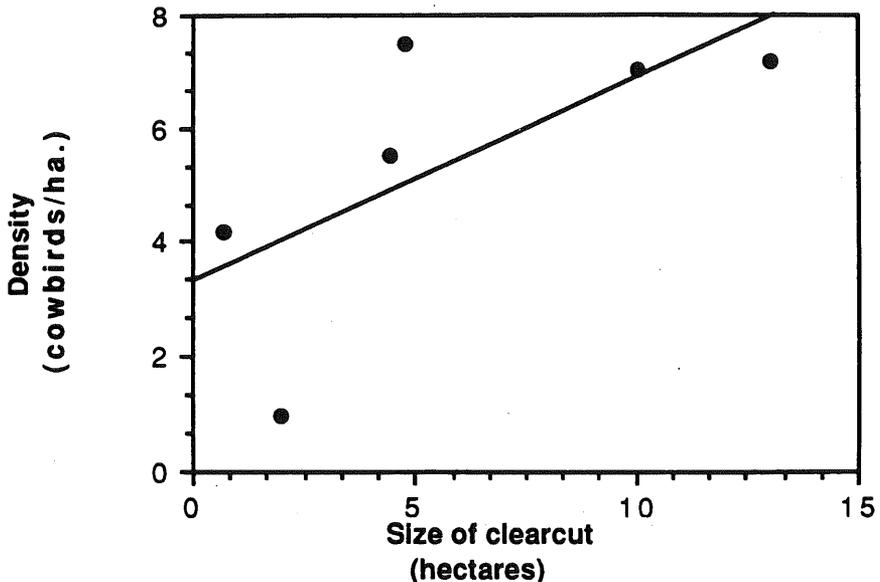


Fig. 1. Relative abundance vs. distance from edge using combined 1989 data from the fifteen exterior edge study sites ($y = 2.0220 - 0.39200x$, $R^2 = 0.800$) and combined 1990 data from the twelve exterior edge study sites ($y = 1.6860 -$

Table 2. Regression coefficients for relative abundance vs. distance from edge for the six 1990 interior edge study sites.

Study site	Regression coefficient
BASKETT	
#1	-0.26
#2	-0.20
BENNETT	
#1	-0.75
#2	-0.59
BOONE	
#1	-0.57
#2	-0.60

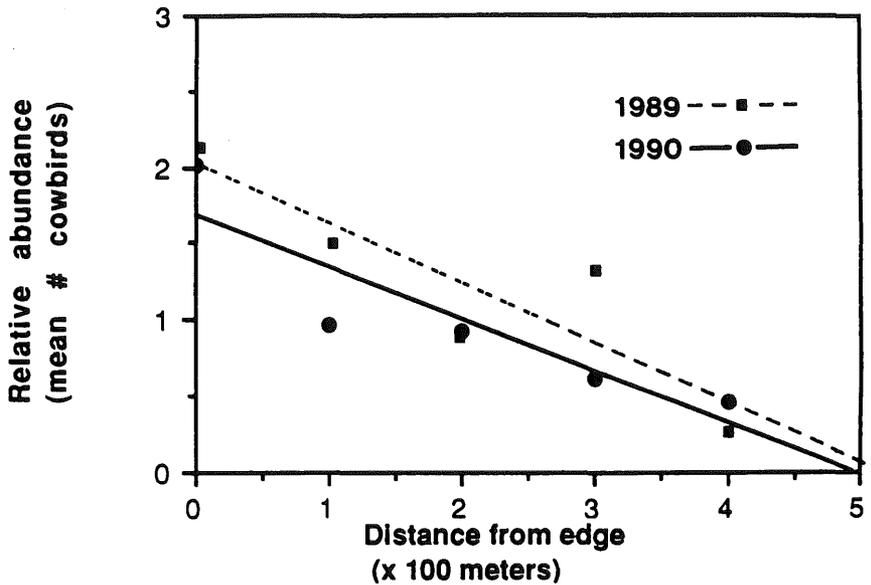


Fig. 2. Density of cowbirds vs. size of interior clearcut study site in 1990 ($y = 3.3245 + 0.35681x$, $R^2 = 0.463$)

relationship between density and the age of the clearcut (perhaps due to the limited age of clearcuts censused), a rank correlation was not calculated for this parameter.

Discussion

Our results have shown that cowbirds travel into the forest at least 400 meters, but the relative abundance of cowbirds significantly decreases with distance from an exterior edge. These results imply that in a large forest, with a low edge-to-area ratio, forest-interior specialists will not be exposed to high levels of parasitism. If the fragment is small, with a high edge-to-area ratio, cowbird densities may be high throughout.

Cowbird densities also were affected by internal openings in the forest. We found that the density of cowbirds increases as the size of the clearcut increases. This suggests that clearcuts should be no greater than 1 ha to decrease the density of cowbirds within the clearcut and therefore decrease the density of cowbirds found within the interior of the forest. Also, the slope for relative abundance in the forest *vs.* distance from clearcut edge increases as the size of the clearcut increases, indicating the high abundance of birds that travel into the interior from the clearcut. As the distance from the clearcut edge increased, the abundance of cowbirds decreased, suggesting that the cowbird prefers to penetrate the forest where an edge occurs (Brittingham and Temple 1983).

While the above pattern suggests negative values to creating large clearcuts within forests, the alternative of unevenaged management also may present problems. Unevenaged management involves the removal of the same amount of trees as clearcutting but the trees are selectively cut in small groups or as single trees throughout the forest. In this system there is an absence of large clearings, but the creation of many small openings spread throughout the forest may be detrimental. Our study reveals the presence of cowbirds in openings as small as 0.2 ha. Therefore, an opening of any size may increase the ability of cowbirds to penetrate into the forest interior.

It is clear that cowbird parasitism could be contributing to the decline of forest-interior bird species in the forests of Missouri (Robbins *et al.* in press). The increase in exterior edge through forest fragmentation and the increase in interior edge through the creation of clearcuts may provide the brown-headed cowbird access to entire forests at unusually high densities. This increase in cowbird densities could increase parasitism rates on the birds in the forest and may explain the 300 ha minimum requirements suggested for many neotropical migrants in this region (Hayden *et al.* 1985).

This study provides several suggestions for management practices of forests where forest-interior birds occur in a highly fragmented environment. If possible, the forest should be large (greater than 1000 ha.) to reduce the negative effects of exterior edges (i.e., provide forest interior that is greater than 400 meters from an exterior edge). When forests are cut, the fragment should be circular or square to reduce the edge-to-area ratio. When clearcuts are made they should be few in number and small to decrease the likelihood that cowbirds will assemble in them. Also, the clearcut should be located as close as possible to the periphery of the forest to decrease the extent of cowbird penetration into the forest from the clearcut.

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Literature Cited

- Ambuel, B. and S. A. Temple. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. *Ecol.* 64:1057-1068.
- Blake, J. G. and J. R. Karr. 1984. Species composition of bird communities and the conservation benefit of large versus small forests. *Biol. Conserv.* 30:173-187.
- Bond, R. R. 1957. Ecological distribution of breeding birds in the upland forests of southern Wisconsin. *Ecol. Monogr.* 13:59-68.
- Brittingham, M. C. and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? *BioScience* 33:31-35.
- Bystrak, D. and C. Robbins. 1977. Bird population trends detected by the North American breeding bird survey. *Polish Ecol. Stud.* 3:131-143.
- Erlach, P. R., D. S. Dobkin, and D. Wheye. 1988. *The Birder's Handbook*. Simon and Schuster, Inc. New York. 785 pp.
- Forman, R. T., A. E. Galli and C. F. Leck. 1976. Forest size and avian diversity in New Jersey woodlots with some land use implications. *Oecol.* 26:1-8.
- Friedmann, H. 1929. *The Cowbirds: A Study in the Biology of Social Parasitism*. Charles C. Thomas, Springfield, Illinois.
- Friedmann, H. 1963. Host relations of the parasitic cowbirds. *U.S. Natl. Mus. Bull.* No. 233, 276 pp.
- Galli, A. E., C. F. Leck and R. T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in New Jersey. *Auk* 93:356-364.
- Gates, J. E., and J. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. *Ecology* 59:871-883.
- Hayden, T. J., J. Faaborg and R. L. Clawson. 1985. Estimates of minimum area requirements for Missouri forest birds. *Trans. Missouri Acad. Sci.* 19:11-22.
- Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. *Auk* 103:593-602.
- Lynch, J. F. and D. F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, U.S.A. *Biol. Conserv.* 28:287-324.
- Mayfield, H. F. 1965. The brown-headed cowbird with old and new hosts. *Living Bird* 4:13-28.
- Meanley, B. 1971. Blackbirds and the southern rice crop. U.S. Fish Wildl. Serv., Resour. Publ. 100.
- Robbins, C. S. 1979. Effects of forest fragmentation on bird populations. *Passenger Pigeon* 41:101-119.
- Robbins, C. S., J. R. Sauer, and B. G. Peterjohn. In press. Population trends and management opportunities for Neotropical migrants. Proceedings of National Training Workshop. Status and Management of Neotropical Migratory Birds. U.S. Govt. Printing Office.
- Robinson, S. K., J. A. Grzybowski, S. I. Rothstein, M. C. Brittingham, L. J. Petit, and F. Thompson. Management implications of cowbird parasitism for Neotropical migrant songbirds. Proceedings of National Training Workshop, Status and Management of Neotropical Migratory Birds. U.S. Govt. Printing Office, in press.
- Rothstein, S. I., J. Verner, and E. Stevens. 1980. Range expansion and diurnal changes in dispersion of the brown-headed cowbird in the Sierra Nevada. *Auk* 97:253-267.
- Snedecor, G. W. and W. G. Cochran. 1980. *Statistical Methods*. Iowa State Univ. Press, Ames, Iowa.

Whitcomb, R. F. C. S. Robbins, J. F. Lynch, B. L. Whitcomb, M. K. Klimkiewicz and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of eastern deciduous forest. Pages 175-205 in R. L. Burgess and D. M. Sharpe (eds.), *Forest Island Dynamics in Man-dominated Landscapes*. Springer-Verlag, New York, New York.

Automotive Air-Conditioning Heat Exchanger Design Implications with Non-CFC Refrigerants

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Abstract: Since the Montreal Protocol and subsequent legislation designed to phase out the CFC refrigerants, including R-12, considerable developmental work has been initiated on alternate refrigerants. The leading candidate at present to replace R-12 in automotive air-conditioning systems is HFC-134a, with a number of others under consideration. Results of studies on alternate refrigerants have been reported at the 1990 and 1991 SAE Congresses, the 6th Miami International Conference on Heat and Mass Transfer (December 1990), and the ASHRAE/Purdue CFC Conferences in 1989, 1990, and 1991. Preliminary results by this author and others have indicated that although the thermodynamic performance of HFC-134a is somewhat less than that of R-12, the heat transfer coefficients under both boiling and condensing conditions are often greater for HFC-134a. This paper reports the results of additional work in translating the thermodynamic and heat transfer performance of the candidate refrigerants to the development of automotive system air-conditioning heat exchangers. Results include the relative weight and material cost for both evaporators and condensers.

Background

The attractive values for latent heat, boiling point, chemical inertness, and low toxicity of several chlorofluorocarbons (CFCs), most notably R-12, have contributed to their wide-ranging use as the working fluid in air-conditioning and heat pump systems. However, in 1974, two scientists at the University of California at Irvine (Molina and Rowland) postulated that chlorofluorocarbons, due their high chemical stability, were migrating into the upper atmosphere without decomposing. There, the chlorine portion of the molecule would be split off by the ultraviolet rays from the sun with the freed chlorine atoms reacting with ozone, creating chlorine oxide as a by-product. Subsequently, the chlorine oxide releases its oxygen, freeing chlorine to continue the destruction of ozone. Although ozone in the atmosphere is considered a pollutant and is controlled under the Clear Air Act, in the stratosphere it absorbs much of the sun's ultraviolet radiation before these rays reach the earth. Exposure to UV radiation is the principal cause of skin cancer and of death from malignant melanoma, the most dangerous form of skin cancer.

CFC's migrating to the stratosphere pose another threat in addition to this effect of ozone depletion. These chemicals, in a manner similar to carbon dioxide but several orders of magnitude more effective, produce a greenhouse effect, altering climate patterns and sea levels.

Automobile air-conditioning systems, as depicted in Fig. 1, today use Refrigerant 12 [Chlorofluorocarbon CFC-12 (CCl_2F_2)]. Refrigerant 22 was used in the past to gain additional refrigerating effect for a given displacement, but the high discharge pressures at idle and slow car speeds were undesirable.

Higher pressures and temperatures also accentuated compressor seal problems. With R-12, the pressures at idle conditions seldom reach 400 psig (2.8 MPa).

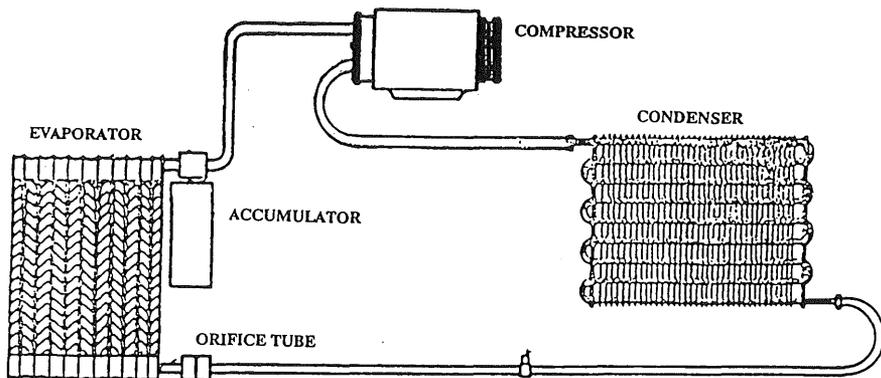


Fig. 1. Typical Automobile Air-Conditioning System

The National Resources Defense Council, the Friends of the Earth, and The Environmental Defense Fund filed a petition on December 3, 1991 that urges EPA to accelerate the phaseout of both CFCs and HCFCs. The brief called for a total phaseout of CFCs by 1995, a ban on the manufacture of products containing NCFC-22 by the year 2000, and a total ban on the use of hydrochlorofluorocarbons (HCFCs) by 2005. EPA had 180 days to respond to the petition. The call for emergency action was prompted by the October 1991 United Nations Scientific Assessments report which indicated significant decreases in ozone levels and that this ozone depletion would prove deleterious to human health. The report was based on what scientists consider the most comprehensive data gathered since monitoring of the stratospheric ozone layer began in 1985 with readings taken by both ground-based instruments and NASA satellites. Based on the information in the October report, the world's largest producer of CFCs announced that it will phase out sales of CFCs in developed countries in 1997, will phase out sales of all CFC and HCFC products for propellant applications by 1995, and will discontinue sales of HCFC-22 in developed countries for most applications by the year 2005.

It appears that the air conditioning and refrigeration industries may soon be competing with the automotive industry for dwindling supplies of CFC-12. About 60% of R-12 goes to the automotive industry, as replacement for the stock of 150 million cars. The leading long term candidate replacement for R-12 is currently R-134a [HFC 134a (CH_2FCF_3)]. Fortunately, the early problems concerning appropriate lubricants seems to have been solved by using ester-based oils.

However, several questions remain on R-134a, particularly regarding toxicity, compatibility with seal materials, and thermal performance. The "strato-

spherically safe" new refrigerant, 1,1,1,2-tetrafluoroethane (R-134a) is thermodynamically similar to R-12. However, R-134a does not contain any chlorine and thus has zero ozone depletion potential. Its physical properties, such as vapor pressure/boiling point and latent heat, closely match those of R-12.

Even with the use of HFC-134a in some new auto models starting in 1992-93, vehicles requiring a CFC-12 type refrigerant will still be operating in the year 2010. A study commissioned by the Department of Energy [1] estimated 60 million vehicles designed for CFC-12 operating in the United States in the year 2000. This is in agreement with a UNEP report [2] showing worldwide automotive CFC-12 demand of 130 million pounds in 2000. The United States has about half of the air conditioned vehicles, and the average yearly consumption from all types of refrigerant losses is one pound per car.

The Editorial Page of the July 16, 1990 issue of *Air Conditioning, Heating, and Refrigeration News* carried the following evaluation of the situation:

The auto manufacturers are in a particularly difficult situation. About 80% of new cars and 50% of light trucks are air conditioned, using R-12. About 75% of the 120 million lb of CFCs used every year by mobile air conditioning is for servicing. Auto manufacturers now have to figure out a way to redesign their equipment to use HCFC-134a. The car makers have committed themselves to using the new refrigerants for the model year 1994.

Whatever the true time schedule becomes, there is no doubt that the time is now for full scale efforts to determine the complete behavior of alternate refrigerants. Considerable developmental work has been completed on issues of toxicity, flammability, and basic thermodynamic and thermophysical properties of several leading candidate replacements, including R-134a. Much additional work remains to determine the consequences of these differing properties on such items as the heat exchangers in automotive air-conditioning systems.

Early reports indicated higher energy requirements for R-134a refrigeration units when compared to existing R-12 systems. As reported in the March 6, 1990 issue of *ACH&R News*,

Based on the thermal characteristics of HFC-134a as compared to CFC-12, HFC-134a theoretically may run about 8% to 10% less in energy efficiency. However, actual tests performed at DOE's Oak Ridge National Laboratory on HFC-134a in systems with potential lubricants have resulted in efficiency deteriorations of 20% and higher.

Dekleva [3] reports that recent cycle modeling experiments indicate that HFC-134a can perform with energy efficiencies equivalent to R-12. Under presently applied conditions, he found that HFC-134a may actually be superior to CFC-12 in terms of energy efficiency. His calculations, based on a modified cycle model in which realistic experimental conditions and design options were included, supported the most recent experimental results, which indicate the efficiency parity between the two refrigerants. Dekleva noted that previous experimental "verifications" of relative energy performances were made without regard to specific characteristics of the two systems. In particular, the choice of non-optimal lubricants for HFC-134a contributed to relatively poor energy-efficiency results. Dekleva also addressed the major problem to date with R-134a, incompatibility with standard refrigerant lubricants. New ester lubricants may have properties that make them ideal for use in HFC-134a alternative

refrigerant systems. His current work indicates that a class of synthetic ester lubricants is indeed compatible with HFC-134a, while offering attractive properties and contribution to energy efficiency of the new refrigeration systems in which they are intended for use.

Based on test work completed at Du Pont, Bateman [4] reports that HFC-134a is not a "drop-in" replacement for CFC-12 in most existing systems and that, depending upon the systems, design modifications may be required to achieve optimum performance. In a previous paper, Bateman [5] discussed in-car performance testing of HFC-134a and CFC-12 in a wind tunnel using a Chevrolet S-10 truck, Mercury Sable, Chevrolet Celebrity, and a Dodge Caravan. Results indicated that a significant amount of development work and system re-design will be required to optimize the use of HFC-134a.

The ASHRAE FUNDAMENTALS Handbook [6] provides additional details on refrigerant properties; the NASA compendium [7] details the ozone depletion and greenhouse warming phenomena; and potential consequences on the HVAC industry are highlighted by McLinden and Didion [8].

As a small part of the continuing developmental effort needed with the alternative refrigerants, this analytical study looks at the potential effect in making such a switch from R-12 as regards the size and cost of the finned tube heat exchangers used for the condensers and evaporators in automotive air conditioning units.

Methodology

Sauer [9] in a previous paper reported the development of computer code, VAPCOMP, for assessing the thermodynamic cycle performance of refrigerants, including R-12, R-22, and R-134a. For a specified cooling capacity, the relative condenser heat rejection rates for R-12, R-22, and R-134a could be determined. The paper also described the algorithms developed for determining the convective heat transfer coefficients under boiling and condensing conditions. A separate computer program has now been developed, using these algorithms, for designing finned-tube heat exchangers such as those used for the evaporator and the condenser in automotive air-conditioning systems.

Refrigerant Properties

Refrigerants investigated in the project consisted of R-12, R-22, and R-134a. For the first two, the thermodynamic properties were obtained from the algorithms found in Downing [10]. The thermophysical properties were obtained from the ASHRAE FUNDAMENTALS Handbook [6].

For R-134a, the thermodynamic properties and corresponding algorithms were obtained from Wilson and Basu [11]. In their paper, new P-V-T, saturated vapor pressure, liquid density, ideal gas heat capacity, and critical constant data were presented. The thermodynamic data were correlated to an equation of state from which enthalpies and entropies are calculated. Shankland, Basu, and Wilson [12] present preliminary low-density vapor thermal conductivity and liquid specific viscosity of R-134a over a limited range of temperature. Empirical correlations were derived which the authors felt represent the data adequately. Additional data on R-134a is sparse; however, it was possible to complete the necessary data set for this investigation from information on producers information sheets [13] [14].

Heat Transfer Coefficients

Air-side Convective Coefficients

The air-side convective coefficients presented by Kays and London [15] have been incorporated in the present work along with normal fin efficiency calculations and thermal contact resistance between fins and tubes as reported by Sheffield *et al.* [16].

Forced Convection Boiling in Tubes

Fortunately, correlations for forced convection have been developed for boiling refrigerants in horizontal tubes which today are more common than the ones involving superposition. All are restricted to test conditions for particular refrigerants, and one should be careful in applying them to conditions outside the test range.

Bo Pierre [17] introduced the Load Factor, $K_f = J\Delta x h_{fg}/L$ in which he effectively combined the Boiling and Martinelli numbers. In the Load Factor expression, J is Joules equivalent of heat (778 ft-lbf/Btu) and Δx is the change in quality that occurred during the evaporation process. He correlated R-12 and R-22 for a wide range of operating conditions with separate correlations for complete and incomplete evaporation. These correlations for the Nusselt number (Nu) with two-phase (tp) flow are listed below:

$Nu_{tp} = 0.009 (Re^2 K_f)^{0.5}$ for $10^9 < Re^2 K_f < 0.7 \times 10^{12}$ and exit vapor quality $< 90\%$ (incomplete evaporation).

$Nu_{tp} = 0.0082 (Re^2 K_f)^{0.5}$ for $10^9 < Re^2 K_f < 0.7 \times 10^{12}$ and up to 11 F superheat (complete evaporation).

Complete evaporation was assumed for this study and the correlations were assumed to hold for R-134a.

Forced Convection Condensation in Tubes

Condensers used for refrigeration and air conditioning systems generally involve vapor condensation inside horizontal tubes. Unfortunately, conditions within the tube are complicated and depend strongly on the velocity of the vapor flowing through the tube. There are two main types of condensation that have been observed to occur in practice. The first is film type condensation, which usually occurs when a vapor relatively free of impurities is allowed to condense on a surface. In such situations, the thermal resistance of the liquid film may not be ignored. In the second type, dropwise condensation, there is much less liquid film on the surface and heat transfer rates could be an order of magnitude greater. For this reason, it would be desirable to have dropwise condensation in commercial applications, but the presence of contaminants, non-condensable gases, vapor velocity, and the composition of the surface all encourage only filmwise condensation unless the surface is carefully prepared and controlled.

Most flow situations involving condensation in HVAC coils are annular and turbulent. The correlation of Ackers, Dean, and Crosser [18] correlates experimental data within 20% and is given by,

$$hD/k_\ell = 0.026 Pr_\ell^{1/3} [R_\ell + Re_v(\rho_\ell/\rho_v)^{1/2}]^{0.8}$$

where

$$Re_l = (4M_l/\pi D\mu_l) \quad Re_v = (4M_v/\pi D\mu_v).$$

Here M_l and M_v are, respectively, the mass flow rate of liquid and vapor.

Refrigerant System Performance

Figures 2 through 4 provide samples of the output information from VAPCOMP for R-12, R-22, and R-134a, respectively.

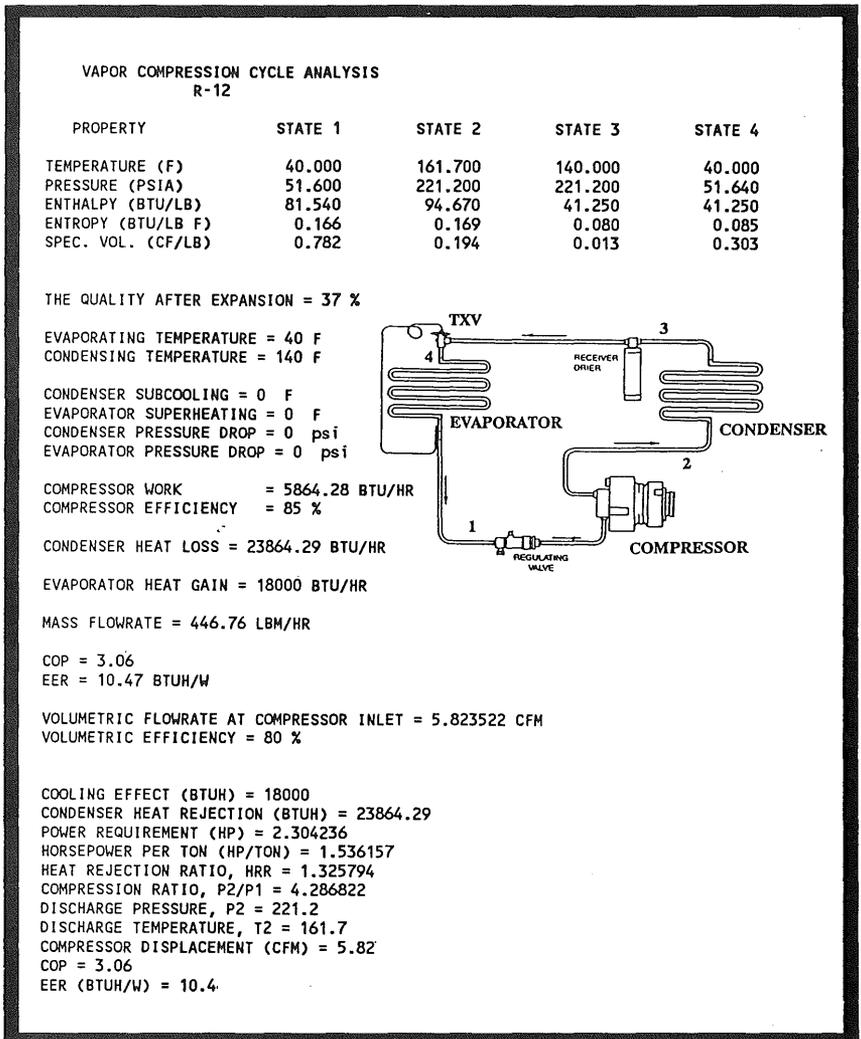


Fig. 2. Theoretical Refrigerant System Performance for R-12.

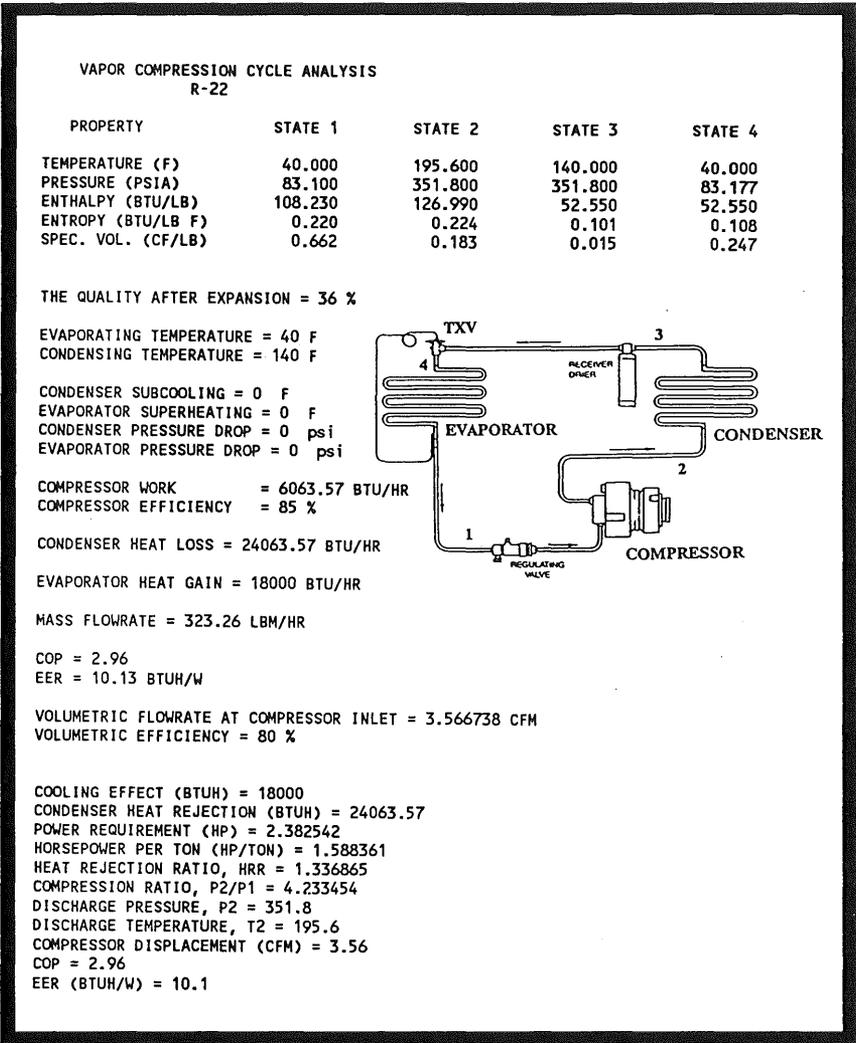


Fig. 3. Theoretical Refrigerant System Performance for R-22.

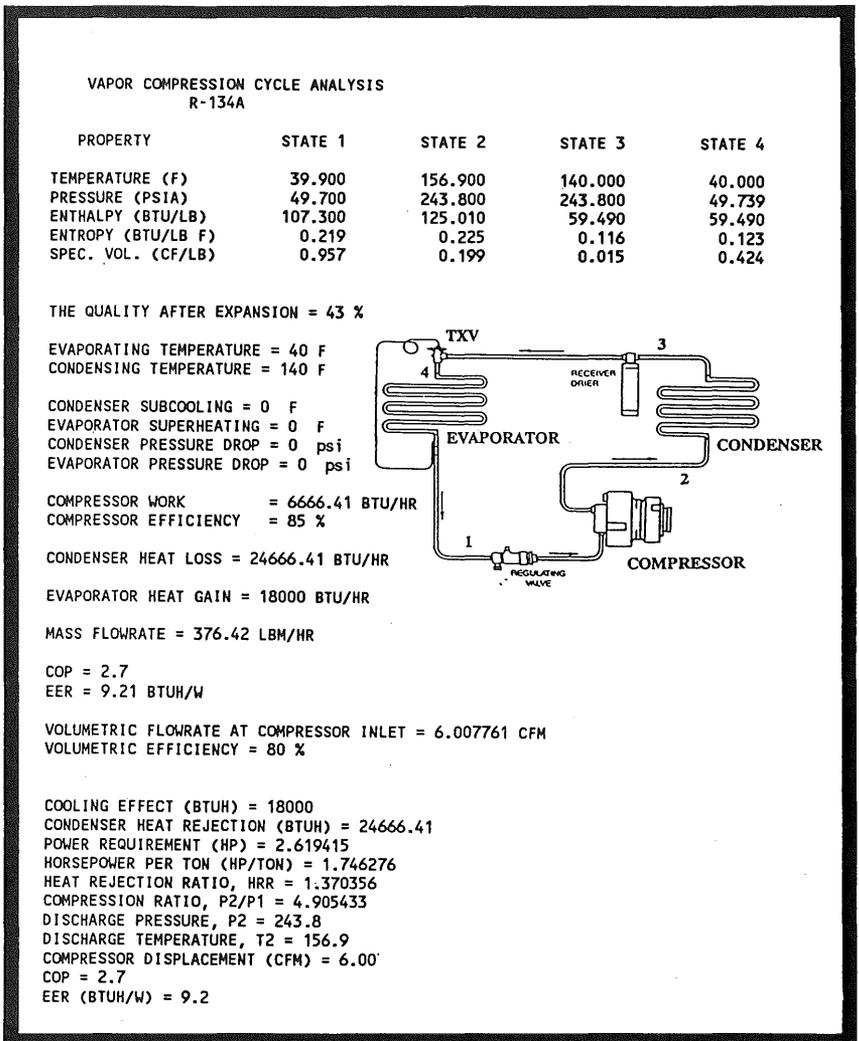


Fig. 4. Theoretical Refrigerant System Performance for R-134a.

For a set of common operating conditions, the program provides output for comparison of the refrigerants on the basis of:

- Energy Efficiency Ratio
- Compressor Discharge Pressure
- Compressor Discharge Temperature
- Compressor Size (Displacement)
- Heat Rejection Ratio (HRR).

Practically all refrigerants in common use today have approximately the same coefficients of performance (energy efficiency ratios) and horsepower requirements. R-134a unfortunately falls below the effective energy performance of both R-12 and R-22. However, at normal operating conditions the EER drop is not severe.

The compressor discharge pressure is an important parameter in that it relates to both power requirement and system weight. The consequence of higher operating pressure is usually an increased initial cost and a less compact system to go along with increased power consumption. The operating pressure should be low enough for lightweight vessels and tubing to contain the refrigerant. R-22 has a much higher discharge pressure than R-12. R-134a has a slightly higher discharge pressure than R-12. The vehicular wind tunnel tests of Struss *et al.* [19] using two vehicles and the same air conditioners for both R-12 and R-134a showed higher head pressures will be generated with HFC-134a. They also reported that the passenger compartment temperatures were in the same range as they were for CFC-12.

The temperature at the discharge of the compressor is the highest encountered by the refrigerant. A low adiabatic discharge temperature is highly desirable. Under normal operating conditions the reaction between the refrigerant and the lubricating oil is slight and of little consequence. However, when contaminants, such as air and moisture, are present in the system in any appreciable amount, chemical reactions involving the contaminants, the refrigerant, and the lubricating oil often occur which can result in decomposition of the oil and the formation of corrosive acids and sludges. High discharge temperatures greatly accelerate these processes, particularly oil decomposition, and often result in the formation of carbonaceous deposits on discharge valves, the compressor head, pistons, and in the discharge line. R-22 has the highest natural discharge temperature of the refrigerants considered and thus the greatest tendency for breakdown of the lubricating oil and motor burnouts in hermetic units.

Wherever there are space limitations, the smaller compressor displacement for R-22 would be a decided advantage. In fact, the principal advantage of R-22 over R-12 is the smaller compressor displacement required, being approximately 40 percent less. Alternately, for a given size compressor, the cooling capacity would be about 40 percent greater for R-22. In this category, R-134a will apparently fail to match the performance of R-12, let alone R-22.

The heat rejection ratio (HRR) is the ratio of the heat rejection rate at the condenser to the cooling rate at the evaporator. This heat rejection ratio, combined with the overall heat transfer coefficient, obtained from the convective coefficients covered in the next section, will dictate the relative size of condenser required for a common cooling capacity. The results of the cycle analyses, as shown in Fig. 5, indicate that the heat rejection associated with a fixed cooling rate (18,000 Btu/hr) is slightly higher for R-134a than those for R-12 or R-22.

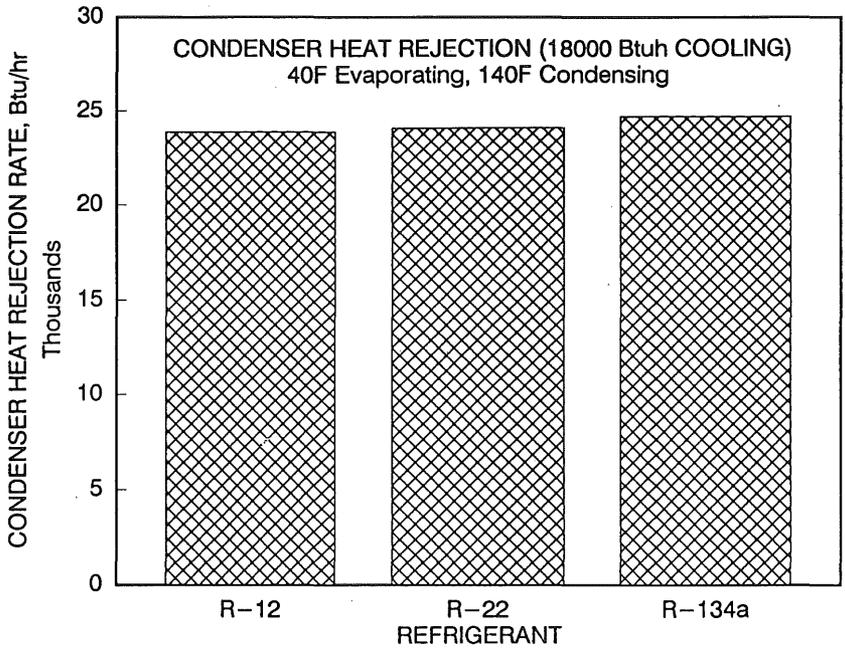


Fig. 5. Condenser Heat Rejection for Common Cooling Capacity (18000 Btu/hr)

Overall Comparative Performances

All heat exchanger cost figures are for the materials (copper tubes and aluminum fins) only.

The comparison of evaporator costs, presented as cost per unit capacity, is given as Fig. 6. As can be noted from the figure, R-134a has a very, very slight cost advantage over R-12.

Relative condenser costs are shown in Fig. 7. As can be seen, the R-22 exchanger is slightly less expensive than either R-12 or R-134a exchangers. For equal capacity, R-134a betters R-12 slightly.

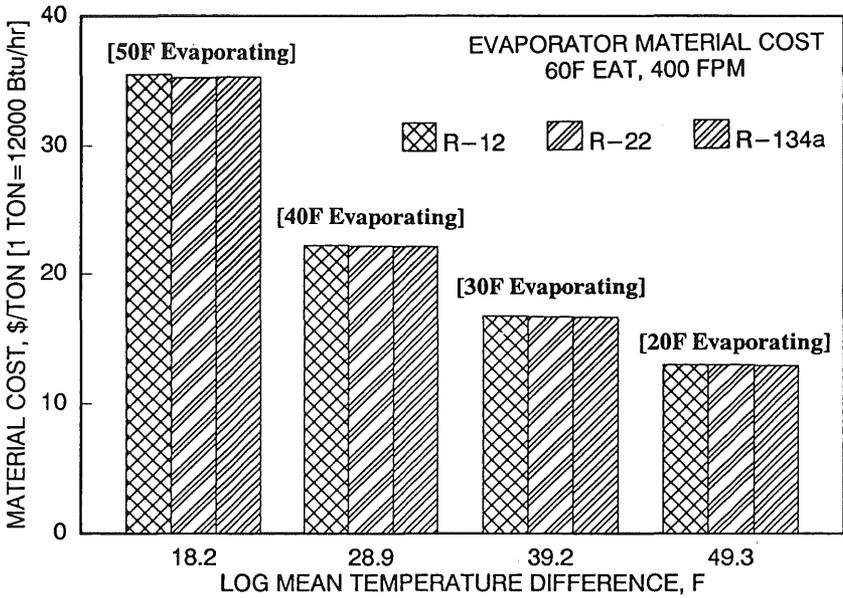


Fig. 6. Relative Evaporator Costs for Various Evaporating Temperatures

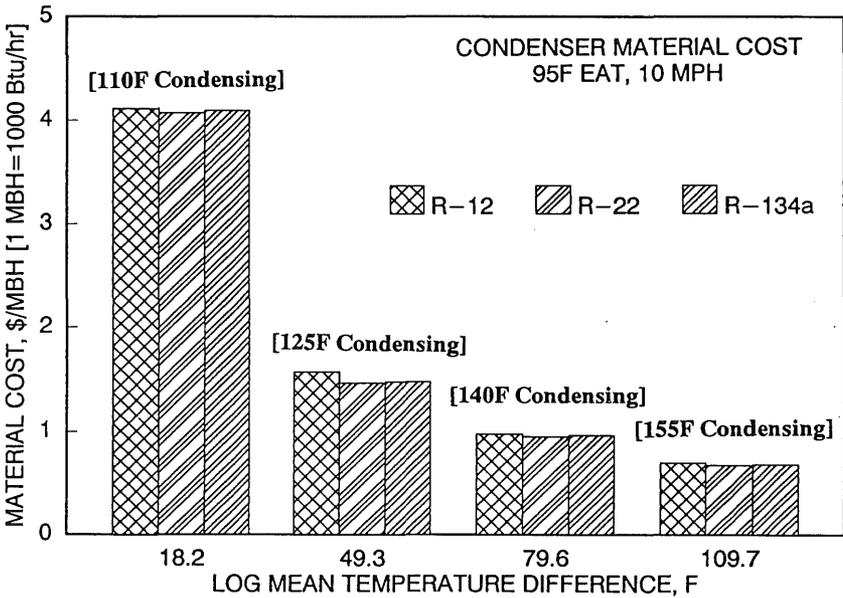


Fig. 7. Relative Condenser Costs for Various Condensing Temperatures

The effect of vehicle design speed on the air-conditioning system is shown in Figs. 8, 9, and 10.

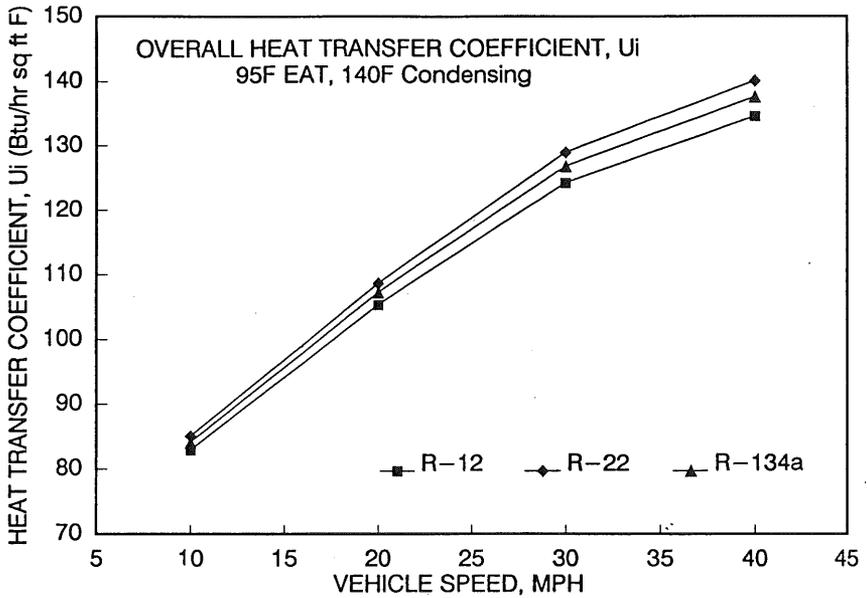


Fig. 8. Effect of Design Vehicle Speed on Condenser Heat Transfer Coefficient

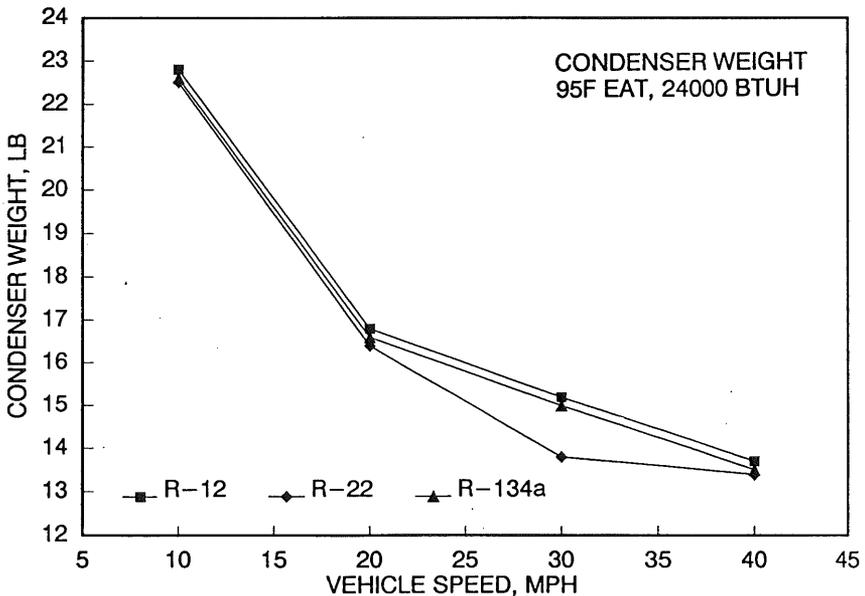


Fig. 9. Variation of Condenser Weight with Design Speed

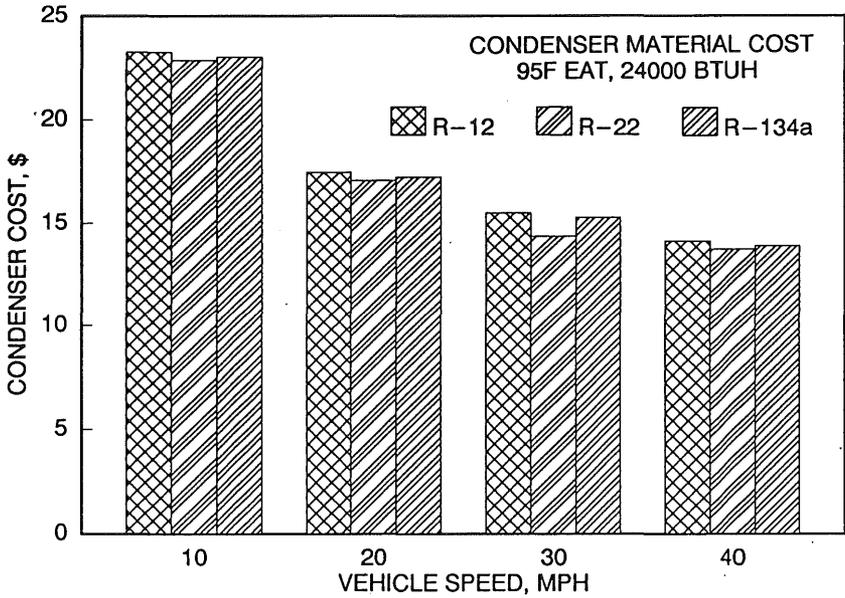


Fig. 10. Variation of Condenser Cost with Design Speed

Conclusions and Recommendations

Because of the high operating pressures encountered, HCFC-22 is not a viable candidate for today's automotive air conditioners although its thermal performance is at least as good as that of CFC-12. With the poorer thermodynamic performance of HFC-134a, the corresponding condenser will need to reject more heat than the R-12 unit, for the same system cooling capacity. However, the higher condensing heat transfer coefficient with HFC-134a offsets the needed increased capacity under some operating conditions. In addition, the higher evaporating heat transfer coefficients obtained *under some operating conditions* with HFC-134a provide slight saving in evaporator cost.

Figure 11 presents the cost penalty versus R-12 units for a typical 1.5 ton cooling capacity.

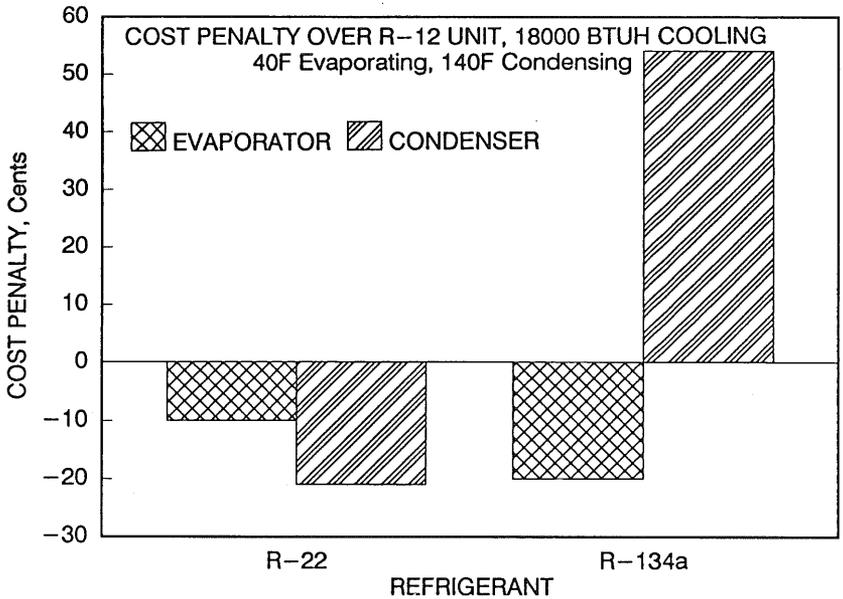


Fig. 11. Automotive A/C Heat Exchanger Cost Differences

As shown in Fig. 12, combining the costs for both evaporator and condenser indicates basically a breakeven situation for all three refrigerants considered. R-134a is only slightly the highest. The very slight potential cost savings for R-22 would not be sufficient to compensate for the increased cost of heavier gage materials needed at various locations in the system due to the higher head pressures experienced with this refrigerant. However, the same gage tubing was used for all heat exchangers in this study.

However, it must be emphasized that the refrigerant properties used throughout this work are for the pure refrigerant and do not include the effect of "contamination" by the lubricant. Considerable additional work, both analytical and experimental, is needed with improved properties to better ascertain the true effects of switching to non-CFC refrigerants.

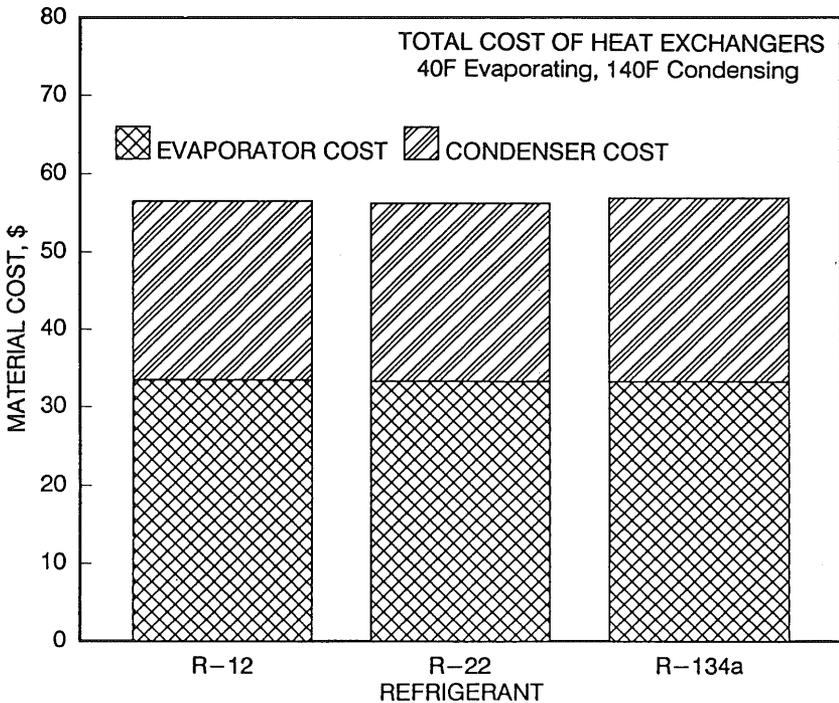


Fig. 12. Automotive A/C Heat Exchanger Costs

References

1. Putnam, Hayes, and Bartlett, Inc., "Assessment of the Impacts Associated with a Total CFC Phaseout," Report for the Department of Energy, Washington, D.C., July 10, 1989.
2. Kuijpers, L. (chair), "Refrigeration, Air Conditioning and Heat Pumps Technical Options Report," United Nations Environment Programme, June 30, 1989.
3. Dekleva, T. W., N. Behrens, J. G. Hartley, F. T. Murphy, and R. L. Powell, "The R-134a Energy Efficiency Problem: Fact or Fiction?," ASHRAE-Purdue CFC Conference, Purdue University, July 17-20, 1990.
4. Bateman, D. J., "Current Development Status of HFC-134a for Automotive Air Conditioning," SAE Technical Paper 900213, International Congress and Exposition, Detroit, MI, 1990.
5. Bateman, D. J., "Performance Comparison of HFC-134a and CFC-12 in an Automotive Air Conditioning System," SAE Technical Paper 890305, International Congress and Exposition, 1989.
6. ASHRAE Handbook, 1985 FUNDAMENTALS, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA 1985.
7. Atmospheric Ozone. Vol. I, II, III. NASA, Washington, D.C. 1985.
8. McLinden, M. O. and D. A. Didion, "CFCs: Quest for Alternatives," *ASHRAE JOURNAL*, Vol. 29, No. 12, p. 32, December 1987.
9. Sauer, H. J., Jr., "Comparative Phase Change Convective Coefficients for CFC and Alternate Refrigerants," *Multiphase Transport and Particulate Phenomena*, T. N. Veziroglu (ed.), Volume 1, pp. 511-530, Hemisphere Publishing Company, New York, 1990.

10. Downing, R. C., "Refrigerant Equations," Paper No. 2313, *ASHRAE Transactions*, Vol. 80, Part 2, 1974.
11. Wilson, D. P. and R. S. Basu, "Thermodynamic Properties of a New Stratospherically Safe Working Fluid - REFRIGERANT 134a," *ASHRAE Transactions*, Vol. 94, Part 2, 1988.
12. Shankland, I. R., R. S. Basu, and D. P. Wilson, "Thermal Conductivity and Viscosity of a New Stratospherically Safe Refrigerant - 1,1,1,2-Tetrafluoroethane (R-134a)," International Institute of Refrigeration Conference, Session 2, Purdue University, July 1988.
13. _____, "Properties of HFC-134a," Technical Information, Freon Products Laboratory, DJB25, E. I. DuPont, Wilmington, Delaware, December 16, 1987.
14. _____, "Fluorocarbons for Tomorrow (HFC-134a)," Genetron Products, Allied Signal, Morristown, N.J., July 1987.
15. Kays, W. M. and A. L. London, *Compact Heat Exchangers*, Second Edition, McGraw-Hill Book Company, New York, 1964.
16. Sheffield, J. W., M. Abu Ebid, and H. J. Sauer, Jr., "Finned Tube Contact Conductance - Empirical Correlation of Contact Conductance," *ASHRAE Transactions*, Vol. 91, Part 2, 1985.
17. Pierre, B., S. F. Review, Vol. 2, No. 1, A. B. Svenska, Flaktabriken, Stockholm, Sweden, 1955.
18. Akers, W. W., H. A. Deans, and O. K. Crosser, "Condensing Heat Transfer within Horizontal Tubes," *Chem. Engr. Prog., Symposium Ser.*, Vol. 55, No. 29, 1961.
19. Struss, R. A., J. P. Henkes, and L. W. Gabbey, "Performance Comparisons of HFC-134a and CFC-12 with Various Heat Exchangers in Automotive Air Conditioning Systems," SAE Technical Paper 900598, International Congress and Exposition, Detroit, MI, 1990.

Nomenclature

D	= diameter
h	= heat transfer coefficient
h_{fg}	= latent heat of vaporization
J	= Joules equivalent of heat
k	= thermal conductivity
L	= length
M	= mass flow rate
Nu	= Nusselt Number
Pr	= Prandtl Number
Re	= Reynolds Number
x	= quality
μ	= viscosity
ρ	= density

Subscripts

o	= outer
tp	= two-phase
v	= vapor
l	= liquid

The Vegetation of Little Bean Marsh

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Abstract: Little Bean Lake contains one of the few remaining natural marshes in Missouri. Using line-intercept transects, Little Bean Marsh was found to be dominated by *Scirpus fluviatilis*, *Polygonum coccineum*, *Sagittaria brevirostra*, *Leersia oryzoides*, *Scirpus acutus* and *Typha latifolia*. No vegetation sequence pattern could be determined. Because of continuous disturbance by periodic floods, the marsh appears to consist of a mosaic of catastrophically induced and maintained patches of vegetation.

Key Words: Little Bean Marsh, marsh mosaic, *Scirpus fluviatilis*, *Polygonum coccineum*, *Sagittaria brevirostra*, *Leersia oryzoides*, *Scirpus acutus*, *Typha latifolia*.

Introduction

The 248-acre Little Bean Marsh Wildlife Area is located at the northeast end of Little Bean Lake in Platte county about 35 air miles from downtown Kansas City, Missouri. Located along highway 45, in sections 11 and 14 of T54N, R37w, the remnant oxbow lies in the upper Missouri River Section of the Big Rivers Natural Division (Thom and Wilson 1980). In 1981, Little Bean Marsh and some surrounding land was purchased by the Missouri Department of Conservation, and made into the Little Bean Marsh Wildlife area. Within the wildlife area, a 151-acre tract described as "the best natural marsh along the Missouri River" (Thom and Iffrig 1985) was designated as the Little Bean Marsh Natural Area.

During the summer of 1986, under a grant from the Missouri Department of Conservation, a vegetation study of the Little Bean Marsh Natural Area was begun. The primary objective of the study was to describe the marsh's present plant community to establish a baseline for future comparisons. Specifically, we sought to answer these questions: 1) what species were present in the marsh; 2) which were most abundant; and 3) how were the species distributed?

The Little Bean Marsh Wildlife Area includes the Natural Area, which is located at the north part of Bean Lake and is characterized by shallow or fluctuating water levels and an abundance of aquatic and marsh plants. The surrounding terrain is typically flat with a few low ridges and terraces. Along with the marsh, the Wildlife Area includes Cottonwood Slough, a six-acre shallow open water slough; about 43 acres of bottomland forest of varying natural quality; and about 31 acres of old fields returning to forest vegetation (courtesy Missouri Department of Natural Resources).

The average annual temperature is 54.5 F (12.5 C). Temperatures range from 27.8 F (-3 C) in January to 78.8 F (26.5 C) in July. Average rainfall is

37.0 inches, coming mostly in June and least in January. Typically early spring brings frequent and rapid fluctuations in weather patterns, with torrential rains often leading to localized flooding. The present landscape is shaped principally by both the longterm effects of continental glaciers, whose southern limits closely parallel the present Missouri River, and the relatively recent flooding cycles of the Missouri River (Baldwin 1973).

The soils of Little Bean Marsh are Haynie silt loam-clayey substratum, Haynie variant silt loam, Lavasy silty clay, and Sarpy fine sandy loam. All are relatively young soils derived from the Haynie-Parkville-Leta soil association. These are typical of depressional flood plan areas (Turner 1985).

The Marsh

The information presented in this section was obtained from the Platte County Historical Society records (Platte County Historical Society 1986) and from interviews in 1986 with Little Bean Lake area resident and historian Edward Kidwell (Personal communications with David LaPlante, Summer 1986).

The time of formation of the ox-bow is unknown. In 1804, Lewis and Clark first surveyed the area and reported an abundance of wildlife, especially waterfowl. They identified the inhabitants as members of the *Missouri* Indian Tribe. Now part of Platte County, the area did not become part of Missouri until 1836 through the Platte Purchase Agreement (Thom and Wilson 1980).

In the mid-1870's, the lake was known as Short Creek Lake. A low land mass, which is southeast of the present Little Bean Marsh, and which was then owned by Elizabeth Grooves and Adam Rambo, separated the upper part of the lake from the main lake (Fig. 1A). The portion which was to become Little Bean Lake remained open and relatively deep. In the 1870's, the lake became Bean Lake (Fig. 1B) and under the ownership of a Mr. A. Kirkpatrick the low land mass became Kirkpatrick Island. The island was accessible by foot only by a bridge on the southwest end of Bean Lake. The upper and lower portions of the lake were still connected at the end of the 19th century. As agriculture in Platte county grew, Little Bean Lake began to change rapidly as more and more silt was deposited from Short Creek. Seasonal flooding also left large deposits of material. By the turn of the century Little Bean Lake had become almost completely separated from the larger Bean Lake save for some drainage channels (Fig. 1C). In spite of continuous siltation, in 1919, the east end of Little Bean Lake was still 20 feet deep in parts. In the 1930's, much of the lake was open water and used heavily by hunters. Interestingly, in contrast to the present, the east end of Little Bean Lake contained more open water than the west. Continued deposition of materials from Short Creek, and significant river floods of 1952, 1973, and 1983, produced shifts in sediment depth. Although areas exposed during one flood would be scoured away during the next flood, Little Bean Lake became gradually shallower (Fig. 1D).

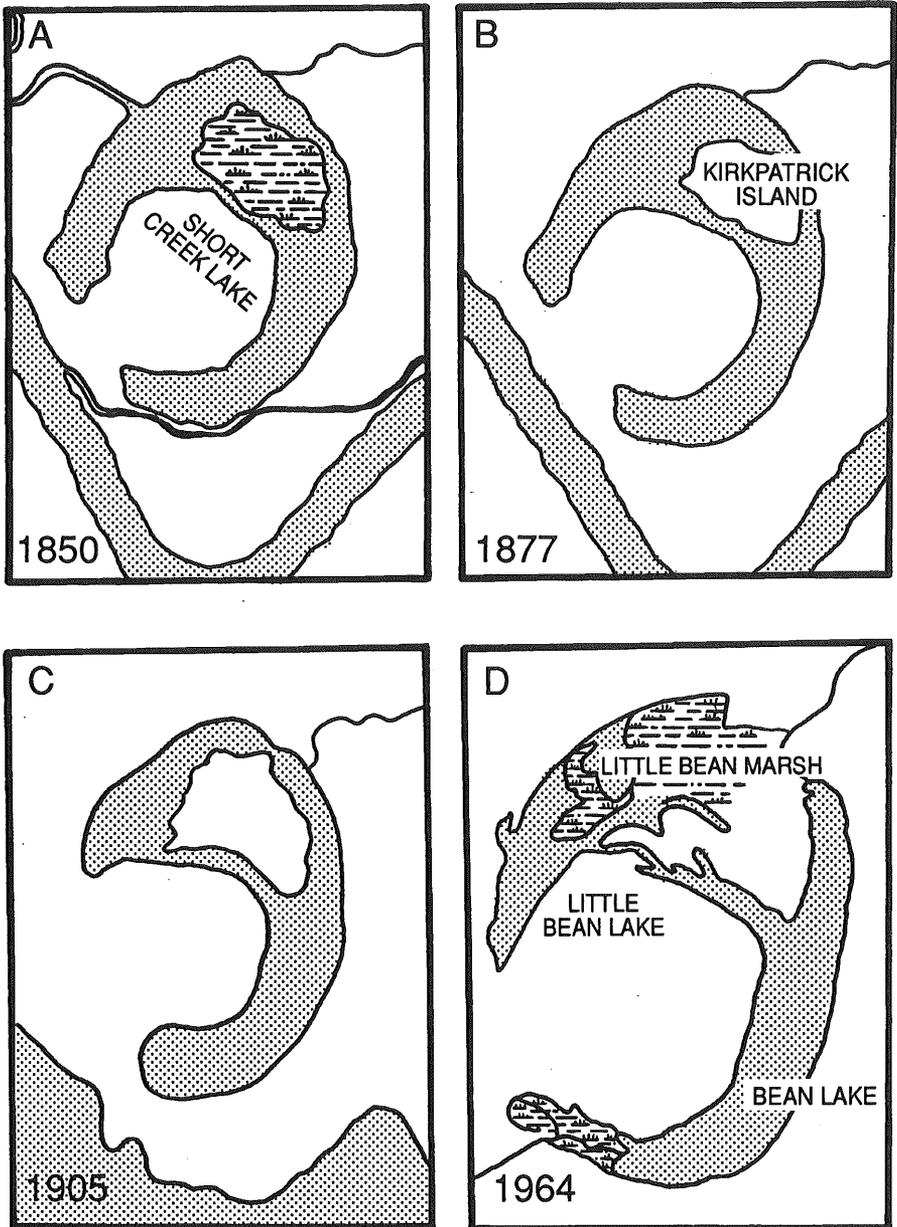


Figure 1. Physiographic development of Little Bean Marsh from 1850 to 1964 (Courtesy Platte County Historical Society). 1A. Little Bean Lake (Short Creek Lake) in 1850. 1B. The Kirkpatrick Island land mass in 1877. 1C. Further separation of Little Bean Lake from Bean Lake, 1905. 1D. Little Bean Lake and Marsh from 1964 to present.

A significant change in the level of the lake occurred as a result of the flood of 1952. Enough silt was deposited in Little Bean Lake and surrounding marshy areas to allow the construction of a more permanent access road. Subsequently, a hunting club purchased the marsh and used it as a hunting reserve. In an effort to increase duck populations, bulldozers were used to create three acres of open water surrounded by a levy at the north end of the lake. The area provided "massive" harvests of American lotus. Smartweed (*Polygonum* spp.) formed huge beds throughout the marsh.

In the 1960's, lotus stands became a nuisance to hunters and were removed to provide open water for waterfowl. By the end of the 1960's, sediment build-up at the mouth of Short Creek was sufficient to block flow into Little Bean Lake. The creek now empties into north end of Bean Lake.

Two more recent floods have caused major changes in the lake water level. In 1973, a winter flood caused by an ice-jam scoured much of the vegetation of the marsh, increasing open water. In 1983, fluvial berms were created in several places in the marsh.

From the above record, we have inferred the following pattern. Materials are brought into the marsh area gradually by Short Creek and rapidly by periodic floods. At times, some areas become high enough to support a more mesic vegetation. These periods of sediment deposition were followed at some time by the scouring and displacement effect of powerful floods. Formerly exposed areas become open water, and formerly open areas become filled with large deposits of material.

Methods

Since our primary purposes were relatively simple, and since preliminary plot sampling in the deep mud of the marsh had turned out to be difficult and very destructive to marsh vegetation, a segmented line intercept method (Canfield 1941) was used to sample the vegetation. We hoped this would restrict excessive trampling to the relatively narrow survey lines rather than to larger areas required by two-dimensional plots. Eighteen survey lines, each 100 m long, were selected in what we believed to be the most representative areas of the marsh community.

All vegetation vertically intercepted by the tape (1 cm wide), 0.5 m above the surface was recorded. For swampy areas containing woody shrubs and sprawling vegetation, the spread-crown (the downward extension of the crown onto the line) intercept was used. Each 100 m transect was partitioned into 10 m survey segments for a total of ten survey segments per line. The segmented line was used to develop parameters for a modified Importance Value (the sum of relative densities, occurrences, and line-coverages). However, subsequent examination of these data indicated line-coverage percentages were an accurate measurement of dominance and differed little from the modified IV developed.

A cluster analysis (SPSS) based on the line coverage was used in hopes of identifying the most similar stands of vegetation (Willard North, Research consultant, at Central Missouri State University). The resulting computer-generated clusters were then compared.

Voucher specimens of all plant species collected are deposited in the herbarium at Central Missouri State University (WARM). Taxonomic nomenclature follows Steyermark (1963) and Great Plains Flora Association (1986).

The Marsh Community

The vegetation of the marsh was dominated by *Scirpus fluviatilis*, 46.8% line coverage, *Polygonum coccineum*, 12.3%, *Sagittaria brevirostra*, 8.3%, *Scirpus acutus*, 7.2%, and *Leersia oryzoides*, 7.4% (Table 1). These five species occupied about 83% of all intersect lines. Three other herbaceous species with less than 7% but over 1% total coverage were *Typha latifolia* (5.2%), *Phragmites communis* (3.5%) and *Cephalanthus occidentalis* (2.2%). These eight species occupied about 93% of all the lines. Woody species, *Salix nigra*, *S. rigida*, *S. interior*, *Cephalanthus occidentalis*, and *Populus deltoides* comprised about 4.5%. Fifteen other species, occupying about 2.5% line coverage, were found. Some mesic species such as *Humulus japonicus*, *Scutellaria lateriflora*, and *Mentha arvensis* were found in the more elevated areas of the marsh.

Hierarchical cluster analysis separated the 18 sample lines into three supposed homogeneous groups according to their coverage values: Cluster analysis group 1 lines were dominated by: *S. fluviatilis* (coverage = 69.2%), *P. coccineum* (7.6%), *S. brevirostra* (7.1%), *S. acutus* (6.9%), and *L. oryzoides* (1.8%). Lines with this cluster group tended to be least inundated.

Cluster analysis group 2 lines were possibly intermediate between group 1 and group 3 lines in amount of flooding. Dominant species within group 2 were; *P. coccineum* (30.5), *S. fluviatilis* (30.1), *Phragmites communis* (8.5), *T. latifolia* (4.7) and *S. acutus* (2.5). Coverage values of *P. coccineum* and *P. communis* were highest in this group when compared to the other two cluster groups. This group may represent lines intermediate between least inundated marsh areas and the most inundated areas (group 3).

Cluster analysis group 3 lines seemed to occur in usually inundated habitats. Dominant species were *L. oryzoides* (26.4), *T. latifolia* (14.3) and *S. brevirostra* (19.4).

However, although divided into 3 groups, examinations of these data show surprisingly few real differences between cluster generated groups in the number and line-coverage of dominant species (greater than 1% coverage), or in rare to uncommon species (with only 1% to 0.1% coverage). More dramatic differences would have been expected in the species makeup of these lines if they in fact represented three different vegetation types. There is no easily discernible pattern. An examination of the groups' similarities using Ellenberg's biomass index of similarity (Mueller-Dombois and Ellenberg 1974), also shows the groups to be quite similar. Between groups 1 and 2 the similarity index is 100%; between groups 1 and 3, 90%; and between groups 2 and 3, 64%.

A reason for similarity of the vegetation groups lies apparently in the patterns of flooding at the marsh. Floodplain vegetation is obviously influenced by periodic flooding. Walker, B. H. and Coupland (1968) concluded that species distribution was more affected by water regime than by soil and its components, with water level fluctuation the most important factor in determining the distribution of many aquatic plants. Hupp (1983) found that river channel features, if inundated approximately 10-15% of the year, support different species than drier or higher areas of the floodplain and frequency of flooding is an integral factor in the formation and maintenance of vegetation pattern. Others (Davenport and Haynes 1986; Sipple and Klockner 1980) also have suggested that plant species and communities occurring naturally along river floodplains evolve in an environment of periodic flooding.

With the constant import of sediments from streams feeding into and filling Little Bean Marsh, a hydric succession of plants responding to an increasing soil base might begin, leading to some sort of bottomland woody community. Except for perimeter areas and for permanently exposed areas, Little Bean Marsh itself does not seem to follow this pattern. In classic hydric succession, as colonies of plants become established, grow, and accumulate sediments and biomass, the habitat is changed, permitting other species to become established and ultimately assume dominance. At the marsh, however, at any given time, floods of varying intensities can dramatically change the subsurface topography in any number of loci by either removing or depositing large amounts of material. The original vegetation is lost and the habitat altered. The disturbed locus is then recolonized by species able to grow there. This leads to a mosaic of microcommunities within the marsh, with any particular spot in the marsh with some combination of species. Walker, D. (1970) also found no universal sequence in plant communities when he studied cores of vegetation deposits in 66 British Lakes. He even found that some woody communities (alder or willow) could be replaced by less woody peat bogs. This suggests that even swampy areas of the marsh may be returned to marsh, or even to open water, if flood waters are violent enough.

Thus it appears, as long as the marsh is subjected to radical water depth changes by periodic flooding, no single place in the marsh may ever complete a hydric succession and reach a stable (woody or otherwise) community; instead, a mosaic of temporary communities of various plant compositions persist in a catastrophically maintained equilibrium. If the present cycle of sediment build-up and sediment removal continues, it is conceivable that Little Bean Marsh will remain in its present condition for the foreseeable future. It is also probable that only when exposed soil levels become stabilized will some type of succession continue to, perhaps, a bottomland forest similar to those found along portions of the Missouri River in northwestern Missouri.

No specific management policies are recommended here. In fact, if the past history of the marsh is an accurate measure of the future, then the marsh will maintain itself through the scouring and depositional actions of future floods.

Acknowledgements

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Literature Cited

- Baldwin, J. L., 1973. *Climates of the United States*. Department of Commerce, USA. Washington, DC.
- Canfield, R. H., 1941. Application of the line interception method in sampling range vegetation. *Jour. For.* 39:388-394.
- Davenport, L. J. and R. R. Haynes, 1986. Aquatic and marsh plants of Alabama II. *Arecidae*. *Castanea* 51(3):291-298.

- Great Plains Flora Association, 1986. *Flora of the Great Plains*, University Press of Kansas, Lawrence, Kansas
- Hupp, C. R., 1983. Vegetation patterns on channel features in the passage Creek Gorge, Virginia. *Castanea* 48(2):62-72.
- Mueller-Dombois, D. and H. Ellenberg, 1974. *Aims and Methods of Vegetations Ecology*. John Wiley & Sons, New York.
- Platte County Historical Society, 1986. *Platte County Historical Society Records*, Platte City, Mo.
- Sipple, W. S. and W. A. Klochner, 1980. A unique wetland in Maryland. *Castanea* 45(1):61-69.
- Steyermark, J. A. 1963. *Flora of Missouri*. Iowa State University Press, Ames, Iowa.
- Thom, R. H. and G. Iffrig, 1985. *Directory of Missouri Natural Areas*, Missouri Natural Areas Committee.
- Thom, R. H. and J. H. Wilson, 1980. The natural divisions of Missouri. *Transactions Missouri Academy of Science* 14:9-23.
- Turner, L. M., 1985. *Soil Survey of Missouri*. USDA and Soil Conservation Service. Washington, DC.
- Walker, B. H. and R. T. Coupland, 1967. An analysis of vegetation-environment relationships in Saskatchewan sloughs. *Canadian J. Botany* 46:509-522.
- Walker, D. 1970. Direction and Rate in Some British Postglacial Hydroseres, in *The Vegetational History of the British Isles*, ed. by D. Walker and R. West. Cambridge University Press, pp. 117-139.

Table 1. Line coverage values of transect lines in percentage and IVs of Little Bean Marsh vegetation in the summer of 1986 (* = 0.9% to 0.1% line coverage; ** = less than 0.1% line coverage).

Cluster Groups and Relative line coverages				
Species	1	2	3	Overall
Species with total coverage greater than 1% (total 92.9%)				
<i>Scirpus fluviatilis</i>	69.2	30.1	17.9	46.8
<i>Polygonum coccineum</i>	7.6	30.5		12.3
<i>Sagittaria brevirostra</i>	7.1	1.3	19.4	8.3
<i>Leesria oryzoides</i>	1.8	2.1	26.4	7.4
<i>Scirpus acutus</i>	6.9	2.5	13.8	7.2
<i>Typha latifolia</i>	1.3	4.7	14.3	5.2
<i>Phragmites communis</i>	2.2	8.5		3.5
<i>Cephalanthus occidentalis</i>	0.4	6.7	0.3	2.2
Species with total coverage between 1% and 0.1% (total 6.75%)				
<i>Jussiaea repens</i>	*		3.1	1.0
<i>Salix interior</i>	**	3.4		1.0
<i>Salix rigida</i>	*	1.1	*	*
<i>Salix nigra</i>	*		2.5	*
<i>Typha angustifolia</i>		**	2.5	*
<i>Polygonum hydropiper</i>		2.2		*
<i>Polygonum lapathifolium</i>	*	*	1.0	*
<i>Polygonum punctatum</i>	*	1.0	**	*
<i>Carex hyalinolepis</i>		1.8		*
<i>Sparganium eurycarpum</i>	*			*
<i>Humulus japonicus</i>		1.2		*
<i>Scutellaria lateriflora</i>		*		*
<i>Mentha arvensis</i>		*		*
Species with total coverage less than 0.1% (total 0.35%)				
<i>Phalaris arundinacea</i>		**		**
<i>Hibiscus militaris</i>	*			**
<i>Populus deltoidea</i>	**		1.0	**
<i>Bidens discoidea</i>	*			**
<i>Bidens cernua</i>	**			**
<i>Boehmeria cylindrica</i>		*		**
<i>Rumex crispus</i>		*		**
Totals	100%	100%	100%	100%

The Effect of Retinol Palmitate on Head Regeneration of $\frac{1}{6}$ Post-Cephalic Segments of the Brown Planarian, *Dugesia tigrina*

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Abstract: This study was done to determine the effect of retinol palmitate, an analog of vitamin A, on head development of $\frac{1}{6}$ post-cephalic segments of *Dugesia tigrina*. A head frequency index was calculated for segments exposed to 2.5 IU/ml, 0.25 IU/ml, and 0.0 IU/ml of retinol palmitate. The head frequency index was plotted against post-cephalic segments and the resultant curves were compared. The planarian life cycle was found to have a profound effect on the regeneration process. Therefore, the experiment was repeated three times during different seasons of the year. Trial I (March) showed significantly higher head frequency averages for body segments 3 and 4 (in the mid-pharyngeal region) in the retinol palmitate concentration of 2.5 IU/ml over the control. A significantly higher head frequency ratio for segment 4 was also found in the 0.25 IU/ml retinol palmitate concentration. Results from Trial II (July) were insufficient to calculate head frequencies due to the high mortality for all segments. Trial III (December) results were similar to Trial I (March) in that an enhancing effect of retinol palmitate on head frequency was observed in mid-pharyngeal segments 3 and 4.

Key Words: *Dugesia*, planarian, head frequency index, vitamin A, retinoids, regeneration, life cycle

Introduction

Planarians are freshwater flatworms from the class Turbellaria that have been studied extensively because of their remarkable powers of regeneration (Wantabe 1935, Child 1941, Bronsted and Bronsted 1954, Flickinger 1959, and Bronsted 1969). Although planarian species vary in their ability to regenerate segments, members of the genus *Dugesia* can generally reconstitute a complete organism from a small fragment of the body. This reconstitution is the outcome of a succession of local inductions and inhibitions that occur in the resulting body fragment, referred to as the blastema (Ansevin and Wimberly 1969). At one time it was thought that neoblasts, or undifferentiated cells, had to migrate long distances from other areas of the planarian's body to the site of the wound in order for the regeneration process to begin, but Bronsted and Bronsted (1954) were able to demonstrate that neoblasts are present to a certain extent in all areas of the body.

Head and tail regeneration in planarians is accomplished by the accumulation of the undifferentiated neoblast cells at the cut surface (Betchaku 1969, Goss 1969). An anterior-posterior axial gradient is believed to exist in the planarian (Child 1941, Coward 1968, Rodriguez and Flickinger 1971), with head formation occurring at the cut end of the worm where there is the highest

level of synthesizing mechanisms (Coward, Flickinger, and Garen 1964). In a transversely cut planarian, the anterior amputation site determines the site of head formation because it has the highest level of physiological activity, with the tail segment having the lowest level. Regeneration is usually poor in pieces taken from the region of the pharynx (Wantabe 1935, Coward 1968).

The degree of successful regeneration in planarians is often measured by the head frequency index, which takes into account the number and percentage of abnormal head regenerates that are found under experimental conditions (Child 1941). Head frequency values are specific under most environmental conditions (Wantabe 1935, Coward 1968). *Dugesia tigrina*, the species used in this study, has demonstrated head frequency values that are highest just behind the eyes and in the tail region. The lowest head frequency values are typically near the pharynx in the middle region of the worm (Wantabe 1935).

Head frequency values can be affected by the length of the body segment, the physiological condition of the regenerating planarian, and environmental factors (Bronsted 1969). Due primarily to warmer temperatures, the planarians usually undergo asexual reproduction by fragmentation in mid-summer and early fall. During the cooler seasons, the planarians develop hermaphroditic sex organs and begin producing cocoons (Kenk 1937, 1940). During much of the sexual cycle, planarians can be easily torn and may die from excessive handling (Whitten and Pendergrass 1980). The planarians may, therefore, show differing head frequencies due to the season of the year.

Vitamin A and its analogs, such as the retinoids, have been shown to have a positive effect on DNA synthesis and cell division (Lotan 1980, Koussoulakos and Anton 1987), and on cell differentiation (Maden 1982). It therefore seems reasonable to suspect that analogs of Vitamin A could have an effect on head regeneration in the planarian.

Some studies (Lotan 1980, Jettan 1984) involving vertebrates have shown that vitamin A has a wide array of effects including chondrolysis, reversal of keratinization, labilization of membranes, increased production of hydrolases, enhancement of cell adhesion, and promotion of mitotic activity. In moderate doses, vitamin A has enhanced the growth of human skin epithelial cells, but in toxic doses it depresses the mitotic activity of the cells (Karasek 1970). Hypervitaminosis A may not only retard the regeneration process, but it may also result in anencephaly, malformations of the eye, and inhibition of limb development in vertebrates (Cohlan 1953, Maden 1982, Niazi and Ratnasamy 1984).

While it is clear that vitamin A and some of its analogs, such as the retinoids, have an effect on cell propagation and differentiation in vertebrates, the effect of these substances on invertebrates is not known. However, based on previous studies it is hypothesized that moderate doses of retinol palmitate (a retinoid) will increase head regeneration in the brown planarian, *Dugesia tigrina*.

Methods and Materials

Pure cultures of adult brown planarians, *Dugesia tigrina*, were purchased for each trial of this study from Carolina Biological, Burlington, North Carolina. The planarians were placed in syracuse dishes containing Brandwein's solution

(Morholt and Brandwein 1986) and allowed to acclimate for a period of one week prior to cutting. The specimens were not fed during this period to lessen the chances of infection from the contents of the intestine (Ansevin and Wimberly 1969, Bronsted 1969). A vitamin A analog known as retinol palmitate, in a water dispersible starch matrix, was used as the treatment. The treatment solution was prepared using 10 grams of the retinol palmitate (2,500 International Units or IUs) dissolved in 1,000 mls of Brandwein's solution. Serial dilutions were made to attain the following concentrations of retinol palmitate: 250 IU/ml, 25 IU/ml, 2.5 IU/ml, and 0.25 IU/ml. The solutions were kept refrigerated until needed and were then warmed to 20 degrees centigrade before using.

A total of 100 adult planarians of the species *Dugesia tigrina*, each between 10 and 12 mm in length, were used in each completed trial of this study. To begin the experiment, each planarian was placed, using a camel's hair brush, on top of a cork. The planarian was decapitated just posterior to the auricles using a sterile single-edged razor blade. The head was discarded and 5 equidistant, transverse cuts were made resulting in six post-cephalic segments of equal length (Fig. 1).

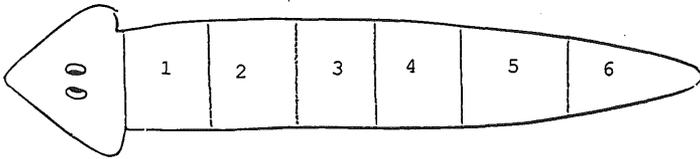


Fig. 1. Transverse cuts made on the planarian.

Immediately after cutting each segment, it was brushed into a labeled sterile petri dish containing 25 ml of the appropriate retinol palmitate solution (0.0, 0.25, 2.5, 25, or 250). In total, 20 segments from the same body level (1, 2, 3, 4, 5, or 6) were placed in each labeled dish for all five of the retinol palmitate concentrations tested.

All cultures were kept in the dark at room temperature during the time the body segments were treated. Using pipettes, the solutions were changed 24 hours after the initial cutting to remove any dead segments and to prevent contamination. New solutions of the specified concentrations were then added and aerated. Subsequent solution changes were done every second day for the rest of the study.

The regenerating segments were maintained for a period of two weeks. All planarians were examined using a dissecting microscope each day the solutions were replenished. Because no further head regeneration was observed after day 10, the results from this day were used to calculate head frequency indices, according to Child (1941), and to prepare head frequency curves. Child

distinguished five categories of anterior head-regenerated structures based on the following head forms: Normal(I); teratophthalmic (II) - normal head shape with abnormal eyespots; teratomorphic (III) - abnormal head shape with normal or abnormal eyespots; anophthalmic (IV) - abnormal head shape with no eyespots; and, acephalic (V) - no new tissue formed (Fig. 2).

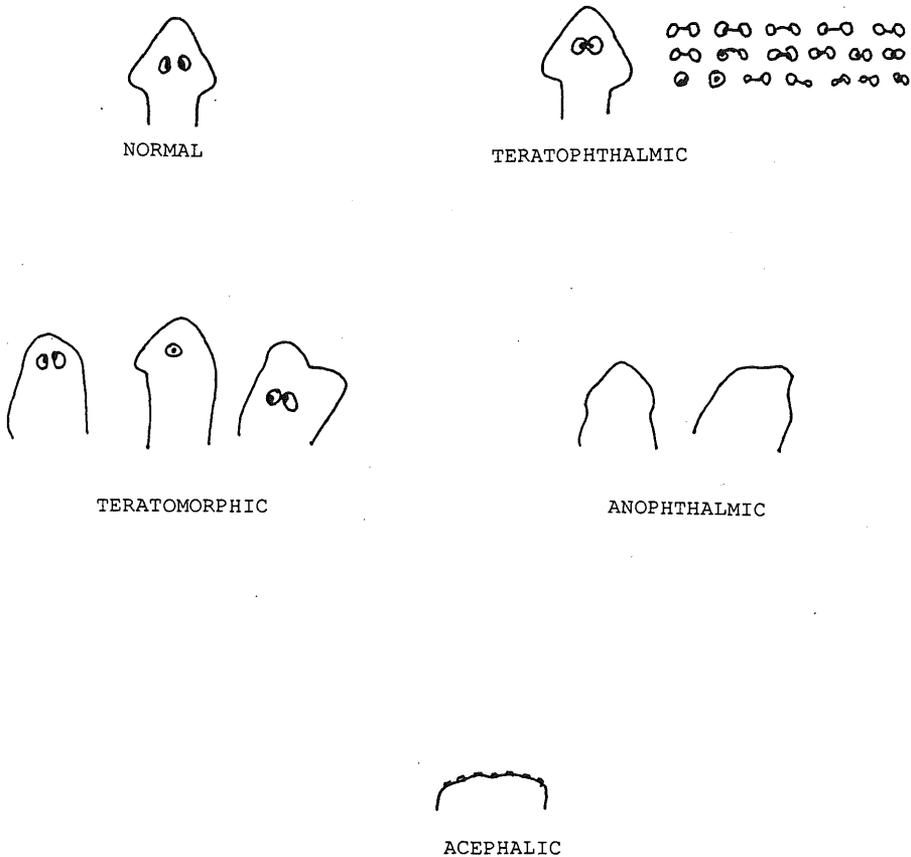


Fig. 2. Head type classification according to Child. (1941)

The calculation of head frequency indices in this study follows Child (1941) by using the following formula:

$$\text{Head Frequency Index} = \frac{100(nI) + 80(nII) + 60(nIII) + 40(nIV) + 20(nV)}{N}$$

where n = the number of planarians in each category, and N = the total number of planarians counted in all categories.

Results

Three separate trials were attempted during this study. The first trial was completed during early March of 1991. In this trial all of the segments exposed to the 250 IU/ml concentration of retinol palmitate died with 12 hours and therefore this concentration was omitted from the final data comparisons. The survival rate in the 25 IU/ml was extremely low and was also omitted from the final comparisons.

Calculated head frequency indices were plotted as the ordinate and the body segments were plotted as the abscissa (Fig. 3.). The control curve, 0.0 IU/ml, showed a decrease in head frequency in the mid-pharyngeal body segments of 3 and 4. This is expected of *Dugesia tigrina* (Wantabe 1935, Coward 1968). In the 2.5 IU/ml concentration there was an increase in head frequency index value compared to the control for all of the body segments. The differences were quite large for segments 3 and 4 (Table I). The head frequency values of both segments 3 and 4 treated at the 2.50 IU/ml concentration were significantly higher than the control (0.00 IU/ml) at P<0.05 using a chi square comparison.

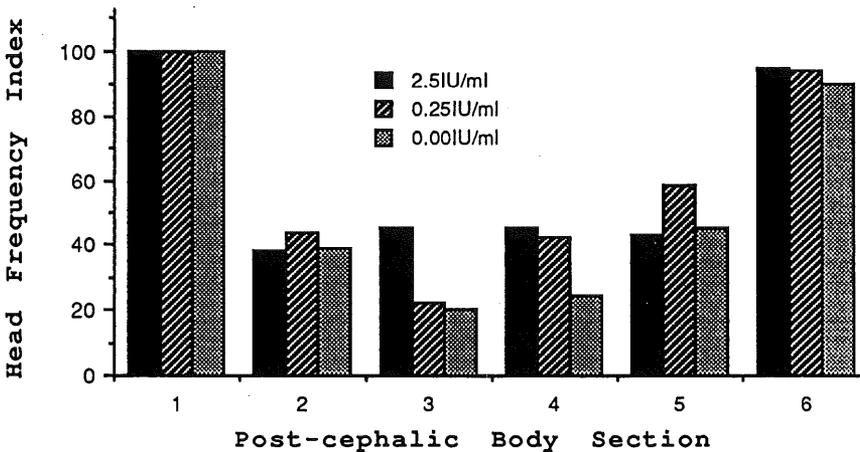


Fig. 3. Head frequency curve ¹/₆ post-cephalic segments of *Dugesia tigrina* exposed to various concentrations of retinol palmitate. (Trial I, March 1991)

Table 1. Head frequency values for planarian segments 3 and 4 of Trial I (March 1991) at three concentrations of retinol palmitate.

Concentration	Planarian Segments	
	3	4
2.50 IU/ml	45	46
0.25 IU/ml	22	42
0.00 IU/ml	20	22

In the 0.25 IU/ml concentration of Trial I, an increase in the head frequency index of the treatment over the control was observed for segments 1, 3, 4, 5, and 6 (fig. 3). However, in this concentration only segment 4 appears to show a substantially greater head frequency index value over the control (Table I). This difference was significant at $P < 0.05$ using a chi square comparison.

The second trial was attempted in early July of 1991. Due to size variations during their life cycle, the adult worms used in Trial II were no larger than 6-7 mm in length. This resulted in an average section size of less than 1 mm. Extremely low survival resulted in insufficient data to calculate any head frequency indices for Trial II.

The head frequency data collected during the third trial in December of 1991 showed a pattern very similar to that of Trial I (Fig. 4). Survival of the sections in the 250 IU/ml and the 25 IU/ml was too low for meaningful head frequency

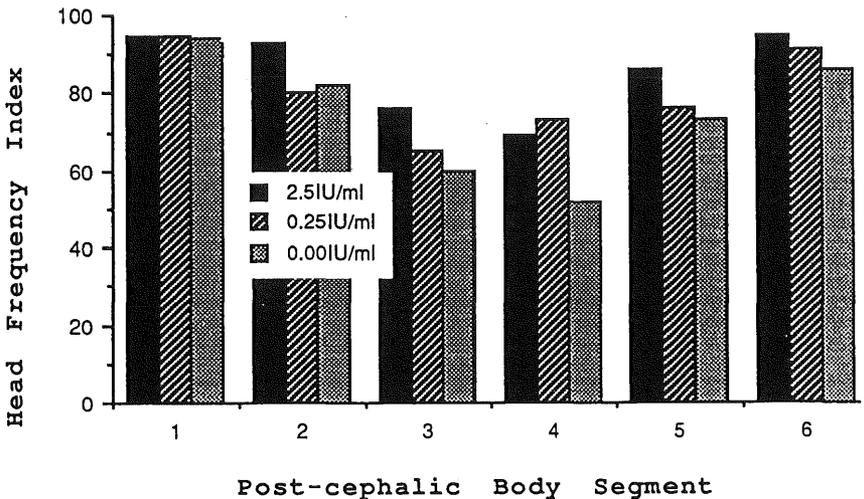


Fig. 4. Head frequency curve for 1/6 post-cephalic segments of *Dugesia tigrina* exposed to various concentrations of retinol palmitate. (Trial III, December 1991)

index calculations. However, in the 2.50 IU/ml concentrations there was a substantial increase in the head frequency index value over the control in both segments 3 and 4 (Table II). These differences were statistically significant at $P < 0.05$ using the chi square comparison.

At the 0.25 IU/ml concentration of Trial III, a substantially higher head frequency index value over the control was only observed for segment 4 (Table II and Fig. 4). This difference was statistically significant ($P < 0.05$) using the chi square comparison.

Table 2. Head frequency values for planarian segments 3 and 4 of trial III (December 1991) at three concentrations of retinol palmitate.

Concentration	Planarian Segments	
	3	4
2.50 IU/ml	76	69
0.25 IU/ml	65	73
0.00 IU/ml	60	52

Discussion of Results

Trials I and III provide strong evidence that retinol palmitate causes an increase in head frequency regeneration in the mid-pharyngeal region (segments 3 and 4) of *Dugesia tigrina* at concentrations of 2.5 IU/ml and 0.25 IU/ml. Therefore, our hypothesis that retinol palmitate would cause an increased frequency of head regeneration was supported for these two concentrations. It should be noted, however, that all head frequency index values of the mid-pharyngeal region were considerably higher in Trial III compared to Trial I. This might be explained by the increased sensitivity of the planarians in Trial I during this part of the life cycle (Whitten and Pendergrass 1980).

Trial I was done during the sexual cycle and Trial III was done as the planarians were approaching their sexual cycle. However, in both Trials I and Trial III the average body length was 10-12 mm compared to the 6-7 mm average body length of Trial II just after the sexual cycle. The small size of the body sections during this part of the life cycle of *Dugesia tigrina* is a probable cause for the sparse survival of segments in Trial II. Life cycle is obviously a very important factor for regeneration of the brown planarian.

Future research to determine the optimal dosage of retinol palmitate, or other analogs of vitamin A, to maximize the increase in head frequency regeneration of *Dugesia tigrina* should be done. The precise mode of action of retinol palmitate on the blastema of regenerating planarians should also be investigated.

Acknowledgment

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Literature Cited

- Ansevin, K and M. Wimberly. 1969. Modification of regeneration in *Dugesia tigrina* by actinomycin D. *J. Phys. Zool.* 172:349-362.
- Betchaku, T. 1969. The cellular mechanism of the formation of a regeneration blastema of freshwater planaria, *Dugesia dorotocephala*. *J. Exp. Zool.* 174:253-280
- Bronsted, A. and H. V. Bronsted. 1953. The acceleration of regeneration in starved planarians by ribonucleic acid. *J. Embryol. Exp. Morph.* 1:49-54.
- Bronsted, A. and H. V. Bronsted. 1954. Size of fragment and rate of regeneration in planarians. *J. Embryol. Exp. Morph.* 2:49-54.
- Bronsted, H. V. 1969. *Planarian Regeneration*. Pergamon Press. New York, N.Y.
- Child, C. M. 1941. *Patterns and Problems of Development*. University of Chicago Press. Chicago, Illinois. p. 176-191.
- Cohlan, S. 1953. Excessive intake of vitamin A as a cause of congenital physiological anomalies in the rat. *Science* 117:535-536.
- Coward, S. J., R. A. Flickinger, and E. Garen. 1964. The effect of nutrient media upon head frequency in regenerating planaria. *Bio. Bull.* 126:345-353.
- Coward, S. J. 1968. The relation of surface and volume to so-called physiological gradients in planaria. *Dev. Bio.* 18:590-601.
- Flickinger, R. A. 1959. A gradient of protein synthesis in planaria and reversal of axial polarity of regenerates. *Growth.* 23:251-271.
- Goss, R. J. 1969. *Principles of Regeneration*. Academic Press. New York, N.Y.
- Jettan, A. M. 1984. Modulation of cell growth by retinoids and their possible mechanisms of action. *Fed. Proc.* 43:134-139.
- Karasek, M. A. 1970. Effect of all trans-retinoic acid on human skin epithelial cells, in vitro. *J. Soc. Cosmet. Chem.* 21:925-932.
- Kenk, R. 1937. Sexual and asexual reproduction in *Euplanaria tigrina* (Girard). *Bio. Bull.* 73:280-294.
- Kenk, R. 1940. The reproduction of *Dugesia tigrina* (Girard). *Amer. Natur.* 74:471-475.
- Koussoulakos, S. and H. J. Anton. 1987. Vitamin A promotes DNA synthesis and mitosis in blastemas in *Triturus alpestris*. *Cell. Bio. Int. Reports.* 11:723-727.
- Lotan, R. 1980. Effects of vitamin A and its analogs (retinoids) on normal and neoplastic cells. *Biochemica et Biophysica Acta.* 605:391
- Maden, M. 1982. Vitamin A and pattern formation in the regenerating limb. *Nature.* 295:672-675.
- Morholt, C. and P. Brandwein, 1986. (3rd Ed.) *A Sourcebook for the Biological Sciences*. Harcourt, Brace, and Jovanovich Publ. New York, N.Y. p. 657 and p. 667-668.
- Niazi, I. A. and C. Ratnasamy. 1984. Regeneration of the whole limb in tadpoles of the roach, *Bufo andersoni*, exposed to excess vitamin A. *Folia Biol.* 26:1-9.
- Pedersen, K. J. 1958. Morphogenetic activities during planarian regeneration as influenced by triethylene melamine. *J. Embryol. Exp. Morph.* 6:308-334.
- Rodriguez, L. and R. Flickinger. 1971. Bipolar head regeneration in planaria induced by chick extracts. *Biol. Bull.* 140:117-124.
- Wantabe, Y. 1935. Head frequency in *Euplanaria maculata* in relation to the nervous system. *Physiol. Zool.* 8:374-385.
- Whitten, R. H. and W. R. Pendergrass. 1980. *Carolina Protozoa and Invertebrate Manual*. Carolina Biological Supply Co. Burlington, N.C.

Resonances in a Simple Continuous System

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Abstract: The analysis of two dimensional or three dimensional open cavities is difficult and requires extensive numerical work to produce solutions of problems involving the response to incident waves or the decay properties of a disturbance originally confined to the cavity and its immediate neighborhood. A simple one-dimensional analog which is amenable to detailed analysis is discussed. The system consists of a semi-infinite vibrating string loaded with a concentrated mass at a point. The region between the mass and the wall corresponds to the interior of the cavity, while the mass acts both as a wall, trapping waves in the cavity, and as the opening, allowing part of the energy to escape. The forced response to incident sinusoidal waves and the decay of waves originally trapped in the cavity are examined. Analogies to a one degree of freedom system are discussed.

Key Words: Vibrating string, resonator, waves, decaying oscillations, trapped waves.

Introduction

The study of the response of an open cavity to an external excitation dates back to Helmholtz,¹ who discussed the relation between the dimensions of an organ pipe and its resonant frequencies. He also investigated the effect of changing the size of the opening on the amplitude and frequency of the resonances.

Helmholtz also discussed the relation between this problem and that of the decay of oscillations once the external excitations are removed.

The organ pipe is the prototype of a class of physical objects that are generally classified as Helmholtz resonators. The common feature among these objects is that they are able to contain wave energy but that they also have an opening through which waves can enter or escape.

Although their origin is in acoustics,² resonators occur in all areas of wave physics: electromagnetic waves (especially microwaves),^{3,4} water waves,⁵ elastic waves, and, at least in the frequency domain, to the tunnelling effect involved in nuclear decay.⁶

The physical principles involved have been understood since the studies of Helmholtz and Rayleigh.² The mathematical analysis presents obstacles because of the inherent two- or three-dimensional nature of cavities. Thus, the analysis is approximate either because some simplifying assumptions are used, as in the work of Helmholtz and Rayleigh, or because numerical methods have to be employed.^{5,7} Although accurate answers can be obtained by these numerical methods, they lack the ability to give a broad picture of the general behavior of the system. Changing a parameter in a system requires a complete recalculation and an inquiry into the location of resonant peaks requires repeated calculations over a range of frequencies. In addition, while numerical methods are well adapted to the frequency response of cavities, they are not suited to the study of the decay of an excitation.

In this paper, a simplified model of an open resonant cavity is presented

which has the advantage that an exact analysis can be carried out both for its frequency response and for the decay of oscillations.

The system consists of a string under tension, which is commonly used as a prototypical system for acoustic waves or waves in general.

The "mouth" of the cavity consists of a simple discontinuity in the density of the string—the placement of a point mass. The effect of a point mass on the oscillations of a string fixed at both ends is a problem that was originally discussed by Rayleigh.

The "cavity" is formed by placing a wall (or clamping the string) behind the "mouth." Because the problem is one-dimensional, it lends itself to simple analysis, and because the wave equation in one dimension has simple time-domain solutions, the problem of wave decay can also be explored with this model.

A similar one-dimensional problem in the context of quantum mechanical tunnelling was investigated by Massmann.⁸

Transmission and Reflection Properties of a Mass

We first consider the problem of wave propagation in an infinitely long string with a finite load of mass M located at $x=0$. This is basically the problem discussed by Raleigh in sect. 136 of *The Theory of Sound*. The analysis is repeated here because we are interested in the transmission and reflection properties of the mass, and as a way of introducing the notation to be used in this paper. An interesting analogous problem was discussed by Ursell⁹ in connection with waves in deep water scattered by a submerged vertical barrier.

We consider a system consisting of an infinite string whose mass per unit length is ρ and which is held under a constant tension F_T . A mass M is attached to the string at $x=0$. The equation governing small amplitude displacements of the string is¹⁰

$$\frac{\partial^2 u}{\partial x^2} - \frac{1}{c^2} \frac{\partial^2 u}{\partial t^2} = 0 \quad (1)$$

where $c^2 = F_T/\rho$.

At the mass, there is a discontinuity in derivative: the net force exerted by the string on the mass accelerates the mass so that at $x=0$

$$F_T \left[\left(\frac{\partial u}{\partial x} \right)_{0+} - \left(\frac{\partial u}{\partial x} \right)_{0-} \right] = \left(M \frac{\partial^2 u}{\partial t^2} \right)_0. \quad (2)$$

Finally, a suitable radiation condition must be imposed at $x=\infty$.

From physical considerations, u is a continuous variable, but a discontinuity in its derivative, travelling with a speed c , is permissible. A stationary discontinuity in its derivative indicates the presence of a mass.

For monochromatic waves, we consider a wave with a harmonic time dependence so that

$$u(x, t) = u(x)e^{-i\omega t} \quad (3)$$

Then Eq. (1) becomes

$$\frac{d^2u}{dx^2} + k^2u = 0 \quad (4)$$

where $k = \omega/c$, and Eq. (2) becomes

$$\left(\frac{du}{dx}\right)_{0+} - \left(\frac{du}{dx}\right)_{0-} - k - \frac{(Mk^2)}{\rho} u(0). \quad (5)$$

If a wave of unit amplitude is incident from the left then, for $x < 0$,

$$u = e^{ikx} + Re^{-ikx} \quad (6)$$

and for $x > 0$

$$u = Te^{ikx}. \quad (7)$$

R is the reflection coefficient and T is the transmission coefficient. The condition that u be continuous requires that

$$1 + R = T \quad (8)$$

while from Eq. (5)

$$1 - R - T = -\frac{iMk}{\rho} T. \quad (9)$$

From Eqs. (8) and (9),

$$R = \frac{iMk}{2\rho} / \left(1 - \frac{iMk}{2\rho}\right) \quad (10)$$

and

$$T = 1 / \left(1 - \frac{iMk}{2\rho}\right). \quad (11)$$

From these expressions it can be seen that the mass is a barrier to short waves ($k \gg \rho/M$) and transparent to long waves ($k \ll \rho/M$).

While this is an unusual behavior of the "mouth" of a cavity, which would normally allow the passage of waves with a wavelength which is short in comparison to the size of the opening and stop long ones, we will use this as a mouth for the cavity being considered here.

The one-dimensional cavity

To construct a cavity we need a region where waves can be contained. If a wall is placed behind the mass, very long waves will not be affected by the mass and will simply reflect from the wall. On the other hand, shorter waves will be partially reflected by the mass and some of the energy will leak into the space between the mass and the wall. These shorter waves have more difficulty getting in but they also have more difficulty getting out. Depending on the wavelength, constructive interference may occur and the amplitude of the trapped wave may be much larger than that of the incident wave. We now turn our attention to this.

For convenience, we take the incoming waves to be incident from the right, and place a wall at $x = -a$ so that

$$u(-a, t) = 0. \quad (12)$$

The deflection u will be represented by two different expressions, one valid for $x > 0$ and one for $-a < x < 0$. For $x > 0$

$$u = e^{-ikx} + Be^{ikx} \quad (13)$$

and for $-a < x < 0$

$$u = A \sin k(x+a) \quad (14)$$

where u has been chosen to satisfy Eq. (4) and the condition at the wall given by Eq. (12).

The conditions at $x=0$ now require:

$$1 + B = A \sin ka \quad (15)$$

and

$$1 - B = iA \left(\cos ka - \frac{Mk}{\rho} \sin ka \right). \quad (16)$$

The solution of these equations is

$$A = \frac{2}{\sin ka + i \left(\cos ka - \frac{Mk}{\rho} \sin ka \right)} \quad (17)$$

and

$$B = \frac{\sin ka + i \left(\cos ka - \frac{Mk}{\rho} \sin ka \right)}{\sin ka + i \left(\cos ka - \frac{Mk}{\rho} \sin ka \right)} \quad (18)$$

The absolute value of B is 1, as it should be, since in steady state oscillations the outgoing energy must be equal to the incoming energy.

The amplitude of the waves in the space between the mass and the wall, however, exhibits a series of resonances. To find these it is necessary to find the maxima of the absolute value of A . To simplify this operation, let $\theta = ka$ and let $\gamma = M/\rho a$. Then

$$|A|^2 = 4 / (\sin^2 \theta + (\cos \theta - \gamma \theta \sin \theta)^2). \quad (19)$$

Differentiating this expression, it is found that the condition for $|A|$ to be an extreme is

$$\begin{aligned} & (\sin \theta + \theta \cos \theta) (\cos \theta - \gamma \theta \sin \theta) \\ & = \theta \sin^2 \theta. \end{aligned} \quad (20)$$

The roots θ_n of this expression are near $n\pi$. Setting $\theta_n = n\pi + \epsilon_n$, Eq. (20) becomes

$$\begin{aligned} &(\sin\epsilon_n + \theta_n \cos\epsilon_n)(\cos\epsilon_n - \gamma\theta_n \sin\epsilon_n) \\ &= \theta_n \sin^2\epsilon_n. \end{aligned}$$

Keeping only the first order terms in ϵ_n gives the approximation

$$\epsilon_n = \frac{1}{\gamma n\pi} \tag{21}$$

for the location of the peaks, with

$$|A_n| = 2\gamma n\pi. \tag{22}$$

These approximations are quite good except for the first peak, where $n=0$. In that case it is necessary to expand to cubic terms. The result is

$$\theta_0^2 = 1/(\gamma + 4/3) \tag{23}$$

and

$$|A_0|^2 = 3\gamma + 4. \tag{24}$$

Figures 1 and 2 show calculated values of $|A|/\gamma\pi$ versus the dimensionless frequency θ for $\gamma=1$ and $\gamma=15$. The general trend implied by the approximations and their accuracy can be appreciated from the graph. Except for the first peak, the peaks are nearly equally spaced and increase linearly with frequency. The accuracy of Eq. (22) can be appreciated by comparing the graphs for the two values of γ , since the peak values of $|A|/\gamma\pi$ are virtually identical for the two masses.

It should be noted that since $\theta_0 < \pi/2$ the sinusoidal portion of Eq. (14) does not reach its maximum value of 1 so that $|A_0|$ is not the true maximum amplitude of the wave in this case. The maximum displacement occurs at the mass and is given approximately by $|A_0| \sin \theta_0$, which, for large m , is given roughly by $|A_0|\theta_0 = 3^{1/2}$.

Decay modes

If a disturbance is produced between the wall and the mass and the system is allowed to move freely, the disturbance will be partially reflected and partially transmitted past the mass and thus there will be a gradual decrease in energy in the space $-a < x < 0$ as the energy radiates towards $x = \infty$.

$$u = Ae^{st} \sinh \frac{s(x+a)}{c}, \quad -a < x < 0 \tag{25}$$

$$u = e^{s(t-x/c)}, \quad 0 < x < ct \tag{26}$$

$$u = 0, \quad x > ct. \tag{27}$$

These expressions satisfy Eq. (1) and the boundary condition at $x = -a$. There is a discontinuity in u at $x = ct$ which will be resolved later. For u to be continuous at $x=0$,

$$A \sinh \frac{sa}{c} = 1. \tag{28}$$

The presence of the mass at $x=0$ requires that

$$F_T \left[\left(-\frac{1}{c} \right) - \frac{A}{c} \cosh \frac{sa}{c} \right] = Ms$$

or

$$1 + \coth \frac{sa}{c} + \frac{Ms}{\rho c} = 0. \quad (29)$$

Expressing the hyperbolic function in terms of exponentials,

$$2 + \frac{Ms}{\rho c} (1 - e^{-2sa/c}) = 0$$

or

$$e^{-2sa/c} = 1 + \frac{2\rho c}{Ms}. \quad (30)$$

Let $z=2sa/c$ and $\mu=4/\gamma$, then

$$e^{-z} = 1 + \frac{\mu}{z}. \quad (31)$$

Equation (31) does not have any real roots since, for real z , the left-hand side is less than 1 only for positive values of z while the right-hand side is less than 1 only for negative values of z . The roots are, therefore, complex and they can be studied by setting $z=\alpha+i\beta$. Then

$$e^{-\alpha} \cos \beta = 1 + \mu \frac{\alpha}{r^2} \quad (32)$$

$$e^{-\alpha} \sin \beta = \frac{\mu \beta}{r^2} \quad (33)$$

where $r^2 = \alpha^2 + \beta^2$.

These equations can be combined into

$$e^{-2\alpha} = 1 + 2\mu \frac{\alpha}{r^2} + \frac{\mu^2}{r^2} \quad (34)$$

and

$$\tan \beta = \frac{\mu \beta}{\mu \alpha + r^2}. \quad (35)$$

Eqs. (34) and (35), however, admit spurious roots since they are obtained by squaring and adding Eqs. (32) and (33) in the one case and by dividing Eq. (33) by Eq. (32) in the other. These operations would produce the same final equations if the left-hand sides of Eqs. (32) and (33) were equal to minus their right-hand sides.

Since these equations remain unchanged when β is a solution, their $-\beta$ is also a solution, so the roots occur in complex conjugate pairs. Moreover, it will be

shown below that α is negative. Thus, it is possible to combine solutions so that for $0 < x < ct$

$$u = e^{-|\alpha|(t-x/c)} \sin(\beta (t-x/c)) \tag{36}$$

thus making u continuous at $x = ct$.

The problem now becomes the numerical one of finding solution pairs (α, β) to Eqs. (32) and (33), or equivalently, to Eqs. (34) and (35). From Eq. (34), since $r^2 < \alpha^2$,

$$e^{-2\alpha} > 1 + \frac{2\mu}{\alpha} + \frac{\mu^2}{\alpha^2} \tag{37}$$

$$= (1 + \mu/\alpha)^2.$$

Examination of this inequality shows that α must be negative but larger than $-\mu/2$, thus

$$e^{-\alpha} > -(1 + \mu/\alpha). \tag{38}$$

This narrows down the range of values of α to

$$\alpha_{\min} < \alpha < 0$$

where α_{\min} is the root of

$$e^{-\alpha_{\min}} + 1 + \mu/\alpha_{\min} = 0. \tag{39}$$

A procedure for finding paired values of (α, β) is then as follows:

1) Starting at $\alpha = \alpha_{\min}$, calculate

$$r^2 = \mu (2\alpha + \mu) / (e^{-2\alpha} - 1),$$

$$\beta = \sqrt{r^2 - \alpha^2},$$

and

$$f = \frac{\sin\beta}{\beta} (r^2 + \mu\alpha) - \mu\cos\beta \tag{40}$$

and increase α until a zero of f is straddled, and then located by bisection or any standard method.

2) Continue increasing α to locate the next set of values. In this way, numerical values can be obtained for α and β . There are an infinite number of roots with $\beta_n = 2n\pi + \delta_n$ and with the α_n getting progressively closer to zero. Approximate expressions for α_n and β_n can be obtained from the original equations. These are:

$$\alpha_n \simeq -k^2/8n^2\pi^2 \tag{41}$$

$$\beta_n \simeq 2n\pi + k/2n\pi \tag{42}$$

and

$$\alpha_0 \simeq -k/4 \tag{43}$$

$$\beta_0 \simeq k^{1/2}. \tag{44}$$

Discussion

The system described behaves as an infinite number of damped oscillators with damping constants $|\alpha_n|$ and resonant frequencies β_n . Since the $|\alpha_n|$ get progressively smaller, the bandwidth of the oscillators gets progressively narrower and the amplitude of the resonances becomes larger. This is analogous to the behavior of a damped, one-degree-of-freedom oscillator.

Since the system is conservative, it may appear at first sight that it should have no damping. However, energy is radiated towards $x = +\infty$ and the radiation losses take the place of the more conventional mechanical damping considered in one-degree-of-freedom systems.

While the equations for the forced oscillations were solved using harmonic time dependence and those for decaying oscillations using exponential time dependence, both could have been approached using harmonic dependence. If we substitute

$$z = 2i\theta$$

into Eq. (31), the result is

$$\sin\theta - i(\cos\theta - \gamma\theta\sin\theta) = 0 \quad (45)$$

which is the equivalent of setting the denominator in Eqs. (17) and (18) equal to zero.

This again is in analogy to the one-degree-of-freedom damped oscillator where the behavior can be deduced from the roots of the dispersion equation.

References

1. Helmholtz, H. L. F., *On the Sensations of Tone*, translated by A. J. Ellis, Longmans, Green, and Co., London, 1895.
2. Lord Rayleigh, *The Theory of Sound*, (1894), Dover Publications, New York, 1945.
3. Borgnis, F. E. and Papas, C. H., "Electromagnetic Waveguides and Resonators," *Encyclopedia of Physics*, Vol. XVI, Springer-Verlag, Berlin, (1958).
4. Harvey, A. F., *Microwave Engineering*, Academic Press, New York, 1963.
5. Lee, J. J., Wave-induced Oscillations in Harbours of Arbitrary Geometry, *J. Fluid Mech.* 45, 375-394 (1971).
6. Merzbacher, E., *Quantum Mechanics*, Wiley, New York, 1970.
7. Banaugh, R. P. and Goldsmith, W., Diffraction of Steady Acoustic Waves by Surfaces of Arbitrary Shape, *J. Acoust. Soc. Am.* 35, 1590-1601 (1963).
8. Massman, H., Illustration of resonances and the law of exponential decay in a simple quantum-mechanical problem, *Am. J. Phys.*, 53, 679-683, (1985).
9. Ursell, F., The Effect of a Fixed Vertical Barrier on Surface Waves in Deep Water, *Proc. Cambridge Phil. Soc.*, 43, 374-382 (1947).
10. Morse, P. M. and Feshbach, H., *Methods of Theoretical Physics*, McGraw-Hill, New York, 1953, p. 124.

Postulation of Two Separate Grammars: Evidence from French and Haitian Creole

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Abstract: The striking differences between the Creole languages and their lexifier language, notably in the area of syntax, have led Creolists to conclude that Creole languages possess a separate grammatical system. The present paper seeks to validate this position by offering comparative evidence from Haitian Creole and French. The determiner system of both languages is analyzed in order to justify the postulation of two distinct systems. Furthermore, an in-depth description of the definite article in Haitian Creole reveals that this grammatical category covers a broader syntactic and semantic scope than it does in the lexifier language. In French, the definite article always appears in prenominal position, and its function is primarily deictic; it specifies the noun. In Haitian Creole, the article "la" is always post-posed and it can occur (unlike French) in environments other than simple nominals, namely adjectivals, adverbials and prepositional phrases; and relative and subordinate clauses. Moreover, it also has a rhetorical and phatic function.

Key Words: Creole languages, French, definite article, lexifier language, Haitian Creole, determiner system

Introduction

David DeCamp (1971: 13-15) dates the birth of the field of Creole Studies to 1959 when the first international conference on Creole Language Studies was held in Jamaica. The second international conference, held in 1968, revealed that the discipline was growing and was becoming a respectable academic field. In 1969, the Modern Language Association annual bibliography began grouping pidgin and creole studies in a separate division rather than treating them as appendages to the other languages. Traditionally, Creole languages as noted by De Camp (1971: 15) were classed as "deviant dialects of standard languages, usually European, with English, French, Portuguese, Spanish, and Dutch the most frequent." They were considered "mixed languages." Thus, a Creole which shares most of its vocabulary with English is called an English-based Creole; with French, a French-based Creole; with Portuguese, a Portuguese-based Creole. The label mixed language is problematic, for it suggests that a Creole is only a potpourri with no uniform coherent structure and grammar of its own and that it is a simplified or corrupted form of the base language. One of the most important contributions of Creole studies has been to demonstrate that Creole languages are not simplified codes, and that their vocabulary and syntactic devices are, like those of any natural language, large enough to meet all the communicative needs of their speakers (Romaine 1988: 38). While acknowledging the influence of the base language on the lexicon of the Creoles, creolists agree that "by no means is all the vocabulary of a creole shared with its

corresponding European language.” Furthermore, they judiciously observe that “in both phonology and syntax the differences between a creole and its lexifier language are usually so great as to make them mutually unintelligible” (De Camp 1971: 16). Indeed, the striking differences between them have led Creolists to conclude that Creole languages possess a separate grammatical system. The present paper seeks to validate this position by offering comparative evidence between a particular variety of Creole, that of Haiti, and its base language, French.

Haitian Creole is undoubtedly one of the Creoles that have received the most attention from linguists and has been the object of several descriptions. This can be attributed to the fact that Haiti is the leading creolophone country of the world, since its entire population, estimated at 5.2 million, speaks the language. The particular linguistic feature offered here as evidence in support of the postulation of two distinct grammars is the determiner system. More specifically, the morphological, syntactic, and semantic structure of the definite article is analyzed in an attempt to show the salient differences between the two systems and to partially refute the notion that Haitian Creole is a simplified or reduced form of French. We now turn to the definite article system in French.

I. Definite Article in French

1.1. Phonological and Morphological Variants of the Article in French

The definite article in French always appears in pre-nominal position that is, it precedes the noun it modifies. It has three basic morphological variants, *le*, *la*, *les*, based on sex reference, gender and number distinctions. Additionally, one phonological alternate singular variant *l'* is used when the following segment begins with a vowel. The definite article in French has a total of four variants.

1.2. Syntactic Distribution of the Article in French

In the French language, the definite article is used exclusively with simple nominal phrases. Simple nominal phrases here refer to a single noun or a noun immediately preceded by an adjective. Definite articles cannot appear with any other syntactic category, such as complex nominals, adverbials, relative and subordinate clauses, as they do in Haitian Creole as will be demonstrated in the course of this paper. We now offer a summary of the different cases where the definite article is used in French.¹

1. To determine nouns that represent beings or things considered as known or that have been previously introduced into the oral or written discourse:

Le livre est ouvert.

(The book is open)

2. With generic and abstract nouns to designate a general class, an entire category of things or beings and a general concept:

J'aime les chiens (I like dogs.)

3. With geographical names, with exceptions of cities:

Paris est la capitale de la France. (Paris is the capital of France.)

4. With names of languages:

Le Français est une belle langue. (French is a beautiful language.)

5. With subject matters:

J'étudie la physique. (I am studying physics.)

6. As a possessive, with nouns that designate certain parts of the body, or faculties of the mind when the idea of possession is already conveyed by the general context of the utterance:

Je ferme les yeux. (I am closing my eyes.)

Having presented the definite article system in the lexifier language, we can now look at the same system in the Creole language in an attempt to see how much influence if any the standard language had on its “derivative” Creole.

II. Definite Article in Haitian Creole

2.2 Phonological and Morphological Variants of the Article in Haitian Creole.

Unlike French, the definite article in Haitian Creole is always post-posed, that is, it is always placed after the syntactic category it modifies. In its singular form, it has five phonological variants, *la*, *lan*, *nan*, *a*, *an*, depending on the nature (consonantic or vocalic) of the preceding segment. *La* occurs when the preceding word ends with a consonant, as in *tab la* (the table) or *chèz la* (the chair). *Lan* occurs when the preceding word ends with a nasal consonant, as in *ti dam lan* (the young lady) or *pàn lan* (the breakdown or the failure). A further case of the nasalization of the definite article into its surface form *nan* occurs in the environment of more than one nasal sound, as in *madanm nan* (the woman) or *chanm nan* (the bedroom), which contain both the nasal vowel [ã] and the nasal consonant [m]. The variant *a* appears when the preceding segment ends with a vowel, as in *tablo a* (the blackboard) or *kaye a* (the notebook), and the variant *an* in the presence of a nasal vowel, as in *pon an* (the bridge) or *pen an* (the bread). Haitian Creole, unlike French, does not make a morphological distinction based on gender or sex difference. However, it does make one of the basis of number. Thus, the plural form of the article is *yo*, as in *kaye yo* (the notebooks), *chanm yo* (the bedrooms), or *tablo yo* (the blackboards). As can be seen, with regard to its various forms, the definite article system in Haitian Creole is certainly not a reduced or simplified version of its base language. In fact, it is more complex, with a total of six forms that are all rule-governed and cannot be used interchangeably at the discretion of a particular speaker.

2.2. Syntactic Distribution of the Article in Haitian Creole

It is at the level of syntactic distribution that the differences between the two grammars are really striking. As stated before, the article in French can only appear in the environment of simple nominals. This is not the case for Haitian Creole. As noted by Lefebvre (1982) and Alexandre, Bentolila, and Fauchois (1983), the determiner occurs in a wide range of syntactic categories, which we shall now examine.

A. With simple lexemes

The term “lexeme” refers to a lexical item that can include a noun, a pronoun, a verb, or an adverb. As will be demonstrated, the article “*la*” in Haitian Creole can modify elements other than nouns.

7. With nouns that are considered specified either by the present context or by previous introduction in the oral or written text. This is the only case of similarity between the two systems.

7a. *Liv la louvri.* (the book is open.)

Unlike the French article, the Haitian Creole article is categorically never used

with generic and abstract nouns, with geographical names, with names of languages and subject matters. Indeed, the French examples presented in 2, 3, 4, 5, are rendered without the article in Haitian Creole as illustrated in the following translations:

7b. *Mwen renmen* ∅ *chen*.

7c. *Pari se kapital* ∅ *Lafrans*.

7d. ∅ *Franse se yon bèl lang*.

7e. *M ap etidye* ∅ *fizik*.

In addition, it cannot be used to replace a possessive as it does in French, as seen in the data presented in 6 above. In Creole, a possessive determiner must be used in this context as illustrated in

7f. *M ap fêmen je m*. (where *m* is the possessive *my*)

8. With demonstrative pronouns

Mwen vin dèyè yon lòt renmèd. Sa a/ sila a pa fè anyen pou mwen.

(I am looking for another medicine. That one (presumably the one given before) did not do me any good)

9. With infinitives:

Kouche a va bon pou ou. (To lay down will be good for you.)

10. with adverbs:

Isit la, se mwen k kòmande. (Here, I am the one in charge.)

At this point it is perhaps appropriate to offer some comments about the semantic function of the Haitian Creole determiner. Examples 7a and 8 are representative of a large portion of the distribution of the determiner. It determines an entity presented by the context. This type of occurrence underscores its referential value. It is understood that the word *liv* (book) must have been already introduced into the discourse and in example 8, the word *renmèd* (medicine) is replaced by a pronoun. We are therefore witnessing the anaphoric function of the determiner. In examples 9 and 10, it is worth noting that the presence of the article is not obligatory. It is optional, since it is perfectly legitimate to say: *Kouche va bon pou ou* and *Isit, se mwen k kòmande* (without the article). In this case, as suggested by Alexandre, Bentolila, and Fauchois (1983) the determiner is used as a rhetorical device to reinforce the weight of the message being transmitted. This case offers an expansion of the semantic scope of the definite article not found in the European languages.

B. With Complex Nominals

11. Nouns and possessives

11a. *Pitit mwen an gen onzan.* (Child my the is eleven)

11b. *Frè m gen de pitit. Pitit li yo fin gran.*

(My brother has two kids. Kids his the are grown)

These two examples show that the article can occur in the environment of possessives. But it needs to be indicated that its realization is optional. It is perfectly grammatical to say *Pitit mwen gen onzan* or *Pitit li fin gran*. In this instance, one can reasonably argue that the article, as we saw a short while ago, serves a rhetorical function. It has a “phatic” use. It suggests more involvement, feelings, and emotions on the part of the speaker.

12. Genitive constructions involving proper nouns:

Under this category of proper nouns, terms of address and titles will be grouped for the sake of convenience. In Creole, nouns involved in a genitive construction are not separated by a preposition, and the second noun is always the possessor.

12a. *Wòb Karin lan bèl anpil.* (Karin's dress is very beautiful.)

12b. *Gato Madan Michèl yo toujou bon.* (Mrs Michel's cakes are always good.)

12c. *Machin prezidan yo koute chè.* (The president's cars are expensive.)

13. Genitive constructions involving commun nouns:

13a. *Jwèt timoun yo nan lakou a.*

(The toys of the child/ren are in the backyard.)

13b. *Pye tab la kase.* (The leg of the table is broken.)

14. Nominals and prepositional phrases:

14a. *Pyebwa bò kay la.* (The tree near the house.)

15. Nominals and relative clauses:

15a. *Kay (ke) mwen achte a gen anpil pyebwa.*

(The house that I bought has a lot of trees.)

These sets of examples demonstrate once again that from the standpoint of syntactic distribution, the article behaves differently in Haitian Creole and in French. In the former, it can be separated from the noun it modifies by other syntactic elements such as genitives, prepositional phrases and relative clauses.

C. *Article as Determiner of Full Clauses*

The two types of constructions that will be analyzed now include the relative clauses and the embedded clauses:

16. *Relative clauses*

16a. *Kay la mwen te achte a gen anpil pyebwa.*

(The house that I bought has a lot of trees.)

This example contrasts with example 15a in the sense that it contains an extra determiner placed after the relative clause. Since the noun *kay* (house) is already determined by the first article immediately following it, one has to account for the presence of this additional article. There cannot be much controversy over the fact that the second determiner specifies the entire relative clause and is used as a rhetorical device which adds a slight nuance to the meaning of the utterance which can be interpreted as "The house that I bought, as you well know, has a lot of trees."

17. *Embedded Clauses*

17a. *Mwen di ou li vini an.* (I told you he came.)

17b. *Depi Mari fin marye a, nou pa wè l menm.*

(Since Marie got married, we do not see her at all.)

Embedded clauses differ from relative clauses in their grammatical function. They do not modify nominals as relative clauses do. Therefore, they do not require an antecedent to which an article can be attached. These facts provide an argument in favor of the claim that the article must modify the entire embedded clause. And, once again, only a rhetorical explanation could account for its presence or absence. The occurrence of the determiner in examples 17a and 17b allows these clauses to be specified respectively as "He came, as he was supposed to." or "Since Marie got married, as we all know she did."

Conclusion

The above analysis has underlined the complexity of the determiner system in Haitian Creole. Its lack of similarity with the lexifier language mandates the postulation of a distinct grammatical system that is not a derivative of the standard code. In fact, the Haitian Creole definite article, as noted by Lefebvre (1982), possesses one striking peculiarity for a language whose word order is SVO (subject-verb-object): it is post-posed. This particular characteristic of the determiner provides a counter example to the theory of linguistic universals proposed by Greenberg (1963).² According to this theory, in all SVO languages, the determiner always precedes the element it modifies while the complements are placed after this element. Another salient difference resides in the fact that the article in the Creole languages has a much wider syntactic distribution than it does in the European languages, where it is essentially a noun determiner. Moreover, by looking carefully at other aspects of Creole languages, one is very hard put to come up with arguments in favor of the reduction, simplification, corruption, or even bastardization theory held for too long. The determiner system treated above is but one syntactic aspect that serves to demonstrate the fallacy of the traditional view. Other aspects have also been dealt with, especially the verbal system of several Creoles with respect to tense, mood, and aspect recently described in Singler's (1990) work. All these descriptions stress the salient differences between these Creoles—Haitian Creole, Papamientu (spoken in Curaçao and the Netherlands Antilles), Capeverdean Crioulo (spoken in the Republic of Cape Verde), Berbice Dutch (spoken in Guyana), Nigerian Pidgin English, and Kru Pidgin English (spoken on the coast of West Africa)—and their lexifier languages. In fact, with regard to the verbal system, no similarity whatsoever could be found with the European languages. Structural evidence convincingly attests to the existence of a distinct grammatical system in the Creole languages, and on the basis of linguistic facts, it is completely erroneous to speak of these languages as deviant dialects of standard languages. Furthermore, on the basis of sociolinguistic evidence—the functions that languages play in their communities—such a position is also unjustified. For example, in the case of Haitian Creole, this language covers all the facets of the lives of the Haitian people. Valdman (1980, 1988), who adapted Gobard's (1976) tetraglossic model, identified four major language functions: the vernacular, which refers to everyday communication needs with intimates; the vehicular, which refers to broader communication (outside the intimate groups) with the outer formal community (administration, schools, media, and the like); the referential, which describes the transmission of the cultural heritage of a particular society (literature-songs-folklore); and the religious, which concerns the need of people to worship. That all these four functions are expressed in Creole for the overwhelming majority of the population suggests that the language is fully equipped to meet all the communicative needs of its speakers.³

The structural facts presented in this paper contribute to the evidence that Creoles are fully developed languages which possess a system of their own. The perception that they constitute an inferior group of languages can be viewed as a direct vestige of colonization. Generally speaking, the European language was the "high language" spoken by the privileged ruling class, and Creole was the "low language" spoken by the oppressed class. The fact that the Creole

languages are found in third world regions and in underdeveloped countries does not make them underdeveloped languages. As the well known French anthropologist André-Marcel d'Ans (1987) notes, "*le fait qu'il s'agisse d'un idiome essentiellement parlé par des gens pauvres ne signifie aucunement qu'il s'agisse d'un langage appauvri*" (the fact that it is a language essentially spoken by poor people does not mean that it is an impoverished language).

Notes

1. For a detailed discussion of these, consult Grevisse and Le Nouveau Bescherelle.
2. as mentioned in Lefebvre 1982, pp. 21.
3. For the bilingual speakers, who constitute roughly 10% of the population, the vernacular function is carried out in both French and Creole. In recent years, an increased use of Creole to perform vehicular, referential, and religious functions traditionally done in French has been documented.

Works Cited

- Alexandre, A.; A. Bentolila and A. Fauchois. "Les modalités en créole haïtien: Approche syntaxique et rhétorique: *Espace Créole* 5:126-71. 1983.
- Ans, A. M. d'. *Haiti: Paysage et Société*. Paris: Karthala. 1987.
- DeCamp, D. "The Study of Pidgin and Creole Languages". In D. Hymes (ed) *Pidginization and Creolization of Languages*. Cambridge: Cambridge University Press. pp. 13-39. 1971.
- Gobard, H. *L'Aliénation linguistique*. Paris: Flammarion. 1976.
- Grevisse, M. *Le bon usage*. Paris: Duculot. 1980.
- Hymes, D. (ed). *Pidginization and Creolization of Languages*. Cambridge: Cambridge University Press. 1971.
- Le Nouveau Bescherelle: La grammaire pour tous*. Paris: Hatier. 1984.
- Lefebvre, C. "L'Expansion d'une catégorie grammaticale: Le déterminant *la*". In C. Lefebvre; H. Magloire-Holly and N. Pou (eds) *Syntaxe de l'Haïtien*. Ann Arbor: Karoma Press. pp. 21-63. 1982.
- Lefebvre, C.; H. Magloire-Holly and N. Pou. *Syntaxe de l'Haïtien*. Ann Arbor: Karoma Press. pp. 21-63. 1982.
- Romaine, S. *Pidgins and Creole Languages*. London: Longman Press. 1988.
- Singler, John. *Pidgin and Creole Tense-Mood-Aspect System*. Amsterdam: John Benjamins. 1990.
- Valdman, A. "La situation linguistique d' Haïti". In A. Valdman and Y. Joseph (eds). *Créole et enseignement primaire en Haïti*. Bloomington: Indiana University Creole Institute. pp. 17-29. 1980.
- Valdman, A. "Diglossia and Language Conflict in Haiti". *International Journal of the Sociology of Language* 71:67-80. 1988.

Effects of Whole-Abdomen Irradiation on Glutamine in C57BL Mice

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Abstract: Glutamine may have a particular role as a preferred energy substrate of the gut and be important for its integrity and function. The gut is one of the major body systems which is known to be very sensitive to irradiation. In stress conditions including radiation, surgery, infection, burns, etc., glutamine consumption may increase with a decrease of plasma glutamine levels. In the present study, we measured plasma glutamine levels in C57BL mice by HPLC (High Performance Liquid Chromatography) after whole abdomen irradiation to a single dose of 1500 cGy. Measurements made at 24, 48, 72, and 96 hour intervals after irradiation were found to be $635 \pm 100 \mu\text{M}$ ($n=7$), $542 \pm 127 \mu\text{M}$ ($n=7$), $542 \pm 104 \mu\text{M}$ ($n=7$) and $364 \pm 61 \mu\text{M}$ ($n=7$) respectively, with a $715 \pm 26 \mu\text{M}$ ($n=7$) control level. A paired student's t-test was performed. There was a 49% ($p<0.0001$) decrease in plasma glutamine level at 96 hours post radiation. Tumor bearing and starved mice also had lower glutamine levels than normal.

Key Words: Glutamine, radiation, starvation, tumor

Introduction

The complications and side-effects of abdominal and pelvic radiation to the gastrointestinal system have been known for years and can be troublesome (Decosse *et al.*, 1969). It has been shown that jejunal mucosal cells are highly sensitive to radiation (Caseret, 1963). Kokal (Kokal, 1986) has reviewed basic mechanisms pertaining to acute stresses of XRT (X-Ray Therapy) on the gut leading to symptoms such as acute diarrhea. The overall practical impact of XRT on nutritional status varies with the extent of the fields; pelvic XRT alone only occasionally has a real practical impact on nutritional status. However, whole abdomen XRT more often has a severe impact on gut function and nutritional status. Radiation-induced intestinal damage is described as destruction of crypt cells or decreased villous height and ulceration of the mucosa (Berthrong, 1986) resulting in bacterial translocation, bloody diarrhea, and even, in more severe cases, bowel perforation or obstruction. The traditional remedies of stool softeners with a low residue diet, iron replacement, corticosteroid enemas, and sulfasalazine have been given to treat complications, but results are only marginally successful (Buchi, 1991).

Glutamine appears to be a major substrate supporting the metabolic functions of the gut mucosa, both in terms of energy supply and in terms of starting material for various metabolic pathways (Windmueller, 1982). Intestinal mucosal cells show an increased consumption of glutamine after abdominal surgery (Souba and Wilmore, 1983).

Glutamine is the most abundant amino acid in plasma and has been classed as a nonessential amino acid because it can be synthesized in animal cells. It has been recently suggested that perhaps it should be categorized as a conditionally essential amino acid because many cells in culture require glutamine for growth (Roth, 1990). Although glutamine is classed as a nonessential amino acid, it may become essential under certain stress conditions such as major surgery, injury, sepsis, starvation, and radiation treatment to the abdominal area. It has been proposed that glutamine consumption is increased by mucosal cells during radiation and prophylactic glutamine supplements may decrease the radiation-induced mucosal damage.

In the present study, we strived to confirm suggestions that radiation stress of the gut in a murine model system decreases plasma glutamine and that glutamine supplementation might be beneficial.

Materials and Methods

The HPLC system (Shimadzu) consisted of two model LC-6A pumps, a model SCL-6B controller and a Rheodyne injection valve with a 20 μ L filling loop. A 100 \times 4.6 mm C₁₈ column was used.

9-Fluorenylmethyl chloroformate and amino acids were purchased from Sigma (St. Louis, MO.). Borate buffer was prepared from Boric acid solution (1M) adjusted with sodium hydroxide solution to pH 6.2. This solution, diluted five times in water, gives pH 7.7. The reagent was prepared by dissolving 155 mg of 9-fluorenylmethyl chloroformate in 40 mL of acetone to give a concentration of 15 μ M. To 0.4 mL of sample (20 times diluted with distilled water) were added 0.1 mL borate buffer and 0.5 mL of the reagent. After about 40 seconds, the mixture was extracted with 2 mL pentane. The extraction was repeated twice. After filtration, the aqueous solution with the amino acid derivative was ready for injection.

The mobile phase consisted of 38% acetonitrile in water and 0.2% acetic acid. Detection was carried out by fluorimetric detector with an excitation wavelength of 266 nm and an emission wavelength of 315 nm. Glutamine was quantified by peak-height measurements.

Male adult C57BL mice weighing 14-16 gm were obtained from Sasco Inc., in Nebraska and were allowed at least one week to acclimate in the Animal Care Facility. During that time, the mice were allowed, ad libitum, standard rat chow and water. Forty-two animals were then randomized to control, 24, 48, 72, and 96 hours post-radiation groups. The 96 hours post-radiation group was also divided into two groups, one with 3% glutamine supplementation and the other without it. Radiation was performed at Phelps County Regional Medical Center. The animals were immobilized by using masking tape and subjected to a single dose of 15 Gy using 9 MeV electron beams to the whole abdomen.

In order to generate tumor, 2×10^5 Lewis Lung Carcinoma cells in 0.2 mL of media were injected into gastrocnemius muscle. Blood samples were drawn about 25-30 days later.

Results

As shown in Table 1, control plasma glutamine level was $715 \pm 23 \mu\text{M}$ ($n=7$); 24 hours after 15 Gy GD whole abdomen irradiation using 9 MeV electrons plasma glutamine level was $635 \pm 100 \mu\text{M}$ ($n=7$), representing a 11% decrease ($p>0.05$); 48 hours after XRT it was $542 \pm 127 \mu\text{M}$ ($n=7$), representing a 24% decrease ($p<0.05$); 72 hours after XRT it was $542 \pm 104 \mu\text{M}$ ($n=7$) representing a 24% decrease ($p<0.01$); 96 hours after XRT it was $364 \pm 61 \mu\text{M}$ ($n=7$) representing a 49% decrease ($p<0.0001$).

A group of 7 C57BL mice were also starved for 48 hours to assess possible role of anorexia in glutamine depletion. At this point they were noticeably ill, exhibiting hypothermia and bradycardia. Plasma glutamine level fell to $577 \pm 37 \mu\text{M}$ ($n=7$), a decrease from control of 19% ($p<0.0001$). This decrease is very similar to the fall noted 48 hours after XRT (Table 2). Tumor-bearing mice had 30% ($p<0.001$) lower glutamine level than normal.

Table 1. Plasma Glutamine Levels in Control and at Various intervals after XRT.

Groups	Plasma Gln M \pm SD(μM)	% Decrease
Control (n=7)	715 \pm 23	
24 hrs Post-XRT (n=7)	635 \pm 100	11%
48 hrs Post-XRT (n=7)	542 \pm 127	24%
72 hrs Post-XRT (n=7)	542 \pm 104	24%
96 hrs Post-XRT (n=7)	364 \pm 61	49%

Discussion

This study examined the effects of whole-abdomen radiation on glutamine level in a murine-model system. Plasma glutamine level progressively decreased after the radiation treatment. The most dramatic depletion occurred at 4 days post-XRT (Table 1). Similar results were obtained by Souba *et al.* (1990) in adult rats.

In the study by Klimberg *et al.* (1990), although there were no difference in arterial glutamine levels between the glutamine-fed and glutamine-free post-radiation groups, glutamine feeding resulted histologically in a doubling of villous height and number.

There have been quite a few studies concerning gut mucosal morphometrics

with or without glutamine supplementation after XRT (Klimberg and Souba; Dolson *et al.*, 1989; Guzman *et al.*, 1989; Souba, Klimberg, and Copeland 1990). Only one of these studies (Souba, Klimberg, and Copeland, 1990) has shown a significant change in plasma glutamine level following XRT.

In our study, the animals without glutamine supplementation had a 49% decrease ($p < 0.001$) in glutamine level, whereas the glutamine-fed group had only a 35% decrease ($p < 0.001$). A paired student's t-test shows the difference between these two groups to be statistically significant ($p < 0.05$). Those without supplementation also had a higher incidence of side effects such as diarrhea or apathy as a group in comparison to those that did receive glutamine (Table 2).

We have also studied plasma glutamine level in tumor-bearing mice. Plasma glutamine level decreased by 30% ($p < 0.001$) from control in tumor-bearing mice (Table 2). Most of the tumors, especially MCA sarcoma, consume glutamine (Fisher *et al.*, 1990) and behave as a glutamine trap. Therefore, glutamine supplementation may become necessary for the host.

In several disease states glutamine need increases and muscle or lung glutamine release may increase as a compensatory mechanism, but internal glutamine supplementation may be insufficient, making external glutamine supplementation advisable (Souba, 1988).

Table 2. Effects of Starvation, Tumor and Glutamine Supplementation on Plasma Glutamine Levels and Observed Symptoms.

Groups	Plasma Gln M \pm SD (μ M)	% Decrease	Observed Symptoms
Control (n = 7)	715 \pm 23		
48 hrs Starvation (n = 7)	577 \pm 37	19%	Hypothermia Bradycardia
96 hrs Post-XRT No Gln suppl. (n = 7)	364 \pm 61	49%	Diarrhea Apathy
96 hrs Post-XRT With Gln suppl. (n = 7)	468 \pm 101	35%	Better than no Gln suppl group
LLC Tumor (n = 7)	500 \pm 59	30%	

In conclusion, we suggest that glutamine should be given prophylactically to patients before or after XRT. The potential therapeutic role of glutamine along with its side effects should be investigated in detail.

References

- Berthrong, M. (1988) Pathologic changes secondary to radiation, *World J. Surg.*, 155:170-183.
- Buchi, K. (1991) Radiation proctitis: therapy and prognosis, *J.A.M.A.*, 265(9):1180.
- Casaret, G. (1963) Concept and criteria of radiologic ageing. In: Harris R.J.C. (ed): Cellular Basis and Aetiology of Late Somatic Effects of Ionizing Radiations, New York, Academic Press
- Decosse, J. J. Rhodes, R. D., Wentz, W. B. (1969) The natural history and management of radiation-induced injury of the gastrointestinal tract, *Ann. Surg.*, 170:369-376.
- Fischer, J. E., Chance, W. T., (1990) Total parenteral nutrition, glutamine, and tumor growth, *J Parenteral & Enteral Nutrition*, 14:86S-89S
- Guzman, G., Bonsack, M., Liberty, J., (1989) Abdominal radiation causes bacterial translocation, *J Surg. Res.*, 46:104-107
- Klimberg, V. S., Souba, W. W., Dolson, D., Salloum, R. M., (1990) Prophylactic glutamine protects the intestinal mucosa from radiation injury, *Cancer* 66:62-68
- Klimberg, V. S., Souba, W. W., Dolson, D. J., (1989) Oral glutamine supports crypt cell turnover and accelerates intestinal healing following abdominal radiation. *J. Parenteral and Enteral Nutrition*, 13 (suppl 1):35.
- Kokal, W. A., (1986) Effects of antineoplastic therapy on nutritional status: surgery, chemotherapy, and radiotherapy. *Clinics in Oncol.*, 5:227-292.
- Roth, E., Karner, J., Ollenschlager, G. (1990) Glutamine: An anabolic effector? *J Parenteral & Enteral Nutrition* 14(4):130S-136S.
- Souba, W. W., (1988) The gut as a nitrogen-processing organ in the metabolic response to critical illness. *Nutritional Support Services* 8(5):15-22.
- Souba, W. W., Klimberg, S., Copeland, E., (1990) Glutamine nutrition in the management of radiation enteritis. *J Parenteral & Enteral Nutrition* 14(4):106S-108S.
- Souba, W. W., Wilmore, D. W., (1983) Postoperative alteration of arteriovenous exchange of amino acids across the gastrointestinal tract. *Surgery*, 94:342-350.
- Windmueller, H. G., (1982) Glutamine utilization by the small intestine. *Adv. Enzymol.* 53:201-237.

Soil Genesis in Rhyolite and Granite Residuum in the St. Francois Mountains

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Abstract: Four Missouri soils, from summit and sideslope positions on rhyolitic and granitic peaks in the St. Francois Mountains, were studied to determine soil genesis and the clay mineral weathering sequences. Three pedons were ultisols and one pedon was an alfisol, which showed strong evidence for a rhyolitic saprolite. Mineralogy was characterized by x-ray diffractometry (XRD), thermal analysis and potassium fixation. Results demonstrated that the major clay minerals were kaolinite, hydroxy-aluminum interlayered vermiculite (HIV), and hydrous micas. Kaolinite is proposed as forming from K-feldspar weathering, while the presence of HIV and hydrous micas are proposed as alteration products of either an aeolian contaminant, the sericitization of the feldspars, or the alteration of primary biotite/chlorite. At two locations, conversion of biotite to chlorite substantially contributed to the presence of vermiculite and hydrous micas.

Key Words: Soil genesis, clay minerals, x-ray diffraction

The term "saprolite" denotes "thoroughly decomposed rock formed in place by chemical weathering of igneous or metamorphic rocks" (Am. Geol. Inst., 1976). It is commonly accepted that soil genesis begins with saprolite formation and that the initial weathering products influence subsequent mineral formation and soil genesis.

Feldspars in soil reportedly weather directly to noncrystalline materials and gibbsite (Calvert, 1980), to halloysite (Eswaran and Bin, 1978), or to either kaolinite or illite (Exley, 1976). DeVore (1959) provided evidence that feldspars may be transformed into micas via a solid state reaction, implying that feldspars may be a possible parent material for illite and vermiculite. Similarly, Stoch and Sikora (1976), in Silesia, observed sericite and/or illite forming via an incongruent dissolution from potassium feldspars.

Differences in the initial product formation are likely the result of minor differences in parent materials, climate, vegetation and the soil solution composition as affected by drainage. Vermiculite, smectites, and illite (clay-micas) are usually considered as the weathering products of micas (Dixon and Weed, 1975; Vincente *et al.*, 1977). Karathansis *et al.* (1983) provided strong evidence that hydroxy-aluminum interlayered vermiculite (HIV) is relatively stable and resists further mineral alteration in humid temperature climates.

Using XRD, chemical analysis, and DTA and SEM techniques, Colman (1982) investigated rind weathering of basalts and andesites. Rind weathering did not result in phyllosilicate synthesis, except for allophane, even though some of the minerals were associated with well-developed Bt horizons. Colman

concluded that the weathering products were formed by degradational processes, except for allophane, and that the clay minerals in the Bt horizons formed more slowly than commonly assumed. Colman inferred that the direct conversion of primary minerals may not be a viable mechanism for phyllosilicate formation; hence, conditions for crystallization of clay minerals in weathering rinds differ markedly from those in adjacent soils.

Fields (1966) showed that allophane contains significant amounts of tetrahedrally coordinated Al. If K-feldspars weather via rind production and allophane production is significant, then the soil solution may be suitable for crystallization of the allophane to tetrahedrally coordinated Al phyllosilicates, such as a micaeous mineral.

Calvert *et al.* (1980) studied a soil-saprolite-granitic gneiss sequence and concluded that feldspars in the saprolite weathered to gibbsite and amorphous aluminosilicate spheres. As the saprolite weathered to soil, silicon-gibbsite reactions sequentially produced tabular halloysite and kaolinite. In Malaysia, Eswaran and Bin (1978) investigated a granitic saprolite-soil sequence and observed feldspar voids with linings of noncrystalline aluminosilicate materials. XRD diffractograms and SEM revealed that the saprolite clay separate was dominated by halloysite with secondary concentrations of feldspars and micas. Kaolinite was present as a trace mineral. The argillic horizon of the overlying soil possessed a clay separate dominated by kaolinite with secondary amounts of gibbsite and goethite. The authors concluded that noncrystalline materials, produced from the alteration of feldspars, altered to halloysite and that the halloysite weathered, during the later stages of soil formation, to kaolinite.

The purpose of this paper is to 1) investigate the physical, chemical and mineralogical properties of selected soils residing on the summit and slopes of the St. Francois Mountains, and 2) to determine the sequence of mineral weathering.

Study Area

The St. Francois Mountains are a group of closely assembled peaks that occupy significant areas of southeastern Missouri. These mountains are composed of Precambrian rocks, the oldest being felsites which have been intruded by granitic and mafic rocks.

The St. Francois Mountains are hot in the summer, especially at the lower elevations, and cool in winter. The January daily average temperature is approximately 0°C, while the July daily average temperature is 25°C. The average rainfall is approximately 100 cm and it is relatively well distributed. (Nat'l. Cooperative Soil Survey-St. Francois Co., 1981)

The soils of the region are dominated by soils representative of the alfisol and ultisol orders (Nat'l Cooperative Soil Survey-St. Francois Co., MO, 1981). The Soil Survey Staff (1975) provides technical definitions for the alfisol and ultisol orders; however, locally these soils are generally associated with humid, temperature climates and a deciduous forest vegetation. The soil profile reveals an acidic to extremely acidic horizon having silicate clays that have slowly migrated from overlying horizons. Alfisols have a moderate base (exchangeable Ca, Mg, K, Na) content, while ultisols have a low base content.

The soils selected for this study are from the Knobtop series (Fine-silty, mixed, mesic, Aquic Hapludults), Irondale series (Loamy-skeletal, mixed, mesic, Typic Hapludults) and the Taumsauk series (Loamy-skeletal, mixed, mesic, Typic Hapludults). The Knobtop and Irondale #1 sites were, respectively, on the summit and southern sideslope positions of Taum Sauk Mountain (Knobtop: S $\frac{1}{2}$, SW $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 4, T 33 N, R 3 E, Ironton Quadrangle; Irondale #1: NE $\frac{1}{4}$, SW $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 2, T 33 N, R 3 E, Ironton Quadrangle; 7 km west of Arcadia, Mo.), while the Taumsauk and Irondale #2 sites were located on the southern sideslopes of Stono Mountain (Taumsauk: NW $\frac{1}{4}$, NE $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 25, T 35 N, R 4 E, Iron Mountain Lake Quadrangle; Irondale #2: SW $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 25, T 35 N, R 4 E, Iron Mountain Lake Quadrangle; 18 km north of Farmington, Mo.).

Vegetation at all sites consisted of white oaks (*Quercus alba* L.), red oaks (*Quercus rubra* L.) and an assortment of grasses and mosses. The forest vegetation appeared to be stunted, especially at the Taumsauk pedon site, as well as other locations where the soil was shallow. Lichens covered segments of an exposed rhyolite of the Van East Group in adjacent areas of Taum Sauk Mountain.

A typical mineral composition for the rhyolites of the Van East Group (parent material for Knobtop and Irondale #1 pedons) includes orthoclase and quartz phenocrysts in an orthoclase groundmass. Accessory minerals include magnetite, chlorite, fluorite, zircon, and apatite (rhyolites of the Van East Group are megascopically, and petrographically similar).

The Taumsauk pedon on Stono Mountain developed in the Stono Granite (“... typically a fine grained, mottled, dull, reddish-brown and green granite, in places porphyritic; light red feldspar and inconspicuous quartz are the principle minerals with small amounts of biotite and hornblende...” (Tolman and Robertson, 1969)). “Feldspars are orthoclase and plagioclase (albite to sodic oligoclase) with plagioclase rarely making up 5% of the rock; mafics include biotite (altered to chlorite), some hornblende and magnetite; mafic minerals represent 3-10% of the rock; the alteration of mafic minerals to chlorite give clean surfaces a mottled greenish cast” (Tolman and Robertson, 1969). The Saprolite containing Irondale #2 pedon developed in Stouts Creek Rhyolite, a formation of the Van East Group. Tolman and Robertson (1969) provide detailed information concerning the mineral composition of the region’s precambrian rocks.

Materials and Methods

One pedon from a summit position and three pedons from southern sideslope positions were sampled for characterization. The Knobtop series represents the summit position, while the Irondale series (2 sites) and the Taumsauk series represent the sideslope positions. The four pedons were sampled and described according to the Soil Survey Manual (1981). Bulk samples were air-dried and passed through a 2-mm sieve for use in subsequent analysis. Particle size separations were made by sieving and centrifugal/gravity sedimentation after removal of organic matter and free iron oxides and dispersing according to the methods in Black (1965). Potentiometric measurements of pH were made in water using 1:1 soil/liquid ratio. Hydrogen and

aluminum were extracted in 1N KCl (Black, 1965). Hydrogen was determined by titration with NaOH and Al according to the aluminon method (Hsu, 1963). The exchangeable bases (Ca, Mg, K, Na) were extracted with 1N NH₄OAc and determined via atomic absorption spectrophotometry.

Oriented whole clay (<2 microns) specimens were prepared for x-ray diffraction (XRD) by sedimentation of K⁺ and Mg²⁺ saturated samples onto glass slides. The Mg-saturation samples were glycerol-solvated by equilibrating in a 5% glycerol-methanol solution. X-ray diffractograms were obtained with a Norelco Geiger counter spectrometer using CuK radiation and a Ni filter. Estimation of the mineral type and relative content was made from the basal spacings and x-ray peak intensity. Vermiculite was estimated in selected clay samples by the K-fixation method of Alexiades and Jackson (1965). Kaolinite was estimated by thermal gravimetric analysis (TGA).

The partitioning of free iron oxides into noncrystalline and crystalline fractions was after Shuman (1980). Iron, Mn, and Al were determined by atomic absorption spectrophotometry.

Results

Soil Physical Properties

The clay distribution substantiates placement of the agrillic horizon (Soil Survey Staff, 1975). Clay concentrations generally increase upon transition into the Bt (illuvial) horizons and then decrease with depth until contact with the underlying bedrock. Sand contents are correspondingly higher for pedons from Stono Mountain. The ratios of very fine and fine sand to the total sand content (sand ratio) are somewhat uniform within each pedon, except for the saprolite containing Irondale site. The saprolite containing Irondale site has a sand ratio which declines with profile depth, suggesting that physical and chemical weathering have been more intense near the soil's surface.

The fine-silt-to-total-silt ratios (silt ratio) are somewhat constant within the Knobtop and Irondale #1 pedons. The silt ratios in the Irondale #2 pedon are constant within the solum and higher than the silt ratios of the underlying saprolite or the pedons from Taum Sauk Mountain. Lower weathering intensities in the saprolite would be expected to produce a coarser silt separate.

The Knobtop pedon (Taum Sauk Mountain) exhibits a moderately deep A-E-Bt-rhyolite horizon sequence (Table 1). The rocky silt loam A horizon abruptly grades to a rock- and cobble-free silt loam E and silty clay loam Bt (argillic) horizons. The yellowish brown and strong brown colors of the E and upper Bt horizons suggest a well drained soil, while the light gray colors in the Bt3 and gravelly BC horizons indicate the presence of a seasonal perched watertable. The common, medium, distinct reddish yellow mottles, and their depth at 58 cm, suggest that the pedon is moderately well drained. The boundary between the BC horizon and the rhyolite is abrupt and wavy, with the rhyolite maintaining a hard crystalline appearance.

The Irondale #1 pedon (Taum Sauk Mountain) has a moderately deep A-E-Bt-rhyolite sequence. The very strongly acid, cobbly silt loam A and E horizons (eluvial) grade to an extremely acid, cobbly clay loam Bt (argillic) horizon. The dark brown and brown soil colors of the Bt horizon and the light brownish gray colors of the BC horizon suggest a seasonal watertable.

Table 1. Profile description for selected soils in the St. Francois Mtn's.

Horizon	Depth	Texture	pH	Structure	Boundary	Colors	Mottles
	cm		H ₂ O				
				<i>Knobtop (Fine-silty, mixed, mesic Aquic Hapludults)</i>			
A	8	Rocky sil	4.4	2fgr	as	10YR 4/4 dark yellowish brown	
E	24	sil	4.3	2fsbk	cw	10YR 5/4 yellowish brown	
Bt1	33	sicl	4.3	2fsbk	cw	10YR 5/6 yellowish brown	patchy clay films (10YR 5/4)
Bt2	48	sicl	4.3	2vfsbk	cw	7.5YR 4/6 strong brown	
Bt3	58	sicl	4.2	2fsbk	cw	10YR 7/2 light gray	common medium distinct (7.5YR 6/6)
BC	71	gravelly sil	4.2	1vfsbk	aw	10YR 7/2 light gray	common medium distinct (7.5YR 6/6)
				<i>Irondale #1 (Loamy-skeletal, mixed, mesic Typic Hapludults)</i>			
A	15	cobbly sil	4.9	3fgr	aw	10YR 3/2 very dark grayish brown	
E	23	cobbly sil	4.7	2fgr	cw	10YR 4/3 dark brown	
Bt1	43	cobbly cl	4.4	2fsbk	cw	7.5YR 5/4 brown	patch clay films (10YR 4/3)
Bt2	61	cobbly cl	4.3	2msbk	aw	7.5YR 4/4 dark brown	
BC	69	cobbly cl	4.1	2msbk	aw	10YR 6/2 light brownish gray	few fine prom. (2.5YR 5/6) common medium distinct (10YR 7/6)
				<i>Taumsauk (Loamy-skeletal, mixed, mesic Typic Hapludults)</i>			
A	13	rocky sl	4.7	3fgr	as	10YR 3/2 very dark grayish brown	patchy clay film (10YR 5/3)
B	20	gravelly sl	4.5	1msbk	irregular	10YR 5/3 brown	many fine prom. (7.5YR 5/8)
				<i>Irondale #2</i>			
A	11	rocky sl	5.1	1fgr	as	7.5YR 4/4 dark brown	
E	38	gravelly cl	4.9	1mpl	cs	5YR 5/4 reddish brown	few fine faint (10YR 7/4)
Bt1	59	gravelly cl	4.6	3msbk	cs	5YR 5/4 reddish brown	few fine distinct (2.5YR 5/6) few fine distinct (10YR 8/8)
Bt2	97	gravelly c	4.6	massive	ds	5YR 5/4 reddish brown	many medium distinct (10YR 8/8) many medium distinct (2.5YR 5/6)
C1	150	gravelly scl	4.6	massive	ds	10YR 4/6 red	*same as Bt2
C2	178	gravelly sl	4.6	massive		5YR 5/6 yellowish red	*same as Bt2

*Rock structure evident as 100-200 mm cobbles with external surfaces having 10 YR 5/3 (brown) color.

The shallow Taumsauk pedon (Site #1 on Stono Mountain) exhibits a very dark grayish brown, rocky sandy loam A horizon abruptly changing to a thin brown gravelly sand loam Bt horizon. The solum-granite contact was not well defined since the granite surface was essentially rocks and cobbles, probably formed by a freezing and thawing mechanism, with wedges of Bt material between the granite rock fragments.

The Irondale #2 pedon (Site #2 on Stono Mountain) has an A-E-Bt-saprolite-rhyolite horizon sequence. The dark brown, rocky sandy loam A horizon abruptly alters to reddish brown clay loam E and Bt horizons. At 97 cm the solum converts to a thick layer of saprolite having a red, gravelly sandy clay loam texture grading to a yellowish red gravelly sandy loam texture. The C1 and C2 horizons show the antedecent rock structure as 100-200 mm cobbles with surfaces having an approximately 5-10 mm thick, brown rind. Interior to these easily disturbed structures are the red soil matrix color and the many, medium and distinct, yellow and red mottling patterns (Table 1).

Soil Chemical Properties

All pedons appear to be uniformly acid. The effective cation exchange capacity (ECEC- the sum of the exchangeable bases plus the neutralizable acidity) is very low, increasing in the Bt horizons in roughly the same ratio as the increases in clay content. Base saturation [base cations/ECEC] is very low for all pedons, except for the Irondale #2 pedon, which should be reclassified as an alfisol. Magnesium and especially Ca are particularly impoverished, while exchangeable Al is abundantly expressed. Except for the very shallow Taumsauk pedon, each A horizon has a higher Ca expression, suggesting that forest biocycling is an important process.

Free iron oxides (Fe not associated with the octahedral positions of layer silicates) were fractionated into noncrystalline and crystalline components (Table 4) to assess soil genesis. Traditionally, noncrystalline Fe-containing oxides are more reactive because of their greater surface areas and they have not undergone transformation to the more crystalline Fe minerals (goethite and hematite). Noncrystalline Fe is relatively constant within each pedon and represents 2-10% of the total free Fe content. The crystalline Fe component generally increases upon transition into the Bt horizons, somewhat corresponding to the clay content distribution. An exception is the Taumsauk Bt horizon where the low Fe content is likely because of gleyed soil conditions.

Manganese (Table 4) is only significantly expressed in the eluvial horizons, where biocycling may be an important process. Crystalline Al was significantly more abundant than noncrystalline Al and intended to increase with profile depth, while noncrystalline Al was relatively uniform throughout the solum. The Al mole fractions (Al/Al + Fe calculations using Table 4 are not shown) for the Knobtop and Irondale pedons on Taum Sauk Mountain are approximately equal to the theoretical limit of aluminum isomorphous substitution (33%) in goethite (Tardy and Nahon, 1985). The eluvial horizons (A and E) for the Irondale pedon from Stono Mountain have smaller Al mole fractions, suggesting that organic-Fe complexes may be important or the iron oxides have a smaller degree of Al isomorphous substitution. The Bt and C1 horizons have Al mole fractions near the limit of Al isomorphous substitution.

Table 2. Particle size distribution.

Horizon	Clay	Silt	Sand	<u>fine & very fine sand</u> sand	<u>fine silt</u> silt
	%	%	%	%	%
			<i>Knobtop</i>		
A	10.76	69.83	19.44	45.28	29.16
E	20.83	67.84	11.38	46.65	30.41
Bt1	27.59	61.35	11.06	37.77	28.24
Bt2	34.21	54.83	10.96	41.74	30.34
Bt3	29.38	53.15	17.47	41.53	49.93
BC	24.37	52.30	23.33	42.39	25.88
			<i>Irondale</i>		
A	4.67	53.51	41.82	54.87	37.71
E	17.31	58.30	24.39	56.27	43.14
Bt1	38.16	38.63	23.21	79.85	39.14
Bt2	30.66	38.24	31.10	54.54	26.78
BC	29.51	36.80	33.69	59.11	41.07
			<i>Taumsauk</i>		
A	16	10	74	41	53
Bt	20	24	56	46	28
			<i>Irondale #2</i>		
A	16	18	66	52	79
E	28	24	48	27	64
Bt1	37	25	38	24	67
Bt2	46	20	34	22	69
C1	21	22	57	14	47
C2	13	30	57	13	46

Table 3. Selected chemical properties

Horizon	-----Exchangeable bases-----				-----KCl ext.-----		Neutralizable acidity	ECEC	BS
	Ca	Mg	K	Na	Al				
						($\text{cmol}_p(+)\cdot\text{kg}^{-1}$)			
						<i>Knobtop</i>			%
A	0.19	0.21	0.32	0.22	1.00	3.99	4.9	19	
E	0.13	0.11	0.31	0.28	3.43	6.30	7.1	12	
Bt1	0.14	0.47	0.32	0.28	5.07	8.10	9.3	13	
Bt2	0.15	2.47	0.42	0.32	5.82	9.45	12.8	26	
Bt3	0.11	2.41	0.41	0.24	4.25	8.85	11.8	27	
BC	0.12	2.21	0.41	0.25	4.96	8.19	11.2	27	
						<i>Irondale #1</i>			
A	1.22	0.63	0.84	0.32	0.00	1.34	4.4	69	
E	0.42	0.34	0.42	0.22	0.47	2.43	3.8	36	
Bt1	0.73	0.86	0.53	0.30	4.34	7.28	9.7	25	
Bt2	0.63	0.71	0.48	0.28	3.86	6.49	8.6	24	
BC	0.39	0.58	0.42	0.21	3.62	6.67	8.3	19	
						<i>Taumsauk</i>			
A	0.28	0.39	0.27	0.19	0.74	2.93	4.1	28	
Bt	0.53	1.04	0.43	0.25	1.76	4.43	6.7	34	
						<i>Irondale #2</i>			
A	2.19	2.32	0.37	0.28	0.40	0.45	5.6	92	
E	1.95	2.31	0.41	0.26	0.56	1.02	6.0	82	
Bt1	1.44	2.86	0.50	0.24	1.52	3.14	8.2	61	
Bt2	0.98	3.00	0.53	0.27	1.92	4.14	8.9	54	
C1	0.79	2.30	0.42	0.23	2.62	3.99	7.8	49	
C2	0.94	2.85	0.48	0.26	1.31	2.91	7.4	61	

Table 4. Sequential extraction of the free iron oxides

Horizons	-----Noncrystalline-----			-----Crystalline-----		
	Fe	Mn	Al	Fe	Mn	Al
	-----mg*kg ⁻¹ -----					
	<i>Knobtop</i>					
A	420	90	470	6700	160	1600
E	340	*	450	9600	50	2200
Bt1	400	*	460	10900	*	2700
Bt2	390	*	500	12000	50	3000
Bt3	450	*	470	11100	*	2800
BC	590	*	230	9700	*	2810
	<i>Irondale</i>					
A	450	210	700	11000	280	2310
E	330	135	580	9200	210	2500
Bt1	410	*	600	14400	*	2600
Bt2	260	*	200	12100	*	3300
BC	600	*	480	15000	*	4300
	<i>Taumsauk</i>					
A	1040	*	320	10600	*	1900
Bt	770	*	530	8900	*	2700
	<i>Irondale #2</i>					
A	2110	60	290	17600	120	2000
E	1480	*	290	14700	*	1800
Bt1	1440	*	250	17600	*	3800
Bt2	1510	*	250	17600	*	4000
C1	1300	*	260	16700	*	4000
C2	1840	*	250	21000	*	3000

*Mn concentration is < 25 mg kg⁻¹

Soil Mineralogical Properties

X-ray diffraction (XRD) patterns for the Knobtop series are similar to those of Aide and Tibbs (1987), although different soil profiles were utilized. The XRD reveals that the clay separate is generally composed of hydroxy-aluminum interlayered vermiculite (HIV), hydrous micas (illite), kaolinite, and quartz. Kaolinite and HIV expressions are somewhat uniform with profile depth, while hydrous micas are somewhat more abundant in eluvial (A and E) horizons. Heat treatments (300°C) only slightly shifted the 1.4nm peak, assigned to vermiculite, towards 1.0nm, implying a high degree of hydroxy-aluminum interlayering. Halloysite was not detected, possibly because of air-drying prior to sieving.

The quantitative determination of vermiculite and kaolinite, showed that vermiculite, as a percentage of the whole clay separate, declined slightly with a depth in the Knobtop and Irondale (Taum Sauk Mountain) pedons. On Stono Mountain, the saprolite-Irondale pedon showed a greater vermiculite concentration in the saprolite region than the overlying solum. Within the Irondale #2 solum, vermiculite expression declined with depth.

Kaolinite was the dominant clay mineral in all pedons. On Taum Sauk Mountain, kaolinite increased slightly with depth in the Knobtop pedon, while the Irondale pedon had significantly reduced kaolinite expression in the BC horizon. Similarly, on Stono Mountain, the kaolinite content declined with depth for the Irondale pedon, until the solum-saprolite interface, where the kaolinite concentration abruptly increased. The Taumsauk pedon showed greater kaolinite expression in the Bt horizon.

Table 5. Quantitative determination of Vermiculite and kaolinite/Halloysite in the whole clay separate.

Horizon	*Vermiculite (%)	*Kaolinite (%)
	<i>Knobtop</i>	
A	10.5	45
E	11.1	43
Bt2	2.3	50
BC	7.5	49
	<i>Irondale #1</i>	
A	17	
E	6	40
Bt1	4	31
BC	7	16
	<i>Taumsauk</i>	
A	4	11
Bt	7	19
	<i>Irondale #2</i>	
A	9	36
E	8	20
Bt2	trace	28
C2	25	42

*Percentages are based on the whole clay separate.

Discussion

Aide and Tibbs (1977) investigated the Irondale, Taumsauk, and Knobtop series on Taum Sauk Mountain and concluded that the HIV and hydrous mica were incompatible with the rhyolite mineralogy. The chemical composition of the interstitial solutions were in agreement with the clay mineralogy. The subsequent discovery of rhyolite saprolite on Stono Mountain permitted a reinvestigation of the hypothesis that rhyolite and granite weathering is primarily responsible for the clay mineralogy.

Fig. 1. displays various reaction pathways, as revealed by the cited literature, for the formation of the clay minerals identified in the pedons. The conversion of mica to hydrous mica and HIV is not particularly controversial, nor is the alteration of feldspar to kaolinite. Evidence for feldspar alteration to a mica-like mineral remains controversial because non-detrital illitic or vermiculitic clay minerals are almost always associated with a micaceous parent material. The contra positive is equally valid.

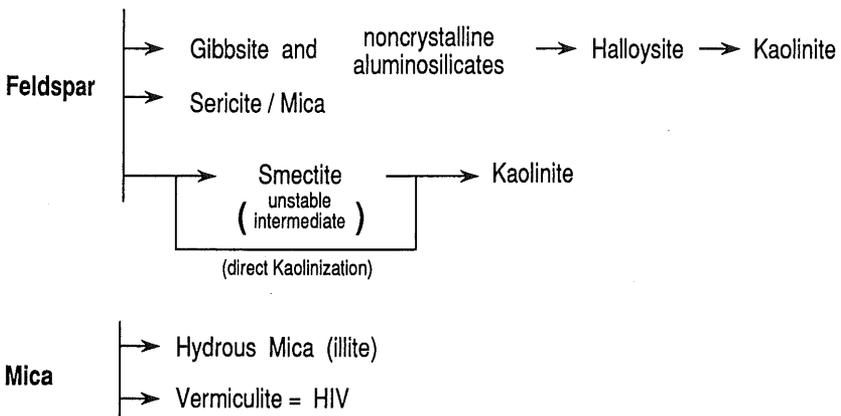


Fig. 1. Pathways describing possible mineral weathering scenarios.

The dominance of HIV and hydrous micas could only be explained by one of four mechanisms: an aeolian origin, loess as a parent material, the formation of sericites or another precursor mineral via feldspar weathering, and the alteration of primary micaceous minerals to HIV. The presence of vermiculite and hydrous micas in rhyolitic saprolite would appear to eliminate an aeolin or loessial origin. Additionally, adjacent regions known to have loess mantles do not appear to have sufficient loess to provide the amounts of micaceous materials found in the pedons. The presence of coarse sand, the impoverishment of Ca and Mg, and the abundance of K (from K-feldspar weathering) do not appear to support an aeolian or loessial origin.

Field inspection of rock samples from the study area reveals a greater abundance of micaeous minerals than formerly reported by Tolman and Robertson (1969). The mineral assemblage of the examined rocks would appear to explain clay mineral formation as: 1) feldspar conversion to kaolinite, 2) biotite/chlorite conversion to HIV.

Literature Cited

- Aide, M. T. and N. Tibbs. 1987. The influence of loess on Ultisol formation on Taum Sauk Mountain. *Trans., Missouri Acad. Sci.* 93-103.
- Alexiades, C. A., and M. C. Jackson. 1965. Quantitative determination of vermiculite in soils. *Soil Sci. Soc. Am. Proc.* 29:522-527.
- American Geological Institute. 1976. Dictionary of Geologic terms. Anchor Press/Doubleday, Garden City, N.J.
- Black, C. A. (ed). 1965. Methods of Soil Analysis. Parts 1 & 2. Agronomy No. 9. American Society of Agronomy, Madison, WI.
- Brown, B. 1981. National Cooperative Soil Survey: Soil Survey of St. Francois Co. Missouri. United States Dept. Agriculture. Washington, DC.
- Calvert, C. S., S. W. Buol, and S. B. Weel. 1980. Mineralogical characteristics and transformations on a vertical rock-saprolite-soil sequence in the North Carolina piedmont. II. Feldspar alteration products - their transformations through the profile. *Soil Sci. Soc. Am. J.* 44:1104-1112.
- Colman, S. M. 1982. Chemical Weathering of Basalts and Andesites: Evidence from Weathering Rinds. Geol. Survey Professional Paper 1246. U.S. Government Printing Office. Washington, DC.
- De Vore, G. W. 1957. The surface chemistry of feldspars as an influence on their decomposition products. *Proc. 6th N.S. Nat. Conf. Clays Clay Min.* 26-41.
- Dixon, J. B., and S. B. Weed (ed.). 1977. Minerals in Soil Environments. Soil Sci. Soc. Am., Madison, WI.
- Eswaran, H. and W. C. Bin. 1978. A study of a deep weathering profile on granite in Peninsular Malaysia: II. Mineralogy of the clay, silt and sand fractions. *Soil Sci. Soc. Am. J.* 42:149-153.
- Exley, C. S. 1976. Observations on the formation of kaolinite in the St. Austell Granite, Cornwall. *Clay Miner.* 11:51-63.
- Fields, M. 1966. The nature of allophane, Part II. Differences in composition. *New Zeal. J. Sci.* 9:608-622.
- Hsu, P. H. 1963. Effect of initial pH, phosphate, and silicate on the determination of aluminum with aluminon. *Soil Sci.* 96:230-238.
- Karathanasis, A. D., F. Adams, and B. F. Hajek. 1983. Stability relationships in kaolinite, gibbsite, and Al-hydroxy interlayered vermiculite soil systems. *Soil Sci. Soc. Am. J.* 47:1247-1251.
- McKeague, J. A., J. E. Brydon, and N. M. Miles. 1971. Differentiation of forms of extractable iron and aluminum in soils. *Soil Sci. Soc. Am. Proc.* 35:33-38.
- Pratt, W. P., R. E. Anderson, A. W. Berry Jr., M. E. Bickford, E. B. Kisvarsanyi, and J. R. Sides. 1979. Geologic Map of Exposed Precambrian Rocks, U.S. Geological Survey.
- Ross, G. J., H. Kodama, C. Wang, J. T. Gray, and L. B. Lafreniere, 1883. Halloysite from a strongly weathered soil at Mont. Jacques Cartier, Quebec. *Soil Sci. Soc. Am. J.* 47:327-332.
- Shuman, L. M. 1985. Fractionation method for soil micronutrients. *Soil Sci.* 140:11-22.
- Soil Conservation Service. 1981. Examination and description of Soils in the Field. Soil Survey Manual. 340-V-22M. U.S. Government Printing Office, Washington, D.C.
- Soil Survey Staff. 1975. Soil Taxonomy. U.S. Government Printing Office, Washington, D.C.
- Stoch, L., and W. Sikora. 1976. Transformation of micas in the process of kaolinization of granites and gneisses. *Clays Clay Miner.* 24:156-162.
- Tardy, Y. and D. Nahon. 1985. Geochemistry of laterites, stability of Al-Goethite, Al-hematite, and Fe-kaolinite in bauxites and ferricretes: an approach to the mechanism of concretion formation. *Am J. Sci.* 285:865-903.

- Tolman, C. F., and F. Robertson. 1969. Exposed Precambrian Rocks in Southeast Missouri. Report Investigations #44. Missouri Geol. Surv. and Water Resources. 9, 2-37.
- Vincente, M. A., M. Razzaghe, and M. Robert. 1977. Formation of aluminum hydroxy vermiculite (intergrade) and smectite from mica under acidic conditions. *Clay Minerals* 12:101-111.

Influence of Organic Matter and O-phosphate on Chromium (VI) Adsorption

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Abstract: Recent investigations of the soil chemistry of chromium suggest that chromium may exist in two forms: (1) the chromate anion and (2) the chromic cation. The present study used chromate adsorption isotherms on selected horizons from six soils differing in texture, pH, and organic carbon. Generally, higher levels of organic carbon were associated with enhanced chromate adsorptivity, while o-phosphate, as a co-solute, inhibited chromate adsorptivity. Organic carbon was inferred to easily reduce chromate, giving appearances of a high selectivity. Chromate adsorption in organic carbon impoverished horizons is proposed to be a combination of anionic reduction by Fe(II)-Mn(II) and an anionic competitive exchange reaction.

Key Words: Chromium, soil, isotherms

The soil chemistry of phosphorus has been extensively investigated. Fox and Kamprath (1970) and Sanchez and Uehara (1980) prepared ortho-phosphate adsorption isotherms and showed that phosphorus was strongly partitioned onto Fe and Al oxides. The magnitude of the adsorption was pH-dependent, with acidic environments favoring adsorption.

The soil chemistry of chromium has only recently received attention, presumably because it has only recently become widespread as a toxic pollutant. Chromium is capable of existing in soil as both the chromate anion (CrO_4^-) and as the chromic cation (Cr^{3+}). Under appropriate conditions these two species are convertible through oxidation and reduction reactions. The chromate anion exhibits chemical properties to those of similar phosphate, while the chromic cation has chemical properties similar to aluminum (Baes and Mesmer, 1976).

Bartlett and Kimble (1976a,b) and James and Bartlett (1983a,b) investigated chromium reactions in soil. Chromate reduction is likely to occur in soil environments having substantial organic matter levels and an acidic reaction. Chromate adsorption was significant in soil environments exhibiting spodic horizons, noncrystalline clays or sesquioxides. Phosphate was shown to inhibit chromate adsorption in equilibrated soil suspensions, especially when phosphate addition was prior to chromate addition. Additionally, these authors observed that a buffered phosphate solution was able to displace a portion of the adsorbed chromate, the extent of displacement being dependent upon pH and the nature of the adsorbing surface. Thus, phosphate and chromate are potentially competitive species for surface sites.

Zachara, Ainsworth *et al.* (1989) measured chromate adsorption, with and without reactive co-solutes, on four subsurface soil horizons differing in pH and clay mineralogy. Chromate adsorption was greatest in acidic materials enriched in kaolinite and crystalline iron oxides. The presence of sulfate and dissolved

inorganic C depressed chromate adsorption. Recently, Eary and Rai (1991) demonstrated that subsoils having Fe(II) are capable of reducing chromate if the pH is less than 4.3. Chromate reduction in acidic subsoils was thought to result in precipitation of (Fe,Cr) (OH)₃. Grove and Ellis (1980) proposed that Fe(II) and Mn(II) may reduce chromate.

The objective of this investigation is to determine chromate sorptivity in a series of soils exhibiting differences in pH, texture, organic carbon, and free iron oxide content and to determine if phosphate is competitive with chromate adsorption.

Soils

Six soils were selected to assess chromate adsorptivity. The first two soils were selected from the Falaya and Crowley series. These soils differ from the other soils in that they have textures finer than silt loam and are classified as poorly drained. Samples from the Crowley sites were sieved to remove particles > 0.1 mm, which consisted almost entirely of Fe & Mn masses. The remaining soils had sandy to loamy textures and were classified as excessively well drained to poorly drained. Routine classification and characterization data for the Falaya and Crowley soils are in Table 1, while Table 2 gives corresponding information for the Malden, Sikeston, Broseley, and Clana soils. All routine wet chemical methods are referenced in Black *et al.* (1965).

Preparation of Chromium Adsorption Isotherms

Adsorption isotherms were prepared by weighing air-dried soil, equivalent to 1 gram of oven-dried soil, into plastic screw-capped vials. Chromate-bearing solutions, having a concentration range from 0.1 to 8 mg Cr/l, were added to the soil and equilibrated > 10 days at 27° C. Soil suspensions had a solution-to-soil weight ratio of 10, with the exact solution weight determined by weighing the screw-capped vials before and after the solutions were added, and adsorption was calculated by difference between the initial and equilibrium concentrations. Ionic strength of the chromium-bearing solutions were maintained at 0.01 M/liter using sodium nitrate. A duplicate set of chromium-bearing solutions were prepared, except the duplicated solutions were also 20 mg P/l. Reagent grade K₂HPO₄ and K₂CR₂O₇ were used to prepare these equilibrating solutions. Phosphorus analysis was performed by reaction with ammonium molybdate with color development affected by stannous chloride (Olsen and Dean 1965), while chromate analysis was by the s-diphenyl carbazide method (Bartlett and Kimble, 1976a).

Results and Discussion

The Falaya series consists of silty textured, acidic soils formed in alluvium. Crystalline and noncrystalline Fe oxides generally increase with profile depth (Table 1). Easily reducible Mn is exceptionally high in the Ap horizon and is moderately expressed in the C horizons, while noncrystalline Mn oxides are concentrated in the C4g horizon.

Table 1. Physical and chemical properties of the Falaya and Crowley soils

Horizons	Texture	pH	cmol/kg		mg/kg			
			Exchangeable Bases	Neutralizable Acidity	†Free Iron Oxalate	Oxides CDB	†Manganese Easily Red.	Oxalate
Falaya (Coarse-silty, mixed, acid, thermic Aeric Fluvaquents)								
Ap	Silt Loam	6.5	9.9	0.05	1680	1610	135	300
C2g	Silty Clay	7.1	8.6	0	880	1420	10	140
C4g	Silt Loam	5.8	9.0	0.3	2100	2130	25	290
Crowley (Fine, montmorillonitic, Typic Albaqualts)								
E	Silt Loam	5.5	2.5	0.7	460	1950	190	40
Btg2	Silty Clay	5.2	14.7	3.7	220	1990	15	10
BCg	Silt Loam	6.9	30.2	0	500	5680	313	340

†CDB = citrate-bicarbonate-dithionite extraction, oxalate = ammonium oxalate-oxalic acid (pH 3.3), Easily Red = ammonium oxalate + 0.2% hydroquinone extraction

Table 2. Physical and chemical properties of the Broseley, Clana, Malden and Sikeston soils

Horizons	% Texture		cmol/kg Cation Exchange Capacity	% Base Saturations	pH (H ₂ O)	% Organic Carbon	mg/kg Free Iron Oxide
	Clay	Sand					
Broseley (Loamy, mixed, thermic, Arenic Hapludalfs)							
Ap1	3	76	6.0	73	6.6	0.6	6900
E1	2	78	3.8	58	5.9	0.1	7000
E2	10	76	7.5	59	6.1	0.2	8500
Clana (mixed, thermic Aquic Udipsamments)							
Ap	5	84	7.0	73	6.9	0.5	7200
B	4	84	4.0	50	5.9	0.1	6900
Malden (mixed, thermic Typic Udipsamments)							
Ap	3	91	4.9	63	6.6	0.4	6400
C1	4	90	4.5	56	6.9	0.1	7800
Sikeston (Fine - loamy, mixed, thermic Cumulic Haplaquolls)							
Ap	9	69	12.3	64	5.3	0.8	9100
C1g	18	58	21.5	80	6.4	0.3	6600
2C	1	97	4.0	73	6.6	0.1	4800

The Crowley series consists of poorly drained soils formed in clayey alluvium. The physical and chemical properties of the E, Btg2 and BCg horizons (Table 1) reflect their clayey parent materials. The acidic E and Btg2 horizons exhibit low and high cation exchange capacities, respectively, while the neutral BCg horizon exhibits a high cation exchange capacity. The E and BCg horizons have significant concentrations of easily reducible Mn, while the Btg2 horizon shows only a minor easily reducible Mn concentration.

Chromate isotherms for the Falaya (Fig. 1) are nearly linear and adsorption decreases from the Ap to C4g horizon. Organic carbon has been shown to effectively reduce the chromate anion to the chromic cation (James and Bartlett, 1983b), hence oxidation-reduction appears to be a dominant mechanism in the Ap horizon. Adsorption in the organic carbon impoverished C2g and C4g horizons is likely because of an anionic exchange reaction and an Fe(II)-Mn(II) induced reduction. Effects of phosphate addition on chromate sorption are negligible for the Ap and C2g horizons, while the C4g horizon displays reduced chromate sorptivity. The C4g horizon shows enhanced accumulations of iron oxides and the soil reaction is decidedly more acidic, conditions promoting the adsorption of the o-phosphate anion. If anionic adsorption is the dominant mechanism in the organic carbon impoverished C4g horizon, then phosphate as a co-solute would be expected to favorably compete with chromate for the available reactive surface sites.

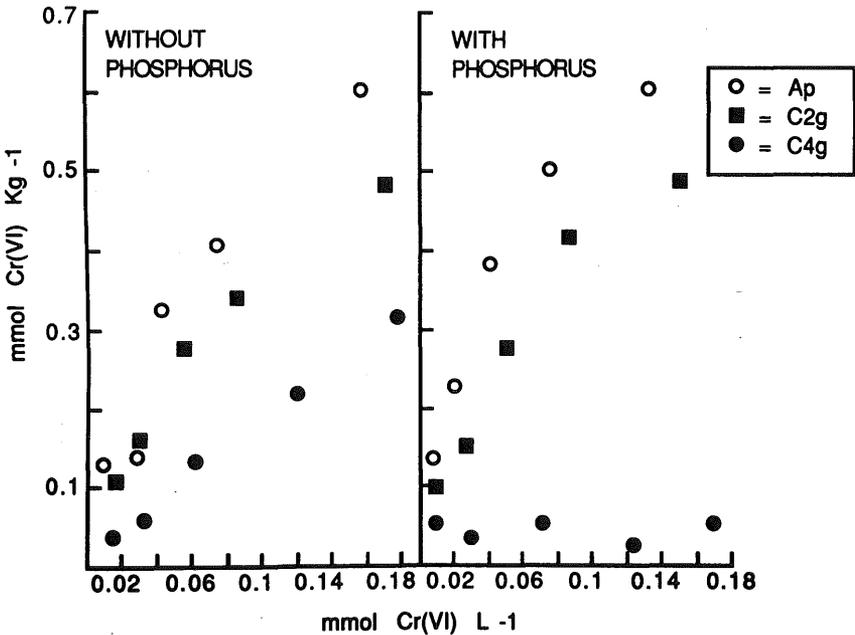


Figure 1. Chromium isotherms for the Falaya series.

Chromate sorptivities for the Crowley soil decrease from the E to BCg horizons (Fig. 2). The E and Btg2 chromate isotherms exhibit near equilibrium ph values of 4.3 and 4.4, respectively, while the BCg horizon has a reaction of 6.7. The abundance of organic carbon and an acidic soil reaction would be expected to reduce chromate, providing a likely mechanism for the greater Ap adsorptivity. The alkaline reaction and low organic carbon contents of the BCg horizon would not be conducive to a significant degree of chromate reduction. The small amount of chromate adsorption in the neutral BCg horizon suggests that an anionic exchange reaction is responsible for chromate's removal from the aqueous phase.

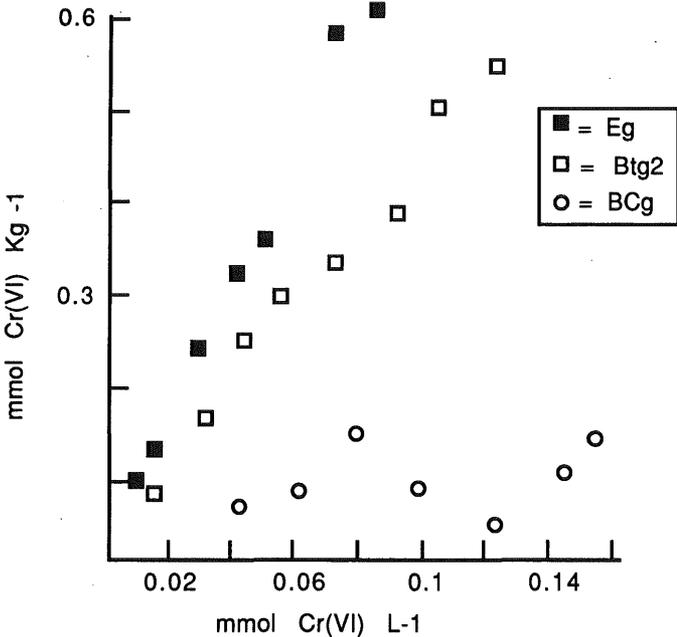


Figure 2. Chromium isotherms for the Crowley series.

The chromate isotherms for the Sikeston loam show that chromate adsorptivity is highest in the organic carbon enriched Ap horizon and the adsorptivity decreases with profile depth. Additionally, the Ap horizon is significantly more acid than the subsoil horizons, an environmental condition conducive to chromate's removal (Zachara *et al.* 1989). The enhanced chromate adsorptivity in the Ap horizon would suggest that organic carbon induced chromate reduction is the dominant reaction. The addition of o-phosphate as a co-solute slightly increased the chromate adsorptivity in the 2C1g and 2C horizons.

SIKESTON

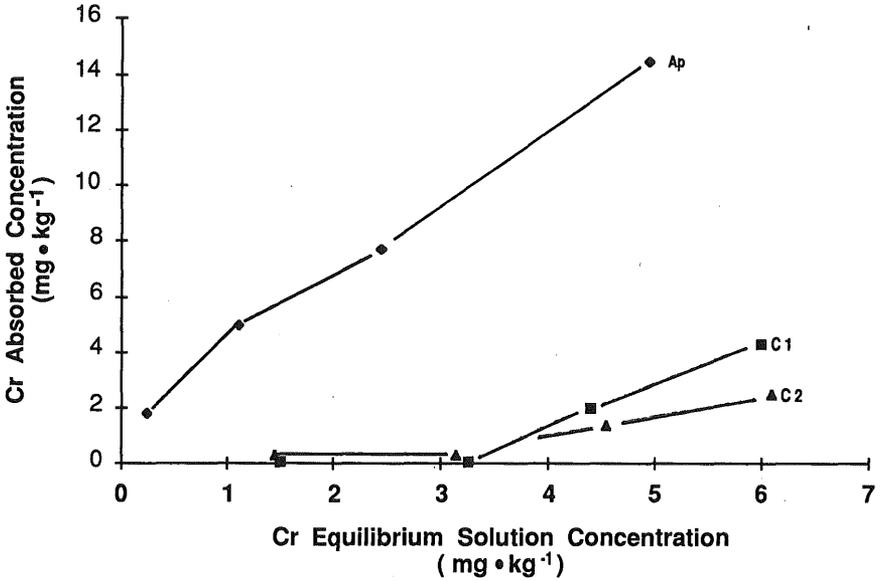


Figure 3a. Chromium isotherms for the Sikeston series.

SIKESTON

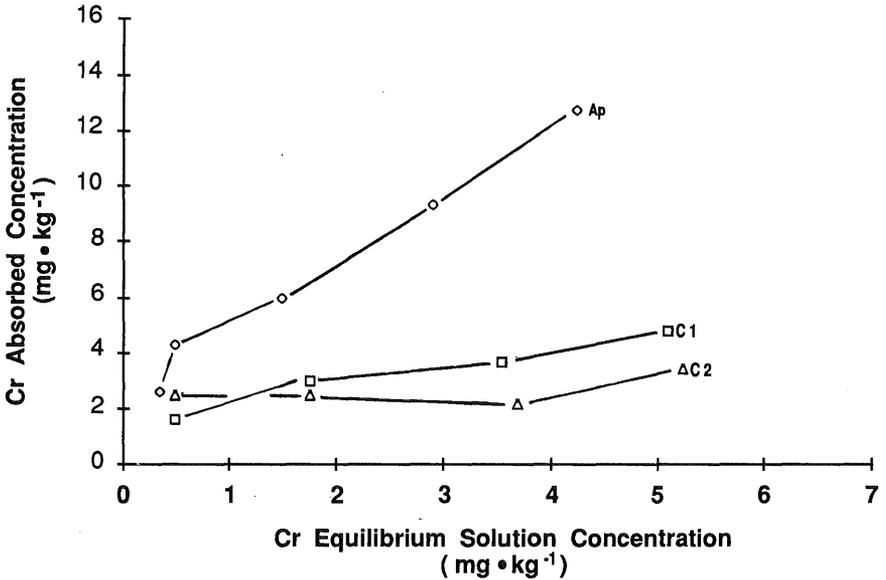


Figure 3b. Chromium isotherms in the presence of phosphate for the Sikeston series.

Chromate adsorptivity in the Clana loamy sand is significantly greater in the organic carbon-impoverished B horizon, suggesting that chromate adsorption is a dominant soil reaction. The near neutral reaction and the relatively low organic carbon content of the Ap horizon reduces the potential for chromate reduction, leading to a comparatively low adsorptivity. The effect of o-phosphate addition was to substantially increase chromate adsorptivity in the Ap horizon and to decrease adsorptivity in the B horizon. The o-phosphate-reduced chromate adsorptivity in the B horizon likely suggests anionic competition; however, no mechanism has been proposed to explain the Ap horizon's increase in chromate adsorption with o-phosphate addition.

Chromate isotherms for the Broseley loamy sand and the Malden sand are somewhat similar to those exhibited by the Clana. The Malden's C1 horizon shows greater adsorptivity than the organic matter enriched Ap horizon, while the Ap, E1 and E2 horizons of the Broseley site exhibit a relatively similar set of chromate isotherms. The effect of o-phosphate is to depress chromate adsorptivity for all horizons, especially for the organic carbon-impoverished subsurface horizons.

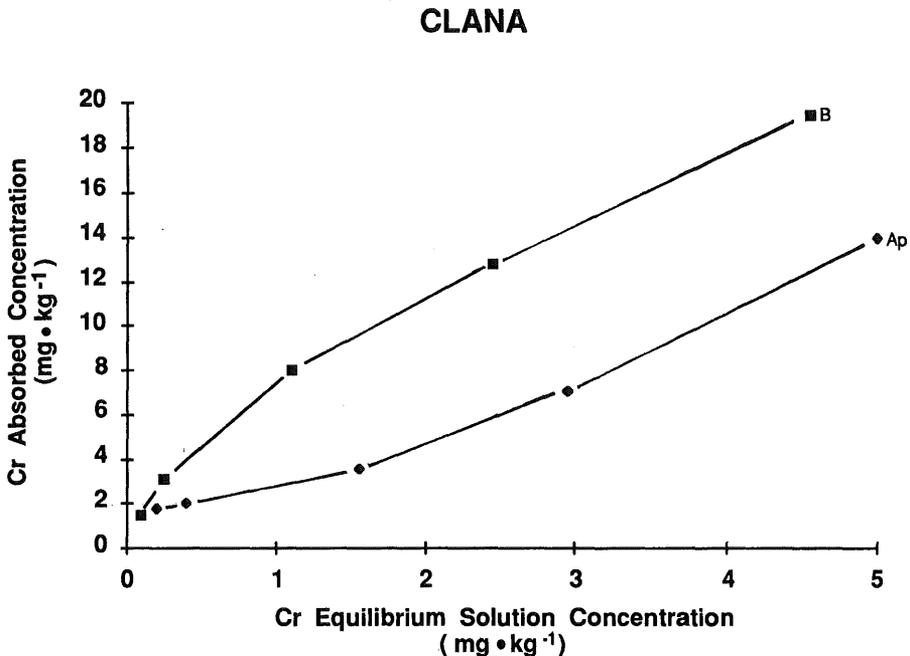


Figure 4a. Chromium isotherms for the Clana series.

CLANA

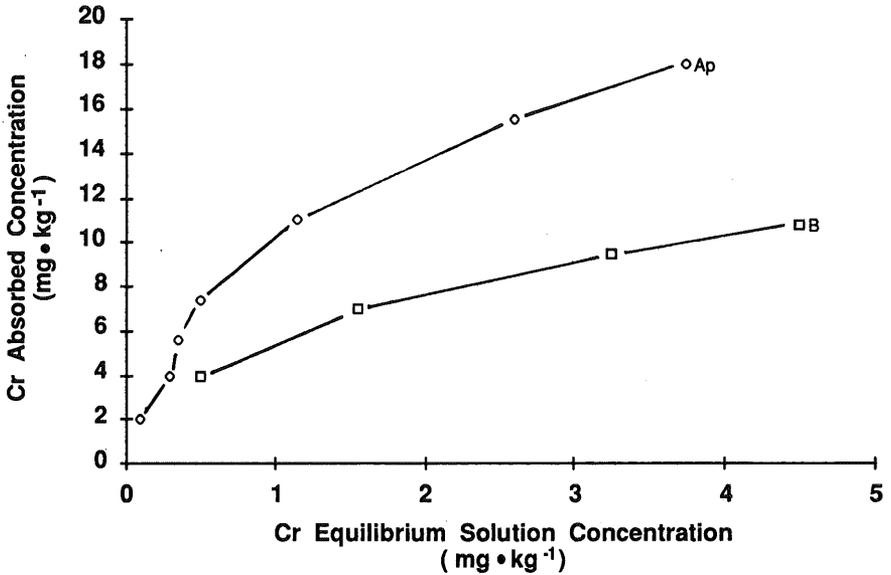


Figure 4b. Chromium isotherms in the presence of phosphate for the Clana series.

BROSELEY

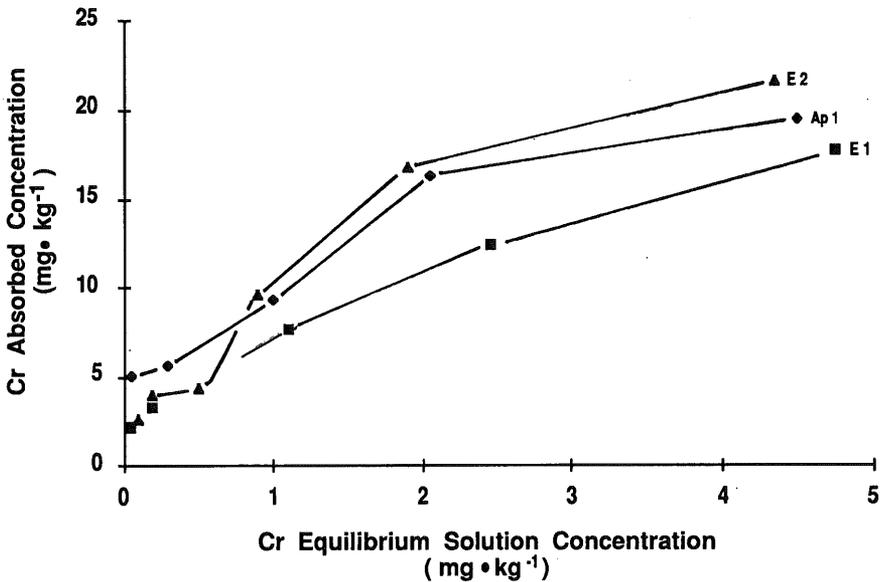


Figure 5a. Chromium isotherms for the Broseley series.

BROSELEY

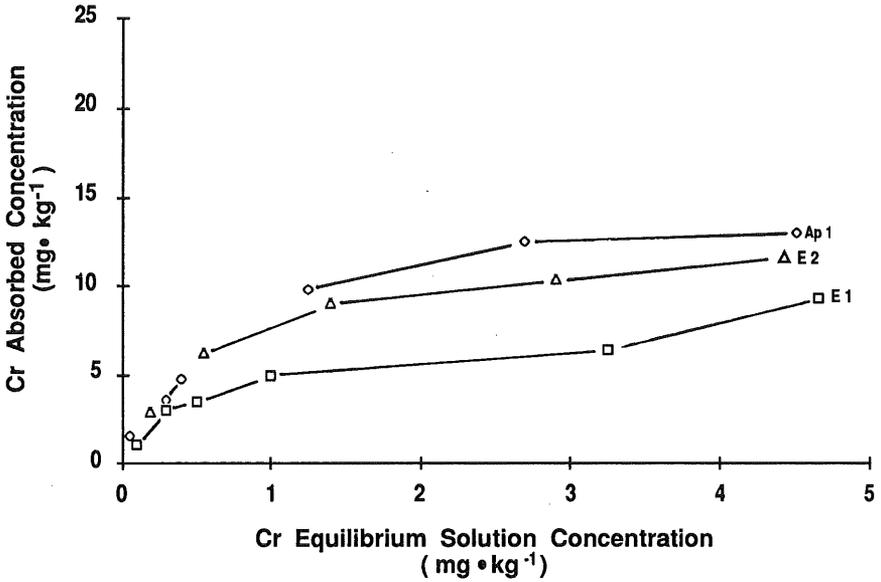
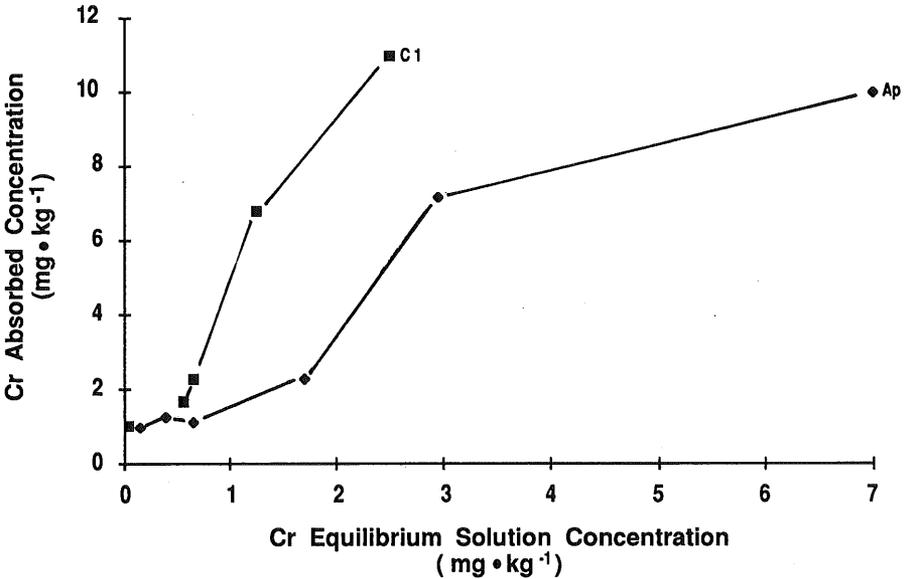


Figure 5b. Chromium isotherms in the presence of phosphate for the Broseley series.

MALDEN



MALDEN

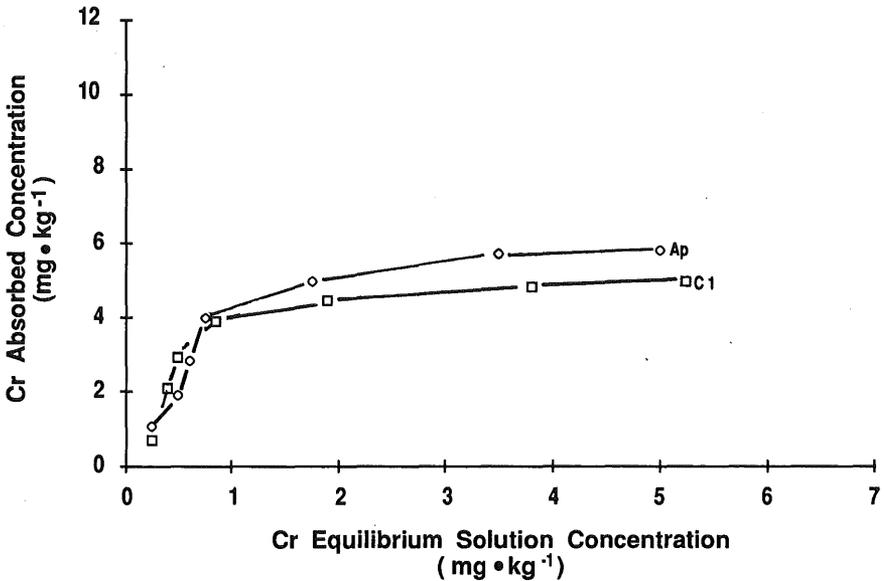


Figure 6b. Chromium isotherms in the presence of phosphate for the Malden series.

Conclusions

Chromate adsorption for the Falaya silt loam and Crowley silty clay loam suggest that chromate is reduced by organic carbon, leading to high chromate adsorptivities in the Ap horizons. O-phosphate additions generally depresses chromate adsorptivity in the illuvial and C horizons, suggesting that chromate is displaced from complexation sites because of a competitive anion exchange reaction.

Chromate adsorption isotherms for the four sandy to loamy textured soils demonstrate that organic carbon was a major factor influencing chromium adsorptivity. The addition of o-phosphate as a co-solute generally reduces chromate adsorptivity in low organic carbon-containing horizons. The effect of o-phosphate on depressing chromate adsorption suggests that phosphate reduces the availability of reactive sites for chromate adsorption because of anionic competition. The mechanism for o-phosphate enhancing the chromate adsorptivity in the Clana's Ap horizon is not clear.

Literature Cited

- Baes, C. F. and R. E. Mesmer. 1976. The Hydrolysis of Cations. pages 211-218. Wiley-Interscience, New York.
- Bartlett, R. J. and J. M. Kimble. 1976a. Behavior of chromium in soils: I. Trivalent forms. *J. Environ. Qual.* 5:379-383.
- Bartlett, R. J. and J. M. Kimble. 1976b. Behavior of chromium in soils: II. Hexavalent forms. *J. Environ. Qual.* 5:383-386.
- Black, C. A. (ed.). 1965. Methods of Soil Analysis. Parts 1&2. Agronomy No. 9. American Society of Agronomy, Madison, WI.
- Eary, L. E. and Dhanpat Rai. 1991. Chromate reduction by subsurface soils under acidic conditions. *Soil Sci. Soc. Am. J.* 55:676-683.
- Fox, R. L. and E. J. Kamprath. 1970. Phosphate sorption isotherms for evaluating the phosphate requirements of soils. *Soil Sci. Soc. Am. Proc.* 34:902-907.
- Grove, J. H. and B. G. Ellis. 1980. Extractable iron and manganese as related to soil pH and applied chromium. *Soil Sci. Soc. Am. J.* 44:243-246.
- James, B. R. and R. J. Bartlett. 1983a. Behavior of chromium in soils. VI. Interactions between oxidation-reduction and organic complexation. *J. Environ. Qual.* 12:173-176.
- James, B. R. and R. J. Bartlett. 1983b. Behavior of chromium in soils. VII. Adsorption and reduction of hexavalent forms. *J. Environ. Qual.* 12:177-181.
- Marshall, C. E. 1977. The Physical Chemistry and Mineralogy of Soils, Vol. II: Soils in Place. Wiley-Interscience, New York.
- Olsen, S. R. and L. A. Dean. 1965. Phosphorus. pages 1035-1048. C. A. Black (ed.), Methods of Soil Analysis, part II. Agronomy #9. American Soc. Agronomy, Madison, WI.
- Sanchez, P. A. and G. Uehara. 1980. Management considerations for acid soils with high phosphorus fixation capacity. pages 471-514. F. E. Khasawneh (ed.), The role of Phosphorus in Agriculture, American Soc. Agronomy, Madison, WI.
- Zachara, J. M. and C. C. Ainsworth, C. E. Cowan, and C. T. Resch. 1989. Adsorption of chromate by subsurface soil horizons. *Soil Sci. Soc. Am. J.* 53:418-428.

Landslides Subsequent to a 4.7 Magnitude Earthquake in the Benton Hills of Missouri

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Abstract: A September 26, 1990 earthquake of modest intensity in southeast Missouri caused or contributed to several damaging slope failures and some structural damage. The slope failures are described in detail and are related to known slope failures nearby and to the economic consequences of smaller earthquakes.

Key Words: Earthquake, landslide, damage, New Madrid Seismic Zone, Benton Hills, Crowley's Ridge, Missouri, Arkansas

Summary

At approximately 3:00 a.m. on September 26, 1990, an earthquake of body-wave magnitude 4.7 occurred near New Hamburg, Missouri. Several landslides followed, the largest of which was observed on the property of Mr. Gary Lomax, less than two miles from New Hamburg. A zone of fissures 2-3 inches wide and 50-70 feet long was discovered the morning following the quake. The fissures formed transverse to the slope below the Lomax dwelling and across the drain field of the septic system, allowing precipitation to infiltrate the slope. Precipitation for October through March was 28 percent above normal. On April 2, 1991, a sudden slope failure occurred when a large block moved 5 feet downslope. Within 24 hours the displacement had increased to 20 feet and the block continued to creep during the following month. On May 3, 1991, an earthquake of body-wave magnitude 4.6 occurred in the New Madrid Seismic Zone 36 miles south of the site. The slide moved 10 feet downslope within 48 hours of this event. By May 21, 1991, there was a total displacement of 61 feet, which has remained stable as of March, 1992. The block carried many large trees, several of which were pushed into a pond at the base of the slope. Other landslides were observed at approximate distances of 0.25, 4, and 67 miles from the Lomax property. Numerous older slumps have been observed in the Benton Hills, where topographic and geologic conditions are conducive to slope failures. Although the Lomax landslide occurred six months after the New Hamburg earthquake, we conclude that the quake was an essential causative factor leading to the slump's occurrence.

Introduction

The study area is located on a south-facing slope in the Benton Hills, a northern extension of Crowley's Ridge. Both Crowley's Ridge and the Benton Hills show evidence of widespread landslide activity in the recent geologic past. While seismically-induced landslides appear to be numerous, few on Crowley's Ridge or the Benton Hills have been mapped and studied (McFarland, 1991;

Stewart & Knox, 1991). More than 200 seismically-induced landslide features have been mapped along the Mississippi River bluffs of western Tennessee and Kentucky by Jibson and Keefer (1984 & 1988). No similar study has been done for Crowleys Ridge and the Benton Hills.

There are similarities between the seismically-induced landslides documented by Jibson and Keefer and the Lomax landslide. Both areas contain similar stratigraphy (layers of sand, clay, and gravel overlain by loess) and of similar age (Jackson and Lafayette Formations [Eocene and Pliocene] vs. Ackerman and Holly Springs Formations [Eocene]). The original slope height and slope angle (approximately 50' relief with 300' length for a 17% gradient) are consistent with those rotational block slides Jibson and Keefer attributed to seismically-induced slope failure. And finally, the climates and vegetative cover of both areas are similar.

There is one striking difference between the Lomax landslide and those mapped by Jibson and Keefer. The seismically-induced slides along the Mississippi River bluffs mapped by Jibson and Keefer have been attributed to the major earthquakes of the New Madrid series of 1811-12. According to Nuttli (1987) this was a sequence of more than 1,900 earthquakes during a five-month period. Nuttli thought at least five of these to have been surface wave magnitude (M_s) 8.0 or greater, another five about M_s 7.7, ten of about M_s 6.7, and 35 of about M_s 5.9. In contrast, the earthquake concluded to have been the initiating factor of the Lomax landslide (and three others) was of body wave magnitude (m_b) 4.7, (September 26, 1990) which is considered a light to moderate quake by seismologists (USGS, 1990).

The Lomax slide, and others triggered by the same quake, are all the more remarkable considering the recent work of Jibson (1991). His study was a theoretical computer model for two landslides in Tennessee known to have been triggered by the 1811-12 New Madrid earthquake sequence. According to Jibson, his "results indicate that an m_b 5.9 is the lower bound threshold at zero epicentral distance that could trigger catastrophic movement of typical block slides in the area while for earth flows, an m_b 5.5 is the threshold earthquake." An m_b 4.7 event releases only one-sixteenth as much energy as an m_b 5.5 and only one-sixty-fourth as much as an m_b 5.9.

Site Location

The Lomax property is located on a southern slope of the Benton Hills in Scott County, Missouri, approximately one mile northwest of Benton and two miles south of New Hamburg (center, NE $\frac{1}{4}$, SE $\frac{1}{4}$, Section 11, Township 28 North, Range 13 East). As shown in Figure 1, the epicenter of the m_b 4.7 event is located in the approximate area of New Hamburg (USGS, 1990).

Stratigraphy of the Area

The stratigraphic unit involved is the Wilcox Group, which is a series of Eocene-age beds of sand, clay, and gravel (see Fig. 2). The Wilcox Group is broken down into the Ackerman and Holly Springs Formations. "On the surface, it is possible to distinguish both the Ackerman and Holly Springs

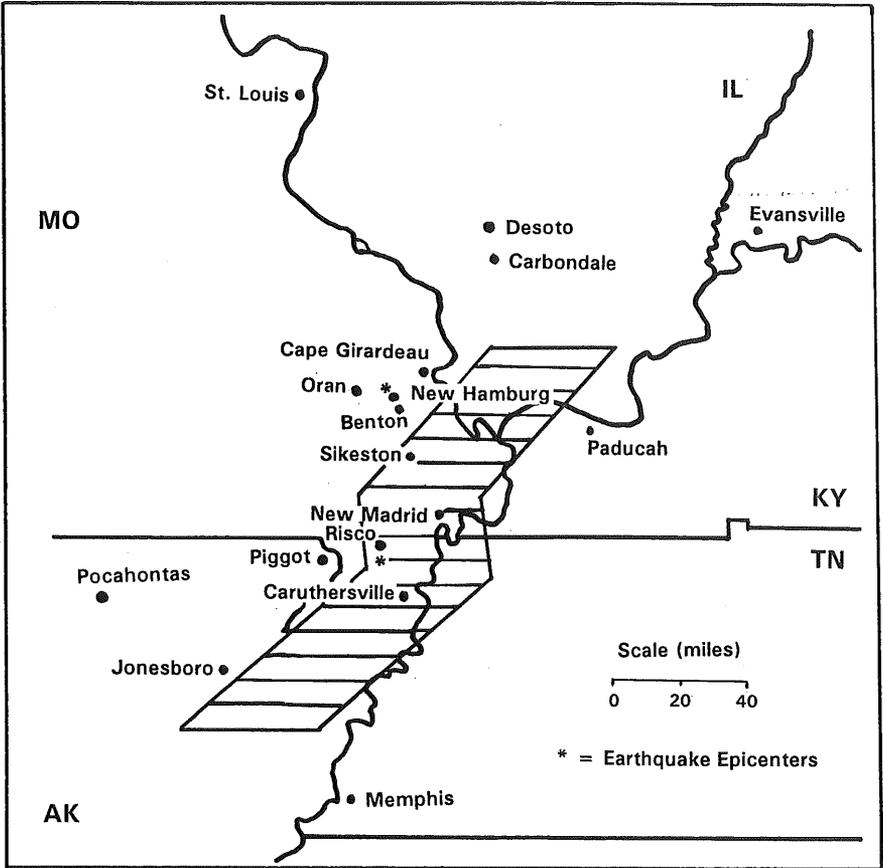


Fig. 1. Region of Study. Hachured area represents the approximate location of the New Madrid Seismic Zone (after Nuttli, 1987, et al.). The asterisk near New Hamburg represents the approximate epicenter of the September 26, 1992 earthquake (USGS, 1990). The asterisk near Risco represents the epicenter of the May 3, 1991 (local date) earthquake (USGS, 1991).

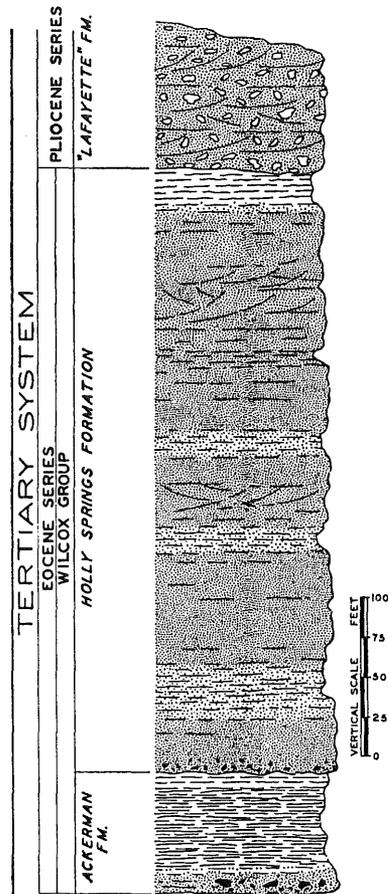


Fig. 2. Regional Stratigraphy (Koenig, 1961)

formations as the lower and upper components of the group, respectively, but these two units are difficult to differentiate in the subsurface." (Koenig, 1961)

"The Ackerman Formation is predominantly a light gray to brown, silty, nonmarine clay . . . the clay in the upper 6 to 8 feet of the formation is very plastic and is bright red or yellow in color (Koenig, 1961)."

The Holly Springs Formation occurs on the eroded surface of the Ackerman Formation. The Holly Springs Formation is essentially a loosely-consolidated sandstone varying in texture and degree of sorting. The formation contains many interspersed layers of "sandy clay, clay, and gravel The clay is sandy or silty, or in some cases pure and plastic. It is multi-colored and ranges from white, gray, yellow, red, lavender, green, brown, and black The base of the Holly Springs commonly contains a bed of rounded, highly polished, black gravel and intermixed coarse sand (Koenig, 1961)."

Highly polished, rounded, black pebbles and sand were discovered at the base of the landslide block. This physical evidence was significant in determining the stratigraphy. The contact between these two formations seems to be involved in numerous older landslides in the region (Knox, 1991).

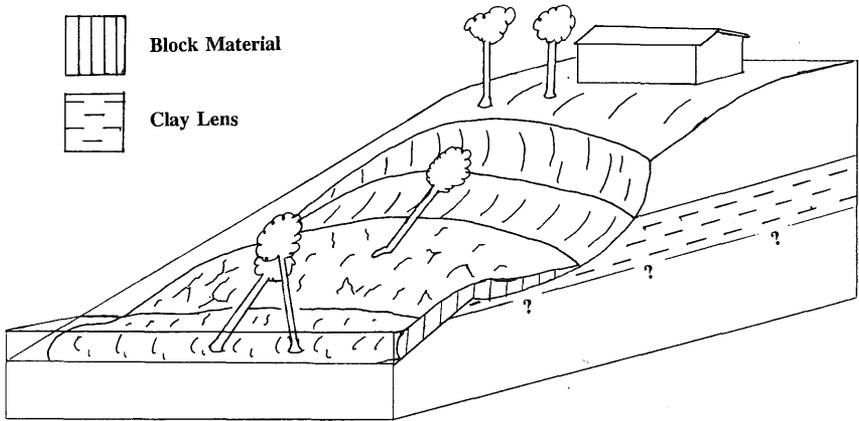


Fig. 3. An idealized block diagram of the Lomax Landslide viewed from the SE. Several trees were carried downslope by the block with some ending up in the pond at the base of the slope. An average dip of 21° was measured on the glide plane. The thickness of the clay layer forming the glide plane was not determined.

Soil Type

The soil in the region of the Lomax property is classified by the USDA Soil Survey as "Memphis silt loam". It is described as a well-drained and moderately-permeable soil which occurs on slopes of from 14 to 40 percent. Resulting from the deposition of loess, this soil has a grayish-brown silt loam surface layer about 3 inches thick and a subsoil of approximately 37 inches. The subsoil is divided into two zones: the upper zone is a yellowish-brown silty clay loam; and the lower zone is a brown silty clay loam. The soil is easily erodible if not covered with vegetation (Festervand, 1981).

Sequence of Events

- 1) September 26, 1990—Occurrence of an m_b 4.7 earthquake with its epicenter near New Hamburg, (USGS, 1990) approximately two miles from the site (see Fig. 1). A zone of fissures 2-3 inches wide and 50-70 feet long opened up in an arching pattern transverse to the slope on the downslope side of the Lomax dwelling.

- 2) Precipitation for October 1990 through March 1991 was 28% above normal (27.33" vs. 21.39") with December 1990 accounting for over 9" (FAA weather data, Cape Girardeau Municipal Airport, less than 8 miles from Lomax).
- 3) March 31, 1991—A sudden slope failure occurred at approximately 3:00 a.m., when the block moved downslope five feet. Upon the first inspection by the authors on April 1, 1991, the block had moved downslope approximately 20 feet (see Fig. 3-6).
- 4) May 3, 1991—An earthquake of m_b 4.6 occurred with its epicenter approximately 20 miles west of New Madrid, near Risco, MO, (Fig. 1) approximately 36 miles south of the Lomax site (USGS, 1991). A further downslope movement of approximately 10 feet occurred within 48 hours of that earthquake.
- 5) No more earthquakes have occurred greater than m_b 3.5 within 70 miles of the site between May 3, 1991, and March, 1992.
- 6) The block continued to slide slowly downslope moving 1.5 feet between May 18 and May 20, 1991 (its last noted movement).
- 7) As of March 1992 the position of the block appeared to have stabilized at a displacement of 61 feet and a vertical drop of 20 feet.

Characteristics and Conditions of the Landslide

The landslide block consists of approximately 75,000 cubic feet of material, originally covering an area of approximately 12,500 square feet downslope from the Lomax residence. The slip face had an average dip of 21°. As of March 1992 the block's position appeared to be stable at 61 feet downslope displacement and a vertical drop of 20 feet.

The landslide appears to be a single rotational block that has broken into numerous smaller sub-blocks near the lower portion of the block (see Figs. 7 & 8). Several large trees were carried with the block into a pond at the base of the slope (see Fig. 9).

The landslide block is comprised of soil and subsoil. The soil comprising the upper portion of the block is an orange-red color (Memphis silt loam). The lower portion of the block was also an orange-red color, however it was poorly consolidated and contained large amounts of sand and pebbles. The landslide material was sitting atop a layer of clay (see Figs. 10 & 11).

The clay layer comprising the slip face was predominantly gray in color, but in places varied in color. The clay's variation in color may indicate it to be a lens of the Holly Springs formation. More likely, the multi-coloring may be resultant from the septic field and the clay lens is the upper surface of the Ackerman formation. Black, highly polished pebbles were discovered at the base of the soil block. The same type pebbles are noted to occur at the base of the Holly Springs.

Soil moisture on the hillside was a definite contributing factor to the downslope migration of the block. Upon first inspection by the authors, the clay layer comprising the slide base was in a plastic state. Several sources contributed to the soil moisture. The fissures opened at the time of the initial ground motion acted as a conduit for the infiltration of above-normal precipitation. Water was continually added to the slope by the septic system. A pond at the base of the

slope may have also contributed to soil moisture. And finally, cool temperatures and dormant vegetation enabled the soil to retain much of the moisture it would lose to evapotranspiration during warmer seasons.



Fig. 4. View of the Lomax Landslide from the east. The Lomax home can be seen in the upper right corner of the photograph. The slump block was still slowly sliding at the rate of several feet per day at this time (April 1991).



Fig. 5. View of the Lomax Landslide from below, standing on the slumped block (April 1991).



Fig. 6. View of the Lomax Landslide from the west (April 1991).



Fig. 7. Upslope view of the Lomax Landslide showing the main slump block had broken into several sub-blocks. The Lomax home is visible through trees at top of slope (April 1991).



Fig. 8. Downslope view of the Lomax Landslide showing the main slump block had broken into several sub-blocks. The pond at base of the slump is visible through trees (April, 1991).



Fig. 9. Several trees were pushed into the pond at the base of the slump block. Note the lobate landscape across the pond. These are thought to be portions of a much older slide on the opposite hill.



Fig. 10. Head scarp and slip face of the slide as seen from the east (April, 1991).

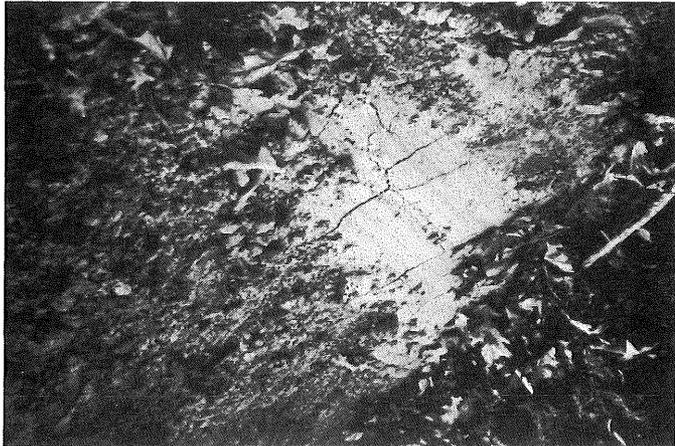


Fig. 11. Striations in the clay of the slide's slip face. Direction of block motion was toward the lower right-hand corner of the photograph.

Other Slope Failures Associated with the September 26, 1990, Earthquake

Three other slope failures have been linked to the September 26, 1990 earthquake. The first of these is located approximately $\frac{1}{4}$ mile SSW of the Lomax landslide on the property of Mr. Keith Koepp. Mr. Koepp is a trained geologist, a graduate of Southeast Missouri State University. According to Koepp, he visited the location on September 25 and the slope was intact. Koepp revisited the site on or about September 28, and at that time discovered the landslide. The location has the same soil type and stratigraphy as does the Lomax site, with the same distinctive clay lens comprising the slide's base. Upon personal inspection of the landslide, it appeared to be a translational block slide with evidence of liquefaction present at the slide's toe. This site is in a wooded area, away from any buildings, roads or dwellings, so that no property damage resulted. The site has no septic field or pond to contribute to soil moisture.

The second slope failure occurred near Oran, MO, approximately 4 miles from both the Lomax site and the epicenter. The site is located on a west-facing slope of the Benton Hills and has the same stratigraphy and soil conditions as the Lomax and Koepp slump areas. A similar order of events occurred as with the Lomax slide. Following the September 26 quake, the property owner, Mr. Holmes, discovered fissures and new uneven places in his yard when he mowed the lawn. Approximately 10 days after the failure of the Lomax hillside, the Holmes property also suffered a failure (sometime between April 7 and 9, 1991). The slump was characterized as a rotational block slide, just as at the Lomax site. The Holmes house, a wooden frame structure with brick facing and full basement, was significantly damaged by this slump and, as at the Lomax property, the septic field was exposed.

The third slope failure occurred 67 miles to the southwest within the city limits of Piggott, Arkansas, far removed from the earthquake's epicenter. Piggott is situated on the eastern slope of Crowley's Ridge. The stratigraphy and soil conditions are similar to the areas of the Lomax, Koepp, and Holmes landslides. At Piggott, the slope failure (an earth flow) was concurrent with the seismic ground motion of the September 26 quake. The slope failure damaged three houses, two severely (Stewart, 1991).

Damage not Related to Landslides

The September 26 quake is credited with widespread damage not related to slope failures. In Pocahontas, Arkansas, 101 miles from the epicenter, a house with a half-basement suffered a cracked foundation on the day of the event. No signs of slope failure were visible in the ground surrounding the home, but the damage was fresh and of the type that a torsional mode imposed upon such a structure could produce (Stewart, 1991). Pocahontas is situated on a slope where the Ozark Uplands meet the Western Lowlands portion of the Mississippi Embayment. The soil parent material is loess over a residuum of red clay overlying dolomite.

Scattered incidents of damage from this earthquake were inspected by Stewart (1991) as far as Desoto and Grand Tower, Illinois, 50 miles to the north. There basements were cracked and one water well was rendered unusable immediately following the quake.

There were instances of differential settling producing cracked foundations, floors, and brick walls in the sandy, water-saturated alluvium near Lake City, Marmaduke, Halliday, and Reyno, Arkansas (75-100 miles epicentral distances), as well as in Advance, Missouri (20 miles epicentral distance). Considering the soil and water-table conditions of these last five locations, partial liquefaction may have been a factor. There were also numerous cases of damage within 25 miles of the epicenter in the regions of Cape Girardeau and Sikeston, Missouri (Stewart, 1991).

No complete survey of dollar losses in property damages has been done for this earthquake. However, the authors conducted an incomplete sampling of public officials and insurance agents in the region which yielded an estimate in excess of \$500,000.

Summary and Conclusions

The slope failure on the Lomax property occurred six months after the September 26, 1990 earthquake. Nevertheless, the authors conclude that this seismic event was a main contributive factor for the landslide. What is the basis for this conclusion? While soil moisture was a definite contributing factor to slope failure, a triggering mechanism was still necessary. If soil moisture were the only factor involved, the slope could very well have failed long ago. The reasoning for this is as follows:

- 1) The septic field had been in place on the Lomax property for more than 15 years without slope failure.
- 2) High amounts of precipitation are not uncommon for the region, but rarely cause landslides. For example, excessive rains in December, 1982, and May, 1986, caused widespread flooding in the area, but no landslides were reported.
- 3) The nearby Koepp landslide had neither a septic system nor pond to contribute additional soil moisture.
- 4) Fissuring immediately following the earthquake of September 26, 1990 was the first event in a sequence culminating in slope failures six months later at two separate locations (Lomax and Holmes) within four miles of the epicenter.
- 5) The original slope height and slope angle of the hillside were consistent with those indicated by Jibson and Keefer (1984 & 1988) to be specifically susceptible to seismically-induced slope failure.
- 6) And finally, the Benton Hills show widespread evidence of slumping of a probable seismic origin in the recent geologic past (last 200 years). In particular, rounded, lobate slopes (see Fig. 9) are adjacent to and within sight of the Lomax property (Field observations of Stewart and Knox, 1990-92).

While we conclude that the earthquake of September 26, 1990, was the initiating event in the Lomax landslide, the timing of the actual slump movement six months later was probably determined by the timing of the subsequent precipitation. If this had been an area of little or no rainfall, the seismically-fissured slopes suffering delayed failures (Lomax and Holmes) may have remained unmoved for a much longer period of time. Therefore, at the time of

their occurrences, the proximate cause of the Lomax and Holmes slumps would have been the increased gravitational loading in response to gradually increasing weight from infiltrated precipitation.

Implications and Recommendations

Light earthquakes in the range of m_b 4.5-4.9 can and do cause slope failures and other serious damage in and around the New Madrid Seismic Zone. The seismologic and engineering literature report numerous instances of slope failures, liquefaction, and other damaging effects from earthquakes of greater than m_b 5.2 in seismic zones around the world. However, little is reported for light earthquakes in the range of m_b 4.0-4.9.

For example, Lemos and Coelho (1991) recently studied slope failures in California, Japan, Italy, and Central America, but cited no cases of damage initiated by earthquakes of less than m_b 5.4, reflecting the tendency to think that light to moderate earthquakes do not pose significant hazards. We believe that this is not because such damages are non-existent or because they are unique to the New Madrid Fault Zone, but because research seismologists and engineers tend to spend their investigative efforts on larger events which find many outlets for publication.

While the hazards demonstrated by the New Hamburg earthquake of September 26, 1990, did not blanket a whole region, they were scattered up to a 100 mile radius and did cause phenomena (viz. landslides) not usually associated with such small events. This suggests that insurance companies and property owners who may formerly have thought that earthquakes less than m_b 5.0 were not a major risk need to rethink the whole issue. While only one home or building in several thousand may be severely damaged by such small events, to the owner and the insurance carrier on that specific property, the financial impact can be quite significant.

In the cases of the Lomax (Benton, MO) and Holmes landslides (Oran, MO), the two houses severely damaged by the slope failure in Piggott, Arkansas, and the one home in Pocahtonas, Arkansas, all had earthquake insurance. In all of these cases, claims were filed and paid by their respective carriers. Insurance settlements for these properties ranged from \$8,000 to \$40,000 each and totaled more than \$150,000 (Stewart, 1991). No property owner would consider these losses as trivial, even if seismologists did classify the earthquake as "light."

The prospect of significant damage from small to moderate earthquakes merits further study. There is a practical need to document, describe, and publish these cases in technical journals. The data of this article are limited to the New Madrid Seismic Zone and the surrounding region. Perhaps the observations here are unique. Perhaps they are not. Damage and significant slope failures from small earthquakes may have escaped documentation in other parts of the world as well.

Acknowledgements

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original determination of the stratigraphy and lithology of the study area and in documentation of the sites. Phylis Steckel provided help in field documentation of the peripheral damage from the New Hamburg earthquake, particularly in Arkansas. Original illustrations were drawn by Glenn Young. And, finally, we thank Ray Knox, Ellen Dillon, and Ed Williams who lent editorial support and focus to the preparation of this paper.

Bibliography

- Festervand, D. F., 1981. *Soil Survey of Cape Girardeau, Mississippi, and Scott Counties, Missouri*. United States Department of Agriculture, Soil Conservation Service.
- Jibson, R. and Keefer, D., 1984. "Earthquake - Induced Landslide Potential for the Central Mississippi Valley, Tennessee and Kentucky," in *Proceedings of the Symposium on "The New Madrid Seismic Zone,"* P. Gori and W. Hays ed., pp 35-391.
- Jibson, R., and Keefer, D., 1988, *Landslides Triggered by Earthquakes in the Central Mississippi Valley, Tennessee and Kentucky*. U.S. Geol. Survey, Denver, Professional Paper 1336-C, 24 pp., with maps.
- Jibson, R., 1991. *Static and Dynamic Analysis of Landslides in the New Madrid Seismic Zone*, Abstract, Seismological Research Letters, Vol. 62, Nos. 3-4, July-Dec, p. 174.
- Knox, B. R., 1991. Personal Communication, Professor of Geoscience, Southeast Missouri State University, Cape Girardeau, MO.
- Koenig, J. W., 1961. "Tertiary Systems," in *The Stratigraphic Succession in Missouri, Vol. XL, 2nd Series* (Howe, W. B., coordinator; Koenig, J. W., editor; Beveridge, T. R., State Geologist). Missouri Geological Survey and Water Resources, Rolla, MO. pp. 126-130.
- Lemos, L. J., and Coelho, P. A., 1991. "Displacements of Slopes Under Earthquake Loading," in *Proceedings: Second International Conference on Geotechnical Earthquake Engineering*, Vol. 2, p. 1051-1056.
- McFarland, J. D., 1991. *Landslide Features of the Arkansas Portion of Crowley's Ridge*, Abstract, Seismological Research Letters, Vol. 62, Nos. 3-4, July-Dec, p. 178.
- Nuttli, O., 1987. *Effects of Earthquakes in the Central United States*, (1990 edition), Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, MO. 50 pp.
- Stewart, D., 1991. *Reconnaissance Damage Report for New Hamburg Earthquake, September 26, 1990*. Insurance report used in settling several claims. 12 pp.
- Stewart, D., and Knox, R., 1991. *Field Trip Guide to Representative Earthquake Features in the New Madrid Seismic Zone*, Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, MO. 56 pp.
- United States Geological Survey, 1990. *Preliminary Determination of Epicenters, September 1990*, National Earthquake Information Center, Denver, CO. p. 7.
- United States Geological Survey, 1991. *Preliminary Determination of Epicenters, May 1991*, National Earthquake Information Center, Denver, CO. p. 3.

Missouri Academy of Science 1992 Annual Meeting

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UNIVERSITY OF MISSOURI-ROLLA

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McNutt Hall

Senior Division

Agriculture and Entomology

Calabrese, D. M., PAPILLONS: diversified endeavors. *THE LONG-LEGGED FLY WAS A WATERSTRIDER* (HEMiptera: Heteroptera: Gerridae). William Butler Yeats (1865-1939) collected insects, immersed himself in the pools at Howth, and admired Alfred Russel Wallace (1823-1913). The entomologist and naturalist in Yeats gave way to the poet. But Yeats' poems often rely on metaphors that only a keen observer of insects could spin. This piece of original research introduces the insects in the works of Yeats. (It also reveals how A. R. Wallace perceived poets.) The report is derived from the author's larger study of the parallels in the lives of Yeats and Wallace.

Carrel, J. E., Division of Biological Sciences, University of Missouri-Columbia. WHO'S EATING WHOM?: MY SECRET LIFE AS A DIET DETECTIVE. As a scientist interested in chemical defensive mechanisms, I often pause to switch my perspective from the prey's to the predator's. In so doing, I focus on the dietary habits of various arthropods such as insects and spiders. What do these small animals eat in the field? How can one quantify the diet of wild invertebrates? Initially I use observational methods, recording the feeding habits of a species, but such records are relatively uncontrolled, qualitative, and limited to animals that are visible above ground. For instance, I examine the remains of prey in the webs and burrows of spiders, but these data are suspect because scavengers may surreptitiously carry away carcasses before they are seen by me. So I design laboratory feeding trials to try to complement my field observations. A more generalized method is the analysis of gut contents in freshly caught animals. For example, our microscopic examination of midgut fluid from rare blister beetles caught in light traps revealed much pine pollen and little else, indicating that they feed almost exclusively on staminate pine cones (1990. *Environ. Entomol.* 19: 1283-1288). Molecular biological tests of gut fluid, such as ELISA and PCR, although costly, can also be used to determine dietary habits of most animals.

Emery, K. M. and English, J. T., Department of Plant Pathology, University of Missouri-Columbia. THE INFLUENCE OF POTASSIUM FERTILITY ON THE DEVELOPMENT OF ALFALFA FOLIAR DISEASES. Multiple harvests of alfalfa (*Medicago sativa*) hay remove up to 500 kg of potassium (K) per hectare of soil per year. To maintain alfalfa production K must be added to the soil; however, little is known about the relationship of K fertility to foliar alfalfa diseases. To determine if the form of K fertilizer used has an effect on the development of fungal leaf spot complexes, five fertilizer treatments were established in a two-year-old alfalfa stand. Replicate treatments of K in combination with Mg and S, and an untreated control were established in a randomized complete block design, and sample shoots were harvested weekly through three, four-week cutting cycles. Harvested shoots were assessed for foliar disease and plant growth information. The 1991 growing season was relatively warm and dry, and consequently, disease levels were low; a maximum of 4.5% of leaf area was diseased in any of the fertility treatments. Preliminary analyses indicated no consistent significant relationships of plant growth or disease development to fertility treatment. Analyses of the patterns of disease increase over time in relation to leaf position within the plant canopy are underway.

Feir, D. and Gelsthorpe, M., Department of Biology, St. Louis University. INCIDENCE OF ANTIBODIES TO *BORRELIA BURGDORFERI* (LYME DISEASE PATHOGEN) IN DOGS IN ST. LOUIS AREA. Many investigators think that dogs might be sentinel animals for the significance of Lyme disease in an area. Although some dogs do exhibit symptoms of Lyme disease, many more have antibodies to the pathogen without exhibiting any symptoms. Frozen dog sera were obtained from local veterinarians. Indirect fluorescent antibody assays were done but were found to be useless because of the cross-reaction with leptospire. All the dogs had leptospirosis vaccinations. An ELISA was developed using alkaline phosphatase as the enzyme. The intensity of the color developed by the enzyme's action on the appropriate substrate was read on a Sigma EIA reader. Positive controls were sera from laboratory-infected dogs. The results of the ELISA test were compared to a commercially available canine Lyme disease diagnostic kit. The incidence of positive dog sera will be discussed in relation to techniques used, Lyme disease incidence in humans in the area, and dog vaccinations.

Gharibgard, M. and Moore, T. M., Department of Agriculture, Central Missouri State University. AN EXPERIMENTAL STUDY ON THE USE OF ROOTING HORMONES ON THE STEM-CUTTING OF *HYPOESTES SANGUINOLENTA* (PINK SPLASH PLANT). The study was conducted to identify the most effective hormones in promoting rooting on the stem-cuttings of *H. sanguinolenta*. Cuttings were treated with 0.2% naphthaleneacetic acid with 4% Thiram (0.2% NAA with fungicide), 0.3% indolebutyric acid with 4% Captan (0.3% IBA with fungicide), 0.3% IBA, 0.3% IBA-NAA (soluble), and 0.15% IBA-NAA (soluble). Samples were placed under a mist system in a RCB design with 6 treatments and 5 replications. After one week, the total length, mean length, number, and dry weight of roots per cut were measured. Data were analyzed by a two-way analysis of variance, and LSD was used for mean separation. All treated groups significantly ($p < .05$) generated more roots than the control group. Soluble groups, specially 0.15% IBA-NAA, had a better effect on promoting root than non-soluble groups. There were no significant differences among the non-soluble hormones.

Glendenning, J. D. and Allen, D. E., Jr., Department of Agriculture, Central Missouri State University. A COMPARATIVE ANALYSIS ON PALATABILITY AND ACCEPTABILITY OF LEAN AND MARBLED BEEF. The general objectives were to determine (1) what portion of the population prefer lean or marbled meat in the display

case, (2) what portion would select a lean or marbled meat as a cooked product, (3) what impact the above experience would have on the consumers' buying behavior, and (4) what price the consumer would be willing to pay for the product selected. One-hundred and forty-eight surveys were collected in three different areas. Of the 148 participants, 76 preferred marbled steak and 72 lean steak as an uncooked product. However, in the taste test, 115 preferred the marbled steak and only 33 the lean steak. Therefore, 77.7% of the population preferred a marbled strip steak in the taste test. The information was then broken down into those who selected lean as the precooked choice and marbled as the cooked steak and those who selected marbled as a precooked choice and lean as a cooked steak. Of the 24 participants that did not presently purchase marbled meat, 16 said there was >50% chance that they would switch to the product and 8 said there was a 100% probability, 19 said there was no chance they would switch to pork or chicken, and 8 reported a 6 to 50% probability. In response to not switching at all, 13 would not and 14 reported some probability to switch. Ages 36-45 and 66 up and the income range of \$20,000 to 29,000 preferred the marbled meat more often. Of the 6 participants that currently did not buy lean steak, most showed some degree of probability that they would switch to the lean steak, a 0% chance that they would switch to pork or chicken, and 66.7 responded no change from marbled. Participants over 56 and lower income participants selected the lean product more often. The survey results show that although people are told to select a lean product out of the meat case, the consumer actually prefers a marbled product for taste and juiciness.

Xie, C., Hooper, J., and Feir, D., Department of Biology, St. Louis University. CHARACTERISTICS OF *BORRELIA BURGENDORFERI* IN CULTURE. *Borrelia burgdorferi* is the pathogen causing Lyme disease. It can be cultured in liquid media and this study was undertaken to describe the appearance and activity of the bacteria under different experimental conditions. Three temperatures were used: 15C, 25C, and 35C. Some cultures were maintained at these temperatures throughout the experiment. Other cultures were moved from one temperature to the other at 2 week intervals and other cultures were moved at 4 week intervals. These changes in temperature simulate to some extent the life history of the spirochetes in humans and in ticks. Subcultures were made as necessary and the effects of subculturing were also recorded. It is known that the spirochetes lose their infectivity after approximately 10 transfers or subcultures. Each new subculture was examined with darkfield microscopy 48 hours after it was made and then 1-2 times a week for the duration of the experiment.

McSparren, T. A. and Karscig, M., Department of Agriculture, Central Missouri State University. FORECASTING FEEDER CATTLE PRICES USING ARIMA MODELS. It was the objective of this study to test time series modelling to find if this manner of prediction could be an accurate method of prediction of feeder cattle cash prices one year in the future. The data used to build the model was monthly cash prices of 400-500 pound feeder cattle at the Kansas City Stock Yards from January, 1960 to April, 1991. MINITAB's ARIMA program was used to process the data. After differencing, a moving average model with the specifications of $0\ 1\ 2\ s = 12$ was found to be the best fit for the data. Some disappointment was experienced in that the chi-square value was not significant at the .05 level of confidence. The model was tested using out-of-sample forecast for May of 1990 to April of 1991. It was observed that the forecast price was quite accurate during times when the actual price was moving between peaks and valleys, but fell short in accuracy at times of price peaks and valleys. The results of this study show that the prices of feeder cattle can be predicted one year in advance reasonably well but only during certain times when prices are cycling toward extreme limits.

Roberts, J. S. and Allen, D. E., Department of Agriculture, Central Missouri State University. EVALUATION OF WEAN-STRESSED STEERS AND HEIFERS ON THREE COMMERCIAL STARTER RATIONS. Research supports the view that weaning and subsequent diet change to a supplemental ration is a stressful time in the life of cattle with the situation being worsened by the additional stress of winter and the exposure to pathogens typically encountered at public auctions. This study was conducted to evaluate three commercially-prepared rations for the rate of gain on wean-stressed steers and heifers. On December 17, 1991, twenty-eight steers and heifers were purchased at a local auction and transported to the Central Missouri State Agricultural Research Center where the study was conducted. The animals were divided into three groups on the basis of sex and size. Each group was given 11.1 pounds of the respective ration per head per day, with free choice fescue hay. After thirty days the animals were weighed individually and the subsequent data retrieved were evaluated via Analysis of Variance. Average daily gain ranged from 2.05 pounds to 1.67 pounds for the groups. Gains from individual animals ranged from 2.67 to 1.00 pounds per head per day, with the highest and lowest scores coming from a single group. These inconsistencies were partially responsible for no statistically significant variation ($p = 0.1838$) in the average daily gain of these animals subjected to the various rations.

Walk, T. C. and Niblack, T. L., Department of Plant Pathology, University of Missouri, Columbia. FACTORS AFFECTING *HETERODERA GLYCINES* EMERGENCE FROM EGGS. Several factors have been tested for their effects on the emergence from eggs of second-stage juveniles (J2) of the soybean cyst nematode (SCN), *Heterodera glycines*. Eggs mechanically freed from cysts were exposed to a variety of treatments for 12-14 d and emerged J2 were counted as a measure of hatching. Stimulation or inhibition was determined by comparison with emergence in water. Surface disinfection of eggs by pretreatment in 0.5% chlorhexidine for fifteen minutes did not significantly affect later emergence in either water or 15 mM ZnSO₄. Storage of cysts in moist sand for 5 months at 3-6°C and pretreatment of the extracted eggs in water at 28°C for seven days greatly reduced stimulation of emergence by 15 mM ZnSO₄ compared with emergence from eggs freshly extracted from mature females. Root exudates collected from Williams 82, Fayette and P190763 soybeans (*Glycine max*) grown in the greenhouse for 42 days all stimulated emergence. Root exudates were collected from Williams 82 soybean and Stacey wheat (*Triticum aestivum*) grown for 23 days, stored for 4 days at 3-6°C, and diluted 1:10; both treatments stimulated

emergence. After storage for 42 days, only Williams 82 exudates stimulated emergence, but at a reduced level. Half-strength Hoagland's solution diluted 1:10 inhibited emergence. Solutions collected from 2, 3 or 4 week old Williams 82 soybean or kidney bean (*Phaseolus vulgaris*) grown in half-strength Hoagland's solution and diluted 1:10 stimulated emergence, while those from Stacey wheat inhibited emergence. Populations of eggs sorted by flow cytometry varied in morphological development and rates of emergence. Populations of SCN eggs are heterogenous in development and emergence is sensitive to a number of treatments. This research was supported by USDA CSRS Grant No. 90-34113-4271.

Wilson, M. A., Aide, M. T., and Khan, V. A., Department of Agriculture, Southeast Missouri State University and George Washington Carver Agricultural Experiment Station, Tuskegee University. INFLUENCE OF CROP COVERS ON YIELD OF POTATOES. Field studies were evaluated with four row covers on potatoes at Blodgett and Diehlstadt, Missouri, on 2 sandy, well-drained entisols. Row covers used were spunbonded polyester, VisPore, insolar and clear slitted. The mean plant heights were significantly different among treatments for the cultivar 'Norchip' but not for 'Atlantic'. Data revealed average and total plant heights were significantly different between the bare soil control and row covers. The grade A marketable weights and total number of 'Norchip' and 'Atlantic' potatoes had a significant contrast at the 0.01 of probability level with cultivars.

Yen, Jyh-herng and Niblack, Terry L., Department of Plant Pathology, University of Missouri-Columbia. OVERWINTER SURVIVAL AND HATCHING OF *Heterodera glycines* IN MISSOURI. Dormancy in the soybean cyst nematode (SCN), *Heterodera glycines*, is a possible mechanism for overwinter survival. Studies were conducted to determine the effect of soybean phenology on the induction of dormancy in *H. glycines*. Four soybean isolines differing for maturity were inoculated with initial population (Pi) of SCN densities in field microplots. Soil samples were collected from each microplot at monthly intervals and processed by elutriation and centrifugal flotation. The effect of treatment (isoline \times Pi) on SCN hatching rate was determined by immersing 1000 eggs in glass distilled water at 27°C for 14 days, and counting the number of hatched juveniles. Ineffectivity was studied in a greenhouse bioassay. Susceptible soybean seedlings were planted in sand infested with 1000 SCN eggs/100 cm³ and maintained in the greenhouse at 28°C. Plants were removed after 5 days, the nematodes within root were stained with acid fuchsin and counted, and root length was determined by a line intersect method. The number of females per root, eggs per root, and eggs per female, and fresh and dry shoot and root weights were determined after 4 weeks. The hatch rate of the "high" and "med-high" Pi both decreased from July to September. There were significant differences in hatching rate among four soybean isolines at the "high" Pi from July to September, but differences were not consistent for the "med-high" Pi. The SCN hatch rate was greater on the latest maturing soybean isolate than on the earliest maturing isolate. There were no differences in the infectivity of juveniles produced in the "high" and "med-high" Pi. The number of juveniles per cm root from the "high" Pi increased from July to September, and there were significant differences among the four isolines ($P < 0.05$) from the "med-high" Pi. The numbers of SCN cysts and eggs did not differ by Pi in July and August, but did differ significantly in September ($P = 0.04$ for cysts and $P = 0.02$ for eggs). The number of SCN cysts from the "high" Pi decreased on all but one isolate, as did the number of SCN eggs. Numbers of cysts and eggs were inconsistent for "med-high" Pi. The numbers of SCN eggs per cyst did not differ for the two Pi. Studies are continuing through the winter. This research was supported by the Missouri Soybean Merchandising Council, Research Agreement No. 078.

Atmospheric Sciences

Zacher, C. A., Atmospheric Electrical Research Organization. OBSERVATIONS OF BRIGHT-COLORED LIGHTNING CHANNELS CORRELATED WITH PLASMA MODEL EXPERIMENTS. Earlier work analyzing spectral characteristics from photographs and showing vivid coloring in both the branched ends of in-cloud lightning concluded that variations in time parameters and/or current strength variations accounted for these bright blue images. Visual observations have been made confirming brilliantly-colored flashes to ground are rare, but they do exist. They are likely to be based on conditions of pre-existent ground streamer under the cloud base and are due to the evaporation and ionization of metallic elements in grounded terminals. The vaporized metal plasma appears to be physically transported upward, entering into the arc core. Now, laboratory experiments with a color-differentiating plasma generator has produced arc channels containing variable length segments of different colors within the same channel and proceeding from both electrodes simultaneously. They meet somewhere between the two poles. This is a visualization technique which supports the structural, temporal, and polarity implications of vividly colored natural lightning.

Biology

Castaner, David, Biology Department, Central Missouri State University. A WOODED BOTTOMLAND COMMUNITY IN THE LITTLE BEAN MARSH WILDLIFE AREA. Previous studies had indicated flooding was a strong factor in marsh community structure in the Wildlife Area. A wet-mesic bottomland community in the Little Bean Marsh Wildlife Area near the marsh was surveyed to ascertain its structure. Tree species in plots along a transect line were recorded. The relative frequency, density, dominance, and their sum, the importance value, were determined for each species over 1cm in diameter. The percentage of ground covered was visually estimated

for each non-tree species. Rough-leaved Dogwood, Redbud, and Pawpaw had the highest importance values of 47.9, 40.6, and 29.4 respectively. Ground cover was sparse with only eleven species present. The make-up of the woody trees and the sparseness of the ground cover are attributed to periodic flooding and/or recent human activities. Supported in part by a Grant from the Missouri Department of Conservation.

Belshe, J. F. and Loman, M. A., Department of Biology, Central Missouri State University. THE EFFECT OF SEROTONIN ON DOMINANCE ORDER IN *ORCONECTES VIRILIS*: PRELIMINARY FINDINGS. The primary objective of this study was to determine if male crayfish could increase their position in a dominance hierarchy after administration of serotonin. Video recordings and direct observations were used to determine the dominance hierarchy of 10 male *O. virilis*. The crayfish were weighed to the nearest tenth of a gram and the length of their carapace was determined to the nearest millimeter. The behavioral, mass, and length hierarchies were found identical. The even numbered crayfish of the hierarchy were injected, intracoelomically, with 0.22 ml to 0.26 ml of 1.4×10^{-9} M serotonin depending on the weight of the crayfish. This dosage range had been determined to be sufficient for excitation without bringing about rigidity of the animal. The injected animals were immediately paired with the next larger conspecific and behaviors were recorded. Two of the five animals tested succeeded in moving up the hierarchy. The behavioral data related to the experiments will be discussed.

Ma, Y., Zhang, R. and Cooper, C. L., Division of Science, Northeast Missouri State University. INDIRECT PHOTOMETRIC DETECTION OF BIOLOGICAL POLYAMINES SEPARATED BY HIGH PERFORMANCE CAPILLARY ELECTROPHORESIS. Putrescine, spermidine and spermine are polyamines which are essential for cell viability and have been linked to tumorigenesis. Although many studies have been conducted on the biology of polyamines, the methods for separation are confined to HPLC and thin layer chromatography. Detection methods often require tedious derivatization or labelling. A rapid separation of polyamines and some related amino acids from cultured tumor cells by high performance capillary zone electrophoresis (HPCZE) with indirect photometric detection is demonstrated. A $75 \mu\text{m}$ (I.D.) \times 60 cm fused silica capillary was used for the separation, and quinine sulfate was used as a background electrolyte (BGE). Three polyamines (putrescine, spermidine and spermine), several amino acids (lysine, arginine, histidine) and simple cations (K^+ , Na^+) were easily separated in less than 10 minutes. Using the indirect photometric detection method, femtomoles of polyamines in PC12 tumor cells were detected from an 87 nl injection volume, and the signal response was linear over two orders of magnitude.

Jones, R. L. and Janssen, G. R., Mathematics and Science Division, Cottey College and Department of Biology, Indiana University. START CODON SELECTION ON A LEADERLESS MESSAGE OF THE PROKARYOTE *STREPTOMYCES FRADIAE*. The *S. fradiae* APH protein is translated from a messenger RNA (mRNA) lacking an upstream untranslated leader. Mutational studies were performed to elucidate start codon selection on this mRNA lacking a Shine-Dalgarno sequence. Translational efficiencies of mutant and wild type *aph* mRNAs were calculated by comparing APH enzyme units/mg total protein in cell-free extracts to concentrations of *aph* mRNA as determined by Northern dot blot hybridization. The leaders 5'-AU-3' and 5'-AUAU-3' reduced translational efficiency 2- to 3-fold and 6- to 7-fold, respectively, relative to wild type. The leader 5'-AUGC-3' resulted in no detectable APH activity while the leaders 5'-AUAUGC-3' and 5'-CAUAUGC-3' restored translation of the *aph* coding sequence. An upstream, out-of-frame AUG therefore apparently prevents translation of the *aph* coding region; but additional nucleotides 5' to the upstream AUG rescue translation of the *aph* coding region AUG, possibly by reducing the translational efficiency of the upstream AUG. Supported by BRSG Grant RR7031-25.

VanTol, E. and Mills, S. H., Department of Biology, Central Missouri State University. TEMPERATURE REGULATORY RESPONSES IN A HIBERNATOR (*SPERMOPHILUS TRIDECIMLINEATUS*) BEFORE AND AFTER HIBERNATION. Nine ground squirrels were stimulated by a series of temperature changes before and after hibernation. The animals' responses in body core, anterior skin, and posterior skin temperatures were monitored as they were exposed to 20 minute sequential intervals of 25, 20, 15, 10C ambient temperatures. Body core temperature differed significantly from before hibernation to after hibernation using analysis of covariance with state as the covariant ($p < 0.05$). Body core temperatures differed significantly over the time as ambient temperature was changed after 20 minutes of exposure to each temperature ($p < 0.05$). The skin temperatures differed significantly between the anterior and posterior skin surface temperatures as they were compared before and after hibernation ($p < 0.05$). Behavior was also monitored during the experiments. Behavior and posture also varied over the different temperature exposures as the animals were compared before and after hibernation ($p < 0.05$).

Klocke, B. J., Tannenbaum, M. G., and Ellis, L. S., Science Division, Northeast Missouri State University. AGGREGATION AND LOWERING OF BODY TEMPERATURE AS OVERWINTERING STRATEGIES IN THE SOUTHERN FLYING SQUIRREL, *GLAUCOMYS VOLANS*. Lowering of body temperature in solitary flying squirrels may be an alternative strategy to aggregating behavior. Both strategies allow for a conservation of energy, yet may increase predation risks. Under simulated winter conditions of 5°C and a 10:14 LD photoperiod, nest and body temperatures of eight flying squirrels were measured while they were nesting solitary and while they were nesting in an aggregate of four. Squirrels were surgically implanted with a transmitter for measuring body temperature and given abundant food and water throughout the experiment. Each squirrel spent 19 days in each treatment (solitary and aggregate). Nest temperatures of aggregating squirrels ranged from 0.7 to 6.1°C warmer. Both treatments resulted in a similar daily fluctuation in body temperature. In hourly comparisons of body temperature between treatments, 47 of 168 were significantly different ($p < 0.05$). The solitary body temperatures were higher in 42 of the 47 comparisons. Under these conditions, lowering of body temperature for a solitary squirrel was not an alternative to aggregation for winter survival.

Bio-Medical

Huang, Ed Tzee-Chang and Corrigan, G. E., St. Louis Veterans Administration Medical Center. CURRENT MEDICAL PARASITOLOGY PROBLEMS IN MISSOURI VETERANS. A review is presented of the major diagnostic problems presented for analysis in a large Veterans medical laboratory. Blood-born leishmaniasis in the returning Desert Storm/Shield veterans presents a problem in blood transfusion. False positive diagnoses of *Entamoeba histolytica* in this same group is problematical. The delayed effects or re-emergence of round worm infestations of the small and large intestine WW2 veterans of the Pacific theatre is timely. The parasite, *Pneumocystis carinii*, has become an indicator of the presence of acquired immune deficiency syndrome. Current analytical methods are described for these and other major problems.

Pierce, J. T., Department of Safety Science and Technology, Central Missouri State University. INNOVATIVE APPROACHES IN DERMAL ABSORPTION MEASUREMENTS. Occupational dermatitis represents a major occupational health problem, but an issue of potentially greater importance is the issue of systemic injury attending dermal absorption. Obviously, these phenomena are interrelated, since damaged skin allows more rapid penetration. Several databases have either been developed or are currently being developed that may prove potentially useful. These databases are dependent upon the quality of data available for inclusion. Databases suffer from the features of rigidity associated with the physicochemical constants used or other factors. Ultimately, we would like to address this problem in a satisfactory manner, being able to at least categorize substances as being of major, intermediate, or minor concern. Investigators are still developing methods for the systematic classification of major use industrial substances into basic categories of rapid, intermediate, or slow penetrants. Comparisons at present among methodologies tend to be tedious: One possible solution to this problem is the use of models. The computer modelling program Stella facilitates modeled flows through heterogeneous tissues by allowing different regions or anatomical structures to be connected in a pattern matching the system's morphology. Time-dependent and steady state models are both possible; nonlinearity does not appear to create special problems.

Rutledge, P. C. and Hollenberg, D., Department of Social & Behavioral Sciences, Lincoln University. ACT TEST PERFORMANCE AS A SUBJECT-SPECIFIC MEDIATING VARIABLE IN THE REBOUND OF SUPPRESSED THOUGHT. Wegner et al. (1987) found that attempting to suppress thoughts of a white bear leads to increased preoccupation with that thought—a "rebound" effect. In two experiments conducted in our laboratory, we have been unable to replicate this effect. Our difficulty in replicating this rebound effect may be related to differences in our and Wegner's subject pools. Our subjects were students at an open-admissions institution which imposes no ACT score requirements, while subjects in Wegner's study were students at a more selective institution. The present study, therefore, examined the relationship between ACT test performance and the existence of the rebound phenomenon. Eighty-four subjects were instructed to: 1) express thoughts of a white bear; 2) suppress thoughts of the bear; and then 3) express thoughts of the bear for another expression period. The number of thought tokens generated about the white bear was recorded for each of the three periods. Sixteen subjects were classified as rebounders (rebounders experienced at least a 50% increase in thought tokens during the second expression period relative to the baseline period) and 68 subjects were classified as non-rebounders. It was found that ACT Math scores were significantly higher for the rebounders than for the non-rebounders ($p < .05$). This indicates that the rebound phenomenon may be mediated by other variables such as ACT test performance. Supported by NIH/NIGMS/MBRS 08202.

Computer Science

Duben, A. J., Computer Science Department, Southeast Missouri State University, SCIENTIFIC COMPUTING IN RUSSIA AND EASTERN EUROPE. This report will describe the current state of scientific computing in the former COMECON countries (Eastern Europe and the republics of the former Soviet Union). Strengths and weaknesses will be discussed, with emphasis on hardware resources, software technology, capabilities of personnel, and the cultural and economic environment of the workplace.

Naugler, David R. and Wallgren, Tom, Department of Computer Science, Southeast Missouri State University. MODULA-2 AS A CORE LANGUAGE. Most Computer Science curricula use a core language in the first few major courses. This first language influences the students' programming even in other languages. Among Computer Science departments changing the language of instruction in their initial courses most are changing either to Modula-2 or Scheme. The choice of an appropriate core language involves many factors. At Southeast Missouri State University most of our Computer Science graduates work in a business environment and few go on to graduate school. The Computer Science department recently switched from PL/I to Modula-2 as a core language. The Modula-2 language and our recent switch to it is discussed.

Sanderson, D. P., Department of Computer Science, Southwest Missouri State University. A DESIGN METHODOLOGY FOR ADAPTIVE USER INTERFACES. The key to improved human-computer interaction is the design of the user interface. This research explores the design of adaptive user interface software systems, that intelligently and dynamically adjust their behavior to suit the goals and expertise of individual users. A new design methodology for adaptive user interfaces has been developed. It applies to a general class of applications for which interaction can be modeled abstractly as a network of high-level states. The application of interest is simulation modeling using the HSL programming language. A task-oriented analysis of potential HSL users yielded an

abstract interface model describing sequences of high-level interactive activities in the form of a state transition graph. Task plans are defined as directed paths through the graph to represent activities conducive to achievement of specific goals. Each high-level state is surrounded by supportive contextual structures. The annotated graph is methodically transformed into a menu-based, adaptive user interface system. The methodology is demonstrated through the design and implementation of the N-CHIME interface system to support development of simulation models written in HSL. Supported in part by NCR Corporation.

Schmidt, B. F., Computer Science Department, Southwest Missouri State University. OBSERVATIONS ON COMPUTER SCIENCE EDUCATION IN CHINA. A number of observations will be reported on undergraduate education in computer science at a typical provincial university in the People's Republic of China. Curriculum, professional activities, facilities, and institutional support will be discussed. Comments will be made on the economic, cultural, and political infrastructure and its relationship with higher education in PRC. This information was gathered during a three-week visit to Shandong Teachers University in March and April of 1991. Funding was provided by the International Advisory Panel of the Chinese Provincial Universities Development Project.

Shade, E., Department of Computer Science, Southwest Missouri State University. IMPERATIVE PROGRAMMING WITH MULTIPLE-VALUED FUNCTIONS. Although modern imperative programming languages such as C++, Ada and Modula-3 are superior to their predecessors in many ways, they are still weak in their handling of multiple-valued functions. None of these languages support multiple-valued functions explicitly; they must be simulated by using procedures with multiple reference parameters. However, procedures with reference parameters are also frequently used just for their side effects, so program readability is compromised because the intended use of such a procedure is unclear. These deficiencies can be avoided by using explicit multiple-valued functions. Although the ability to return multiple values is present in some functional languages, notably Common Lisp, the formulation presented here is unique in that return values are named just like parameters, and results may be returned by reference as well as by value. In addition, formal parameters and global variables can appear in the formal result list, which provides a clean way to specify static pass-by-reference. The use of multiple-valued functions raises a number of issues, such as how multiple values are accessed and how multiple-valued functions behave when embedded in expressions. A syntax and operational semantics of multiple-valued functions will be provided that addresses these issues, together with some efficient implementation techniques. The ideas will be illustrated with a number of practical examples, including the specification of a general input/output library.

Conservation

Becknell, R. K.¹, Journet, A. R. P.², and Henson, M.³ ¹Department of Natural Resources, Festus, MO. ²Department of Biology, Southeast Missouri State University, Cape Girardeau, MO ³Department of Natural Resources, Meramec State Park, Sullivan, MO. ECOLOGICAL RESTORATION OF HARDWOOD FORESTS IN MISSOURI: CRITERIA AND PROGRESS. Missouri's Department of Natural Resources currently manages approximately 8000 acres of land that was historically forest but which has been cleared for agricultural purposes. The department has determined that the goal for restoration should be an approximation of forest conditions prior to European settlement. This is achieved first by consulting and verifying historical records. Then local topography, geological conditions, elevations, hydrology and soil characteristics are evaluated in relation to the requirements of the hardwood species suggested. Finally, seed collection and seeding are undertaken and progress is monitored. This paper reports on the status of these restoration attempts in Missouri's State Parks.

Boardman, J. L. and Ellis, L. S., Division of Science, Northeast Missouri State University. NEST SITE SELECTION BY SOUTHERN FLYING SQUIRRELS (*GLAUCOMYS VOLANS*) IN NORTHEASTERN MISSOURI. Nest site selection by southern flying squirrels (*Glaucomys volans*) as a function of microhabitat was studied in an oak-hickory forest in northeastern Missouri. Sites sampled were placed into three categories. Nest boxes installed on an established grid were categorized as either being a used box or an unused box. The third category, made up of natural cavities, was identified by radiotracking flying squirrels during the day. Twenty-one microhabitat variables were measured around ten randomly selected sites from each nest site category. Twelve of these variables described characteristics of the den tree and den cavity; nine were characteristics of the microhabitat surrounding the den tree. Comparisons among the three nest site categories indicated that flying squirrels preferred a lower amount of vegetation cover near the ground (<50cm) surrounding their nest sites ($p < 0.05$). Less ground cover surrounding a nest site may indicate a more complex canopy structure. Heterogeneity of the forest structure between Big Creek State Forest and other geographical areas may explain results that conflict among studies.

Hendershott, A. J., Whitehead, L., Journet, A. R. P., and Sadler, J., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. DISTRIBUTION AND VEGETATION RELATIONSHIPS OF *ECHINOCEREUS CHISOENSIS* IN BIG BEND NATIONAL PARK, TEXAS. Previous surveys on the density of *Echinocereus chisoensis*, the Chisos Pitaya, revealed such a low population density that the species was placed on the endangered species list. The only examples of the species were some 800 representatives located between elevations of 1900 ft. and 3000 ft. on the eastern and southeastern slopes of the Chisos Mountains. The objective of this study was to survey the area and map additional representatives of the species, and conduct a multivariate analysis of the vegetation associations of the species to identify habitat requirements and allow prediction of further possible sites where the cactus might be found. Approximately 100 additional specimens were found, but no vegetation relationships were revealed.

Gum, S., Hill, G., and Journet, A. R. P., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. THE DISTRIBUTION AND VEGETATION RELATIONSHIPS OF *CHAMAECYSE CHAETOCALYX* IN BOQUILLAS CANYON, BIG BEND NATIONAL PARK, TEXAS. *Chamaecyse chaetocalyx*, is a small woody perennial that occupies the rocky cliffs of the Rio Grande in Brewster County, Texas. Prior to this study, only 81 specimens of the species were documented to exist in Big Bend National Park; the status of the species is uncertain. The objective of this study was to locate and map representatives of the species at various elevations in a series of four transects on the cliff of Boquillas Canyon, on the U.S. border of the Rio Grande, and undertake a multi-variate analysis of the vegetation relationships of the species.

Larson, B. D., Journet, A. R. P., and Taylor, S. H., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. IS THE CYPRESS FOREST OF BIG OAK TREE STATE PARK A DOOMED COMMUNITY? Big Oak Tree State Park contains some of the few remaining acres of old bottomland and cypress swamp not only in the state, but in the entire region; among the trees present are included several state and national champions. As a result of many decades of human modifications to the area, soil moisture patterns have been considerably altered. This study was designed to explore the size structure among tree species in the cypress forest at Big Oak Tree State Park in order to assess the pattern in forest regeneration. The conclusion we draw from this analysis is that the cypress area has been invaded by several tree species requiring dryer soil conditions than is characteristic of cypress forest. This suggests that without significant intervention, the cypress stand is ultimately doomed to extinction.

Lehmann, J., Missouri Whitewater Association and **Tansil, J.** Southeast Missouri State University. PUBLIC AGENCY/PRIVATE ORGANIZATION INTERACTION FOR INSTALLATION OF RIVER GAUGE. The upper St. Francis River is the only true whitewater in Missouri and draws hundreds of paddlers and spectators from 7 states during its approximate 5 month season of sufficient rainfall runoff. The river experiences rapid fluctuation of water levels. Obtaining timely data on water levels, especially after heavy rain has been difficult for paddlers. In 1991, the Missouri Whitewater Association, an organization of recreational whitewater paddlers inquired about installation of a real-time, automated river level gauge on the St. Francis River. Excess government equipment, a telemark gauge (river level is described by a series of beeps) and modem was usage-donated and installed by the Army Corp of Engineers at their existing gauge house located at the MO Highway 72 bridge west of Fredericktown, MO. Significant problems were lack of precedent of public agency/private citizen interaction by the Army Corp of Engineers and U.S. Geological Survey and the costs for burial of an underground electrical line. Installation costs for the buried electric line were donated by the Missouri Department of Conservation in addition to the annual fees for phone and electric service. Gauge is now operative and available via ordinary phone line to those seeking St. Francis river level at that moment.

Schlater, A. L. and Messick, J. P., Department of Biology, Missouri Southern State College. THE DISTRIBUTION OF THE ARMADILLO IN MISSOURI. The nine-banded armadillo, *Dasypus novemcinctus*, is apparently expanding its range in the midwestern United States. The objectives of this study were to document the historical and present distribution of the armadillo in Missouri, and identify climatic and other factors which correlate with changes in distribution. We mailed questionnaires to 207 conservation officers and selected biologists throughout Missouri. Of the 162 (78%) questionnaires returned, 42% of the respondents reported sightings from 51 counties. The earliest reported sighting by this survey was in 1958, and 46% of the respondents believe that the armadillo is increasing in their area. We are examining weather records for changes which coincide with the apparent northward march of the armadillo, but results are incomplete.

Sneed, N., Higgins, S., and Journet, A. R. P., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. DISTRIBUTION AND VEGETATION RELATIONSHIPS OF *BRONGNIARTIA MINUTIFOLIA* IN BIG BEND NATIONAL PARK, TEXAS. *Brongniartia minutifolia* is a woody shrub that is associated with arroyos running from the desert plateau towards the Rio Grande in an area adjacent to the Old River Road, on the southern and southeastern slopes of the Chisos Mountains. Previous reports suggested that the distribution of the species is restricted to only one or two arroyos. The purpose of this study was to survey arroyos in the area to obtain more data on the range of the species, to map individuals and populations, and to undertake a multivariate analysis of the vegetation relationships of the species.

Speck, D. C. and Timme, S. L., T. M. Sperry Herbarium, Pittsburg State University. PRE-RESTORATION VEGETATIONAL ANALYSIS OF A DISTURBED LIMESTONE SAVANNA IN SOUTHWEST MISSOURI. As stated in the park's master plan, one of the goals for Wilson's Creek National Battlefield is to restore the battle site to its presettlement landscape, which was savanna. Since few high quality, limestone savannas exist as models, and management prescriptions for this habitat type have not been perfected, comprehensive baseline data and continued monitoring of the restoration will provide necessary feedback. An efficient process for assessing the vegetation was designed using cover classes on stratified, random-nested plots along a permanent baseline. The initial analysis covered 6 ha and determined frequency and importance values for 24 woody species, 18 shrubs, and 99 herbaceous species. 20 bryophytes were identified. The study defines key floristic components for limestone savanna and indicates that those still present on the site should respond favorably to minimal restorative treatments.

Engineering

Chao, W. W., Dai, W., Kunze, J. F., and Loyalka, S. K., Nuclear Engineering Program, University of Missouri-Columbia. THE EFFECTS OF DISSOLVED GAS ON THE CALCULATION OF NATURAL CIRCULATION HEAT REMOVAL. The purposes of this research are to evaluate the dissolved gas effects of a natural circulation loop and the calculation of the natural circulation with the transient code RELAP (REactor Loss of coolant Analysis Program). An electrical-heated, natural-circulated benchmark experiment loop was built to access the simulation ability of RELAP under low temperature ($<140^{\circ}\text{F}$), low pressure (1 atm.). Temperature histories were recorded at several locations of the loop by a data acquisition system. Flow velocities in the test channels were measured by dye injection method. The experimental results showed that under subcooled nucleated boiling condition, the dissolved gas increased the heat transfer coefficients by factor of 1.25 to 1.42, and the flow velocities were reduced by 10% as well. The simulated results by RELAP are closer to the degassed test conditions. The dissolved gas increases the heat transfer effects and reduces the flow for the natural circulation loop, and were not addressed in the RELAP coding. Supported by U.S. Department of Energy.

El-Gizawy, Sherif, A. and Wood, R. A., Industrial and Technological Development Center, University of Missouri-Columbia. QUALITY CHARACTERIZATION FOR A RESISTANCE BRAZING PROCESS SYSTEMS. The quality characteristics (joint strength and excess silver flow) of the resistance brazing of electric contact materials were investigated using three dispersion-strengthened alloys joined to electrolytic tough pitch copper. The process system parameters studied were the filler metal, the brazing current, the number of current pulses, the brazing pressure, the heating and the cooling cycles. A Taguchi-class orthogonal array experiment was conducted and the analysis of variance and signal-to-noise ratio techniques applied. Experimental confirmation of the predicted optimum parameters substantiated the validity of the quality analysis and optimization methodology. The process behavior was quantified by mechanical testing. Microstructural evaluation supported the mechanical test results.

Gu, Y., Vosnidis, G., and Kunze, J. F., Department of Nuclear Engineering, University of Missouri-Columbia. A STUDY OF THE DECONTAMINATION OF METAL SURFACES AS A FUNCTION OF SOLUTIONS OF VARYING pH, IN THE ACIDIC RANGE. The outside surfaces of HLW shipping casks made of stainless steel or titanium become contaminated after being immersed in the spent fuel storage pools of nuclear power plants. After the casks are removed from the pool and scrubbed clean by the health physics personnel, they are shipped out. Upon arrival at their destination health physics swipes reveal substantially higher levels of removable contamination, which violates Nuclear Regulatory Commission regulations, and usually brings a citation and fine. In this study, 42 stainless steel coupons, type 402, nominally $1/32$ inch thick, by $4'' \times 4''$ and 30 titanium pipe samples $6''$ long, Schedule 40, $6''$ diameter were exposed in the contaminated waters of the Callaway Nuclear Power Plant spent fuel storage pool for various periods of time. The pool currently has a pH 4.8 and contains Co-60, Cs-137, Cs-134, Mn-54. The samples were then soaked in solutions of pH=3, pH=5, pH=7 for different periods of time. After the soaking they were left to drip dry at room temperature and were counted on gamma spectrometers. Little difference was observed in the removing performance between the three pH solutions. The fraction of activity removed from the pipes was 50% for nine hours of soaking and 75% for 13 days. The plates, with about the same Cobalt absorbed but much less Cesium, did not clean up as well.

Jang, Dong Y. and Han, Sung W., Department of Mechanical and Aerospace Engineering, University of Missouri-Columbia. ANALYSIS OF STRUCTURAL EFFECTS ON THE STABILITY OF THE CUTTING PROCESS. The chatter analysis in the cutting operation has been investigated by many researchers, but the combined dynamic effect of tool and workpiece-spindle structure on chatter vibration has been paid little attention to, although the stability of cutting process depends on the relative vibrations between the tool and the workpiece. In this paper, the combined dynamic effect of tool and workpiece-spindle structure on the chatter vibration of cutting process is proved through computer simulations using a unified computer simulation model of the cutting process. It considers the dynamic factors of the workpiece-spindle structure and tool assembly. The multiple regenerative and damping effect on the cutting forces are considered. The increase of stability at low cutting speeds is also discussed in terms of a damping effect due to the relative motion between tool and workpiece.

Jones, Robert F. and El-Gizawy, A. Sherif, Industrial and Technological Development Center, University of Missouri-Columbia. EXPERIMENTALLY-BASED QUALITY DESIGN METHODOLOGY FOR ELECTRO-MECHANICAL PRODUCTS. An experimentally-based quality engineering methodology is presented. This is an integrated approach, involving statistical experimental design, and the quality loss function. The methodology is used as the mean by which variability of a product performance and quality loss are reduced. The method is implemented using a case study from the electromechanical product industry.

Hsin-Chun, Wu, Yi-Wang, Lo, and Kunze, Jay F., Department of Nuclear Engineering, University of Missouri-Columbia DESIGNING AN OPTIMUM NEUTRON BEAM FROM AN ACCELERATOR. FOR USE IN BRAIN CANCER RADIOTHERAPY. Low energy accelerators which use specific neutron producing reaction like Li-7 (p,n) Be-7 reaction might produce optimum neutron energies with little gamma ray contamination. The high energy neutrons need to be removed or shifted to lower energy (lev to 10 Kev) by using moderator and filter. The requirements of moderator consist of elements with high scattering cross section for fast neutron, small scattering cross section for intermediate neutrons, and small neutron capture cross section. Al_2O_3 , $\text{Al} + \text{D}_2\text{O}$, BeO , Be and SiO_2 have being tried for the moderator materials for both reactor-based and accelerator-based neutron sources. This study is using 2.5 Mev with 20 mA current of protons as incident particles. This design has been done with a Monte-Carlo neutron-photon code. The goal is a neutron beam of sufficient magnitude to provide the desired dose

to a tumor in one hour of irradiation. It is assumed that the tumor has been previously "labelled" with 20 micrograms of B-10 per gram of issue.

Pulse, D. L., Caruthers, P. E., and Caruthers, R. G., Distribution Engineering, The Empire District Electric Company. INTERNAL BUILDING WIRING AND GROUNDING FOR SENSITIVE ELECTRONIC LOADS. Customer reports of damaged or malfunctioning sensitive electronic loads have increased dramatically in the last decade. Utilities have found themselves forced to investigate the causes of these problems and effective mitigation techniques. Often customer problems are falsely attributed to poor power quality or equipment failure. In actuality, antiquated or inadequate wiring and grounding can be traced to approximately 80% of the cases. In many instances, problems appeared even though the building met all applicable electrical codes. Technologies capable of solving equipment incompatibility can be found in various configurations. Economics, reliability, efficiency, physical dimensions, and effectiveness must be taken into consideration before adopting the optimum solution. However, many problems can be mitigated with relatively inexpensive wiring modifications. Over 60 case studies have been investigated to date yielding quantitative and qualitative results. Several of these case studies will be presented.

Varm, V. K., Department of Engineering Technology, Missouri Western State College. A UNIQUE DESIGN AND APPLICATION OF FLOWABLE FILL AT AN ABANDONED POWER PLANT. This study was conducted to develop design of a flowable, self-levelling, self-consolidating backfill material, known as Controlled Low Strength Material for application at an abandoned power plant to close off an existing tunnel and five deep wells. Six different mix designs were developed using variable quantities of ASTM Type I cement, ASTM Type C Flyash, sand and water. Forty-eight 6 × 12 inch cylinders of the flowable fill material were tested at 3, 7, 14, and 28-day intervals. Compressive strengths ranging from 150 psi at three days to 442 psi at twenty-eight days were obtained. In this study it is indicated that by reducing cement and increasing flyash, a 28-day compressive strength of 442 psi and a density of 95 pcf were obtained which not only met the project requirements but also proved to be very economical.

Jang, Dong Y. and Liqin, Wang, Department of Mechanical and Aerospace Engineering, University of Missouri-Columbia. PREDICTING STRESS DISTRIBUTION IN A WORKPIECE USING FINITE ELEMENT METHOD. The microstructure in the surface region of machined parts is an important aspect in evaluating their performance in tribological applications. Reliability and performance of a machined component depend on the residual stress distributions which are decided by the stress distributions arising during the machining operations. This paper presents the instantaneous stress information on a workpiece during and orthogonal cutting operations using a finite element method. Residual stress distributions were also obtained by studying the history of stress and strain relationship during the plastic deformation. The results show that shear plane angle and load distribution on the shear plane are important factors in deciding the region of plastic deformation and patterns of residual stress on a machined workpiece.

Environmental Science

Carrel, J. E., Division of Biological Sciences, University of Missouri-Columbia. NATURAL SUCCESSION IN ABANDONED SURFACE COAL MINES IN MISSOURI. I will summarize laboratory and field studies on ecological succession in abandoned coal surface mines conducted from 1975 to 1982 by a team of ten professional scientists and their associates at the University of Missouri-Columbia. We found that microbial and plant invasion of abandoned spoil banks is rapid, but the development of these communities is very heterogeneous in time and space, so succession is difficult to describe using conventional field techniques. We solved some of these problems using remote sensing methods. Our data also indicated that development of soil ecosystems is slow and highly patchy because it is often limited by excess acidity and ionic solutes or by lack of nitrogen and/or carbon sources which are required by heterotrophic microorganisms and invertebrates.

Pierce, J. T., Department of Safety Science and Technology, Central Missouri State University. OCCUPATIONAL AND ENVIRONMENTAL HEALTH ISSUES ASSOCIATED WITH OPERATION DESERT STORM. The long-awaited environmental terrorism commenced in late 1990 with fires, spills, explosions, and chemical releases in Kuwait, and throughout the Persian Gulf region. While researchers are just now assessing the broader environmental issues at stake, additional questions remain concerning the health and safety of Kuwaiti nationals as well as American civilian and military populations. A summary of air pollution data emphasizes overexposures to particles and irritant gases. Lessons learned from the conflict include the dimensions of damage possible and the wartime limitations of international and national agencies that could normally assess and remediate problems. A need exists for integration of well-designed longitudinal studies that are done in conjunction with hazard assessments. Strategies to avoid an "Agent Orange" indeterminate outcome are also important.

Sharp, J. R., Department of Biology, Southeast Missouri State University. THE EFFECT OF EXPOSURE DURATION TO MERCURY ON THE DEVELOPMENT OF THE ORANGETHROAT DARTER. *ETHEOSTOMA SPECTABILE*.

Cleavage stage embryos (8-16 cell) were exposed to 0, 10, 20, 40 or 60 ppb Hg⁺⁺ for 1, 2, 4 or 8 days (24-h static renewal bioassay). Four median effect concentrations were calculated: 96-h LC50, AB50 (abnormal development), SH50 (successful hatch) and VH50 (viable hatch). The 96-h LC50 concentrations for embryos exposed for 8-d, 4-d, 2-d and 1-d were 68.1, 60.6, 64.5, 93.5 ppb; the AB50 values were 40.6, 40.1, 45.0 and

60.8 ppb, for the respective exposure times. Commonly observed embryonic terata included dwarfism, microcephaly, microphthalmia, synophthalmia, cardiac malformation and pericardial edema. SH50 values for 8-d, 4-d, 2-d, and 1-d exposed embryos were 34.2, 34.4, 48.4, and 72.2 ppb respectively. Spinal deformities (scoliosis, lordosis, kyphosis), synarthrosis of the jaws, and enlarged yolk-sacs were noted among fry. VH50 values for 8-d, 4-d, 2-d and 1-d exposed embryos were 18.5, 21.1, 35.2, and 49.2 ppb. Several deformed fry were preserved, sectioned, stained, and read for subsurface histopathological lesions (e.g. retinal degeneration and necrosis, neural deterioration and pyknosis, as well as a loss of skeletal muscle).

Spratt, Henry G., Jr., Department of Biology, Southeast Missouri State University. RELATIONSHIPS BETWEEN SOIL TOTAL SULFUR CONTENT AND BACTERIAL SULFATE REDUCTION IN THREE LOW-SULFATE FRESHWATER AQUATIC ENVIRONMENTS. Sulfate reduction rates and total sulfur (TS) content was determined for soils from three low-sulfate aquatic environments. The environments sampled included: a wetland at the Mingo National Wildlife Refuge, near Puxico, MO; a pond at the KELSO Wildlife Sanctuary, near Cape Girardeau, MO; and a wetland in Lebanon State Forest, near New Lisbon, NJ. Sulfate concentrations ranged from 20 to 130 μM for all sites, limiting to most sulfate reducing bacteria. There was a positive relationship between the sulfate concentration and the soil's TS content, with lowest average values of sulfate and TS recorded in Mingo samples (30 μM and 6.5 $\mu\text{mol/g}$ wet, respectively), and highest values found in NJ samples (75 μM and 19.5 $\mu\text{mol/g}$ wet, respectively). The rates of sulfate reduction were also positively related to the site's sulfate concentration. TS contents, however, did not correlate to the sulfate reduction rates. This difference seems to be related to variation in soil total organic carbon, which ranged from 10% to 98%, by weight, possibly representing different carbon sources for the sulfate reducing bacteria at the different sample sites.

Exercise Physiology

Langenfeld, M. E. and Venable, D. F., Departments of Biology and Health & Leisure, Southeast Missouri State University. CREATINE KINASE AND CREATINE KINASE-MB DURING A 48-HOUR FOOT RACE. Elevated creatine kinase (CK) has been observed accompanying acute myocardial infarction and subsequent to various physical activities, especially prolonged exercise. The purpose of this study was to examine responses of CK and the isoenzyme, CK-MB, during a 48-h ultraendurance event. Three male runners participated in this study. Their objective was to cover as much distance as possible during a 48-h timespan. All runners included sleep periods during the event. Prior to the start of the race, and approximately every eight hours throughout, blood samples were drawn at trackside. Samples were analyzed for total CK and for CK-MB. The participants completed 137, 203, and 234 km during the event. Levels of total CK pre-race were 77, 91, and 68 IU/L. CK-MB was zero for all runners pre-race. The total CK value for a runner aged 30 yr who claimed to never train for ultraendurance running rose 300-fold to 27,518 IU/L with an accompanying CK-MB level of 4127 IU/L. Maximum values for the other runners were 8946 and 4134 IU/L for total CK and 1880 and 492 for CK-MB. CONCLUSION: Total CK and CK-MB values for these ultraendurance runners spanned a wide range. For all subjects both CK and CK-MB rose over the first 24h and remained elevated over the final 24h. In situations involving suspected myocardial infarction, interpretation of elevated levels of CK-MB among persons who have recently completed ultraendurance events must be approached with caution.

Forensic Science

Corrigan, G. E., St. Louis Veterans Administration Medical Center. CURRENT EDUCATIONAL ACTIVITIES IN THE FORENSIC SCIENCES IN THE STATE OF MISSOURI. A survey of the state-wide activities in forensic science education for the purpose of defining availability and scope of training opportunities is presented. Direct interviews of educators and training directors for current programs were conducted. Analysis of programs indexed in current educational and forensic catalogs was completed. Comparisons were made with the disciplines represented in the American Academy of Forensic Science and other international organizations. Certification of the activity was considered and evaluated. A composite of current programs is presented relating the major formal areas of training and education in the forensic sciences.

Pierce, J. T., Prince, J. J., and Foale, C. S., Department of Safety Science and Technology, Central Missouri State University. EFFECTS AND DETECTION OF SOLVENT USE AND ABUSE. By law, drugs are defined as articles intended for use in diagnosing, curing, treating or preventing disease in people or animals. Drug abuse occurs as individuals take substances for other than their intended purposes, and in a manner that can result in damage to the person's health or ability to function. Drug abuse testing, in conjunction with effective programs for the rehabilitation of individuals, has functioned to aid individuals and society. Little recognition has been made of the neurobehavioral effects of the unintentional, occupational use of solvents and industrial substances. The law enforcement implications of impairment that occurs through both voluntary and involuntary (occupational) exposures are enormous. The immunoassay technology that greatly aided drug abuse testing, is becoming available in the solvent arena. This presentation examines facets of solvent use and abuse, including forensic implications, and surveys the availability of newly available biotechnologies aimed at better detecting parent compounds and their metabolites.

Geology-Geophysics

Biggs, T. C. and Bolter, E., Department of Geology/Geophysics, University of Missouri-Rolla. SOIL-CHEMICAL PROPERTIES OF THE RESIDUUM OF CALLAWAY COUNTY, MISSOURI. A geochemical study of ten sites was conducted in order to better understand the migration behavior of potential contaminants in the subsurface. Laboratory research indicates the unconsolidated materials have a significant range in the following parameters: grain size, soil pH, iron and manganese oxide content, cation exchange capacity (CEC), total organic carbon content (TOC), and clay mineral type and content. Alluvium, loess, glacial till, and Ordovician, Devonian, Mississippian, and Pennsylvanian residuum were collected from rock quarries within the county. Sixty samples were wet sieved and the soil pH was determined from each total sample. Iron and manganese oxide and CEC were determined by atomic absorption analysis on the less than 200 mesh fraction. Settling velocities and TOC content were determined on the less than 200 mesh fraction, and clay mineralogy was ascertained from the less than 6 micron fraction by x-ray analysis. Alluvium and loess appear to be generally silt to sand sized, possess low adsorption capacities and clay mineral content, therefore indicating relatively moderate to high permeabilities. The other soil types tend to be generally clay to silt sized, possess moderate to high adsorption capacities and low to high clay mineral content, therefore indicating relatively low to moderate permeabilities.

Broomhead, S. P. and Rupert, G. B., Department of Geology and Geophysics, University of Missouri-Rolla. APPLICATION OF GROUND PENETRATING RADAR (GPR) IN THE SEARCH FOR AN AFRICAN-AMERICAN CEMETERY. A ground penetrating radar survey is to be performed at the Brinker Log Cabin near St. James, Missouri for the purpose of detecting unmarked graves dating to the early nineteenth century. The three phase project will begin in a cemetery of approximately 50 marked graves, with an equal number of unmarked graves. Scans will be performed on 3 ft. gridlines with a GSSI model 4800 ground penetrating radar system with a 550 Mhz transducer. Depths of burial are expected to lie between 3 and 6 feet below the ground surface, with graves oriented in an east-west direction. In the first phase, profiling over known grave sites will generate a characteristic grave response for the soil conditions in the area. Phase two will entail location of unmarked graves in the cemetery by way of comparison of profiles taken over unmarked grave sites to the characteristic response of known graves. Phase three will involve using the radar unit to locate and delineate an African-American cemetery approximately one-half mile north of the known cemetery. Surface examinations have been unsuccessful, as the area has been permitted to revert to natural conditions. Subsurface radar profiling of the area is expected to disclose the location of possible grave sites. Through comparison of the profiles to those of the known cemetery, the limits of the African-American cemetery will be delineated for preservation of the cemetery.

Cwick, G. J. and Ravichandren, G. R., Department of Earth Sciences, Southeast Missouri State University. GEOBOTANICAL ASSESSMENT OF MINERALIZED SITES IN SOUTHEAST MISSOURI USING REMOTE SENSING TECHNIQUES. On-going investigation continues into the use of geoprocessed Landsat Thematic Mapper (TM) multispectral data as a means of identifying geobotanical indicators which might denote the occurrence of near-surface mineralization at two sites in southeast Missouri. The sites are the Silver Mines area located in Madison county and the Zell Mine site situated in St. Genevieve county. Both sites are suitable for assessment of this kind since they are overlain by relatively continuous forest cover and have geochemical evidence of anomalous metal concentrations in the soil. The TM data were digitally processed using principal components and vegetation index (ratio's) methods to generate "enhanced" images capable of delineating spectral changes in the dominant tree species growing in each area. Preliminary results have revealed the presence of several geobotanical features of interest or spectral relationships which appear to be associated with mineralization or related geologic activity.

Emerson, J. W., Earth Science Department, Central Missouri State University, Warrensburg, Missouri, 64093. A LATE PALEOZOIC VALLEY-FILL SANDSTONE IN CENTRAL MISSOURI. An unnamed sandstone body has been mapped from Cooper County, southwest for more than 60 miles through Pettis, Henry, and St. Clair Counties. It is disconformable on both Mississippian and Pennsylvanian rocks. Outcrops and well records indicate a maximum thickness of 70-90 feet. Outcrop width is from one to two miles. Crossbedding directions are predominantly south (36%), and southwest (46%). Geometry and sedimentary structures indicate a fluvial origin. The very fine to medium sandstone is poorly sorted and is a quartz arenite to lithic arenite. Thin-sections from ten localities show that the major minerals are quartz, microcline, perthite and muscovite. Accessory minerals are rutile, green and grown tourmaline, zircon, ilmenite, kyanite, epidote, staurolite, and apatite. Altered schist and phyllite fragments are common in all samples. The major mineral and accessory mineral assemblages indicate a source from metamorphic rocks and from recycled sedimentary rocks.

Erickson, D. R. and Bolter, E., Department of Geology and Geophysics, University of Missouri-Rolla. SOIL-CHEMICAL PROPERTIES OF MISSOURI RESIDUUM: STONE & TANEY COUNTIES. A study of the geochemical properties of soils in these counties was conducted and will be compared to data from other sites through out the state. The results of this study will be used to see if future mapping by these properties is practical. Analysis of the following characteristics: pH, grain size distribution, iron and manganese content, cation exchange capacity, total organic content, and clay mineral content will be conducted. Samples were measured for soil pH and were wet sieved with an 80 mesh sieve for the initial separation for grain size analysis. It is hoped that the characteristics of these sites will have parameters that will allow a state wide survey.

Ethington, R. L., Department of Geological Sciences, University of Missouri-Columbia. CONODONT EVIDENCE FOR THE AGE OF THE BIG FORK CHERT, ARKANSAS AND OKLAHOMA. The Bigfork Chert is a

unique unit within the thick, dominantly siliciclastic Ordovician sequence of the Ouachita Mountains. Lack of identifiable fossils from the chert beds required that the age of this unit be interpreted relative to the subjacent Womble Shale and overlying Polk Creek Shale. On this basis, it has been correlated with part of the Viola Group in Oklahoma and of the Kimmiswick Limestone in Missouri and Arkansas. Modest numbers of conodonts have been found in limestones interspersed within the lower part of the chert sequence near Mt. Ida and Caddo Gap in Arkansas and in the Stringtown Quarry in southeast Oklahoma. These conodonts provide unequivocal evidence that lower Bigfork is as old as Rocklandian (high Middle Ordovician) and supports the traditional correlation that was based solely on stratigraphic position. One species from near Mt. Ida previously was known only from Shaanxi Province in China. Supported by American Chemical Society Petroleum Research Fund 21167-AC8.

Felton, R. M., Geology/Geography Department, Northwest Missouri State University. STRATIGRAPHIC SIGNIFICANCE OF INTERBEDDED SHALES IN THE WINTERSET LIMESTONE MEMBER, DENNIS FORMATION (PENNSYLVANIAN, MISSOURIAN). The Winterset was studied in an area extending from Linn County in east-central Kansas to Adair County in southwestern Iowa. Three widespread Winterset shales were found to be important for deciphering the internal stratigraphy of this predominantly carbonate unit. The lower two thin, conodont-rich shales are interpreted as transgressive sediment-starved marine shales that separate regressive carbonate successions. These shales descend southward from northwestern Missouri and merge with the Stark Shale Member in east-central Kansas. The upper shale is largely terrestrial and overlies a mid-Winterset exposure surface in west-central Missouri. This exposure surface apparently truncates the lower Winterset cycles northward and merges in northern Missouri and Iowa with another exposure surface at the top of the Winterset. These relationships suggest that the overlying Fontana Shale Member of Iowa is equivalent to the Winterset and Fontana in east-central Kansas. Supported by Northwest Faculty Research Grant.

Bishop, C., Fielding, L., and Rechtien, R., Department of Geology and Geophysics, University of Missouri-Rolla. GRAVITY TERRAIN CORRECTIONS FOR TWO-DIMENSIONAL TOPOGRAPHIES. Gravity corrections commonly used today include the free-air correction and the Bouguer correction. The free-air correction compensates for the difference in elevation from the datum plane to the station, while the Bouguer correction compensates for the air and rock that is extra or missing between the datum plane and the station by replacing the material with an infinite slab. The Bouguer correction overcompensates by virtue of the assumption of an infinite slab and does not allow for variations in density of the rock with respect to elevation. The 'Rechtien Correction' was derived to compensate for this overcorrection and density variations in gravity data taken along a linear traverse. The 'Rechtien Correction' uses a FORTRAN program that calculates the correction using horizontal slabs of varying width and thickness, which are inputted into the program. The width corresponds to the span of the topographic feature to be corrected for, as measured along the direction of traverse. The thickness is determined by the number of slabs used to correct for the extra or missing air and rock. Because the 'Rechtien Correction' corrects only for the terrain in the linear traverse, overcompensation is eliminated. The 'Rechtien Correction' can be tailored to fit most any two-dimensional situation. The results show that the 'Rechtien Correction' is the better correction to use when working with two-dimensional topographic features.

Fraunfelder, G. H., Department of Geology, Southern Illinois University at Carbondale. AN INVERTEBRATE MEGAFUNA FROM THE CAVE HILL MEMBER OF THE KINKAID FORMATION OF SOUTHEASTERN ILLINOIS. A well-preserved, bivalve-dominated fauna from an isolated shale outcrop of the Cave Hill Member of the Kinkaid Formation in Pope County, Illinois, was investigated. This fauna contains the bivalves *Aviculopecten inspeciosus* Girty, *Aviculopecten jennyi* Girty, *Aviculopecten* sp., *Myalina elongata* Girty, and *Phestia* cf. *stevensiana* (Girty); the brachiopods *Lingula* sp. and *Orbinaria?* sp.; as well as the nautilus *Orthoceras caneyanum* Girty. The composition of this fauna, as well as the delicate nature, good preservation and modes of living, is suggestive of a relatively quiet water, shallow marine community. In addition, good preservation implies little transport. All of the bivalve species present are characteristic of Paleozoic onshore communities, as is *Lingula*. *Orbinaria?* and *Orthoceras* often occur with pectinoids like *Aviculopecten*. The bivalve species present also suggest the correlation of the containing beds with rocks of Chesterian age in Arkansas.

Furman, Francis C., Department of Geology and Geophysics, University of Missouri-Rolla, Rolla, MO 65401. ULTIMATE IGNEOUS SOURCE OF (Zn, Ba, F and Fe) IN EAST TENNESSEE MISSISSIPPI VALLEY-TYPE (MVT) MINERALIZATION. Appalachian metamorphism mobilized F and Ba from granitic basement horst blocks, and Zn and Fe from Ducktown-type Sedimentary Exhalative (SEDEX) deposits from metalliferous Anakeesta Formation in the Precambrian Southern Blue Ridge Rift. Restoration of the southern Appalachians to pre-Alleghenian palinspastic conditions reveal an alignment of: 1) Knox MVT mineralization with the western margin of the Blue Ridge Rift and Ducktown-type SEDEX deposits and barite veined granites. 2) Marion, Virginia barite-pegmatite district with the Wilkes North Carolina pegmatite district. 3) metalliferous Sevier Basin with the metalliferous Blue Ridge Rift and. 4) Sevier Basin Conodont Alteration Index (CAI) axis with the metamorphic axis of the Blue Ridge Rift. The ascending metalliferous brines formed the MVT, SEDEX mineralization in the overlying Knox shelf margin and were trapped by the Conasauga, Sevier, and Chattanooga shales in adjacent basins.

Hagni, A. M. and Hagni, R. D., Department of Geology and Geophysics, University of Missouri-Rolla. MINERALOLOGY AND CHARACTERIZATION OF LIME ROASTED PYRITE AND ARSENOPYRITE FOR GOLD LEACHING. Microscopic and sub-microscopic gold commonly occurs in the sulfides pyrite (Py, FeS₂) and arsenopyrite (Asp, FeAsS). To recover refractory gold from Py and Asp, these sulfides are roasted to create porosity and permeability prior to cyanide leaching. A new technique of lime roasting (adding Ca(OH)₂) is being tested for

retention of contaminant sulfur and arsenic and effectiveness of gold extraction. The lime roasting of pyrite at 500°C contains anhydrite (CaSO₄), oldhamite (CaS), calcium sulfite (CaSO₃), hematite (Hm, Fe₂O₃), magnetite (Mt, Fe₃O₄), and minor amounts of pyrrhotite (Po, Fe_{1-x}S) and pyrite. At 600°C and 700°C, the main constituents are CaSO₄, CaS, and Hm. The roasted Asp at 450°C contains arsenic sulfides and Hm. At 650°C, CaSO₄, CaS, and Hm are present. The textures indicate excellent permeability and porosity at high temperatures. At lower temperatures, rims of low permeability and porosity surround many of the Py and Asp particles. Also at low temperatures, the complete oxidation process from Py to Po to Mt to Hm can be observed in individual particles. Currently under study are gold concentrate, roast calcine, and cyanide leach residues to determine the phase relationships of the gold.

Karakus, M., Hagni, R. D., Department of Geology & Geophysics, and **Moore, R. E.,** Department of Ceramic Engineering, University of Missouri-Rolla. LUMINESCENCE CENTERS IN SYNTHETIC MINERALS. Cathodoluminescence (CL) centers in synthetic minerals found in ceramic build-ups were investigated. Well-known transition metal ions, Mn²⁺, Cr³⁺ and rare earth (Sm³⁺, Dy³⁺, Tb³⁺, Eu³⁺) centers as well as lattice defect centers (F⁺ and V⁻) were identified in most minerals. Tetrahedrally coordinated Mn²⁺ activator produces identical broad emission band at around 520 nm in (green) spinel and hibonite, while octahedrally coordinated Mn²⁺ activator produces a similar broad emission band at around 625-630 nm (red) in forsterite and spinel crystals. Yellow CL anorthite is characterized by a broad emission band at around 550-570 nm due to Mn²⁺ + activation. Spectra of red CL corundum crystals exhibit a narrow emission line due to Cr³⁺ activator. Sm³⁺ also produces sharp lines at 560, 603, 642, and 702 nm in reddish violet hibonite crystals and glasses. CL spectra of oldhamite consist of two broad bands at about 520 and 585 nm due to Mn²⁺ and Ce³⁺ activators. Quartz and cristobalite crystals exhibit blue, brown, yellow, pink, and red CL, but their spectra are not suggestive of any certain luminescence mechanisms. Their CL also varies with time. The nature of the emission bands in periclase (510-550 nm), monticellite (430-470 nm), and mellilite (425 nm) is not clearly defined but thought to be related to the lattice defects (anion or cation vacancies). Similar defect centers also were found in some blue CL anorthite, forsterite, sapphire, spinel, and hibonite crystals. Electron microprobe analysis of these minerals suggest that their FeO contents were not high enough to quench the cathodoluminescence. CL polarization also was observed for most of the anisotropic crystals. Supported by American Foundryman's Society.

Keller, D. J. and Bolter, E. A., Department of Geology and Geophysics, University of Missouri-Rolla. MINERALOGY AND GEOCHEMISTRY OF MISSOURI FLINT CLAY DEPOSITS. The geochemistry and mineralogy of four flint clay deposits (Pennsylvanian, Cheltenham Formation) in Gasconade County Missouri, was investigated relative to their refractory behavior. Forty-five core samples were characterized by XRD SEM-EDS, ICP, and AA to determine the mineralogy and chemistry clay and non-clay minerals. The clay mineral content, determined by XRD, is primarily poor to well crystallized kaolinite with minor illite, illite/smectite mixed layer, chlorite and boehmite. XRD analysis of the non-clay minerals revealed the presence of francolite (Ca₅(PO₄)₃(F)), crandallite (Ca Al₃(PO₄)₂(OH)₅ * H₂O), variscite (Al PO₄), wavellite (Al₃(OH)₃(PO₄)₂*5H₂O) free quartz, and pyrite. Francolite, observed with SEM, occurs as very small (approximately 1µm) subhedral to euhedral crystals dispersed throughout the clay. The presence of francolite was chemically determined by comparing the ratio of CaO to P₂O₅ the of the sample (determined by EDS) to that of published data. Variscite occurs as thin veinlets (generally 1 to 2 mm thick) throughout the core. Future work will include ICP and AA analysis to confirm the mineralogical identifications made by XRD. Total organic carbon analysis (TOC) will also be used in the final analysis.

Knox, B. R., Department of Earth Sciences, Southeast Missouri State University. GEOMORPHIC EVIDENCE OF RECENT SEISMICITY ON AN EXTENSION OF THE NORTHWEST BRANCH OF THE NEW MADRID SEISMIC ZONE. The areas of maximum surface disturbance by seismically-induced liquefaction attributed to the 1811-12 events in the New Madrid Seismic Zone do not match well with maps of epicenters of present seismic activity. This is particularly true of a zone that extends at least 30 miles northward from New Madrid to Bloomfield and beyond. Lineations from landsat imagery and from old airphotos reveal a zone of seismically-induced liquefaction features which trend well beyond the area of present high epicentral density. Portions of the east-facing escarpment of the Bloomfield Hills segment of Crowley's Ridge which are on trend with these lineations contain unusually high numbers of slope failure-related landforms, which also suggest strong ground motion in geomorphically-recent times. That this zone lines up well with Black Fault mapped from the St. Francis Mountains to the Ozark Highlands Escarpment suggests a structural, and probably a seismic, connection.

Knox, B. R. and Stewart, D., Department of Earth Sciences, Southeast Missouri State University. MATCHING THE MORE DRAMATIC CONTEMPORARY ACCOUNTS OF THE NEW MADRID EARTHQUAKE WITH GEOLOGY. The greatest of the New Madrid earthquakes occurred on February 7, 1812. Eyewitness accounts of events range from completely fanciful to quite credible. Our studies of landforms that still remain, plus reviews of reports of modern geologic research, are matched with our analyses of contemporary and near-contemporary historical accounts. Many reports of the more dramatic effects of the earthquake do indeed match the findings of geology. "Waterfalls" on the Mississippi River appeared in two locations. One of these created a dam that lasted long enough to force a retrograde flow for a few hours, and this also contributed to the flooding of the sunk land that became Reelfoot Lake and the overwhelming of thousands of acres of mature forest. Downstream from this dam the discharge of the river dropped dramatically, leaving some boats stranded. The second of the waterfalls was longer lived, and caused most of the reported destruction of river boats and deaths among their crews.

Laudon, Robert C., Department of Geology & Geophysics, University of Missouri-Rolla. COMPUTER CONTOURING—SOME COMMON PITFALLS. Geologists today are relying more and more heavily on computers for common mapping procedures. A number of excellent contouring packages are available today and all of them have obvious as well as hidden pitfalls. Many people are using these packages without understanding what the computer is actually doing with results that are, in some cases, disastrous. Experience has shown that:

1. Data must be edited carefully before contouring. Apparent volcanos and sinkholes are likely to be caused by bad data points.
2. Bad data points commonly result in gradients that can extend to areas far beyond the bad data area.
3. Correct data points combinations that result in strong gradients can give very peculiar and erroneous results.
4. Be very careful of edge effects, that is, contour lines that are extrapolated beyond data to the edge of the map.
5. Coarse grids can give very peculiar results, and in some cases data may not even be honored.
6. Be careful of residuals. Anomalous residuals are commonly caused by bad data points on one of the surfaces.

Liggett, G. A. and Nelson, M. E., Department of Geosciences, Fort Hays State University (KS) and Division of Science, Northeast Missouri State University.

TAPHONOMY OF THE BLONQUIST ROCKSHELTER, NORTHEASTERN UTAH: A PRELIMINARY REPORT. The Blonquist Rockshelter is located on the northern flank of the Uinta Mountains in Summit County, Utah, approximately 80 km northeast of Salt Lake City. The sediment package is stratified, contains both exogenous and endogenous sediments, and ranges in age from late Pleistocene (ca. 11.14 ka) to medial or late Holocene (5.91 ka). The entire package is fossiliferous and thousands of gastropods, insects, teleost fish, amphibians, reptiles, birds, mammals, and plants have been recovered. Many organic-rich layers may be associated with past occupation by packrats (*Neotoma*). However, the completeness of the individual elements, the apparent gastrointestinal etching on many bones, the association of hair with some bones, and the similar size of many animals represented by the fossils, support the conjecture that various raptors may have contributed to the fauna.

Nold, John L., Dept. of Earth Science, Central MO State U. A COMPARISON OF B.S. SCIENCE REQUIREMENTS IN MISSOURI—ARE WE READY FOR THE 90'S? Interdisciplinary science is becoming more important, especially with regard to environmentally-oriented projects. Are the requirements for Bachelor of Science degrees in the various sciences giving university graduates the broad background that will be needed to meet this trend? Comparison of the requirements for B.S. degrees in geology, biology, chemistry, and physics for three universities in Missouri show that biology, chemistry, and physics degrees have fewer required courses in the other sciences than does geology, and this perhaps suggests that their graduates are not well prepared for interdisciplinary work. Geology degrees, all having requirements in mathematics, chemistry, and physics, are more broad-based than the other sciences, but could perhaps benefit by adding requirements in biology. The reasons for the various science disciplines requiring courses for their majors in some of the sciences but not in others is perhaps based at least in part on the concept of importance of the various disciplines in the hierarchy of the sciences. The hierarchy of the perceived relative importance of science disciplines to each other (and to society?) perhaps comes at least in part from the degree to which the science is mathematically quantifiable. The disciplines which are more descriptive, like geology, are not perceived as being as important as the more mathematically sophisticated disciplines like physics. Those of us in the earth sciences need to watch for scientific discrimination of this sort and attempt to educate fellow faculty members, students, Deans, etc., that while our science is not as readily quantifiable as some of the sciences, it is no less complex and does not belong at the bottom of any kind of hierarchy of importance.

Oboh, F. E., Department of Geology and Geophysics, University of Missouri-Rolla. PALYNOFORMS FROM THE MIOCENE OF THE NIGER DELTA. Several species of pollen and spores, a few dinoflagellate cysts and algal remains, and many specimens of microforaminiferal test linings have been recovered from three boreholes. Igbomatoru-1, Kolo Creek 27 and Kolo Creek 29. The important palynomorph species include *Crassoretitritetes vanraadshooveni*, *Magnastriatites howardi*, *Zonocostites ramonae*, *Multiaeroelites formosus*, *Peregrinipollis nigericus*, *Rhoipites irregularis*, *Racemonocolpites hians*, *Graminidites annulatus*, *Verrutricolporites rotundiporus*, *Verrucatosporites usmensis*, *Spirosyncolpites bruni*, *Cicatricosporites dorigensis* and *pachydermites diederixi*. Two new species, *Rhoipites jegedei* and *Foveotricolporites sowunmii*, have been recognized in the Kolo creek sediments. In the well igbomatoru-1, three palynological zones were identified and they were combined with foraminiferal information to date the sediments as Middle to Late Miocene. The Kolo creek samples were dated as the earliest part of the Middle Miocene. The distribution of the palynomorphs in the three boreholes have also provided paleoecological information for the sediments. The abundance of the grass pollen *Graminidites* in the Kolo Creek sediments, as opposed to the present-day Niger delta, is probably indicative of slightly drier conditions during the Middle Miocene.

Pugh, A. L. and Jacobson, R. B., U.S. Geological Survey, Rolla, Missouri. RECENT GEOMORPHIC EVOLUTION OF LITTLE PINEY CREEK, PHELPS COUNTY, MISSOURI. During the past 75 years many residents of the Ozark Plateaus (locally known as the Ozarks) have become concerned that the Ozark streams were becoming choked with gravel. This study was conducted to assess the timing and possible causes of gravel aggradation on Little Piney Creek. Surficial stratigraphy of Little Piney Creek valley bottoms indicates four distinct periods of deposition since the mid to late Holocene. The latest period seems to have begun nearly 200 years ago.

at approximately the same time as European settlement of the basin began. Analysis of census data, historical aerial photography, and recollections of local residents indicate that land-use disturbance of uplands has contributed to the sand and gravel aggradation in Little Piney Creek. However, analysis of historical precipitation and discharge data also indicates a strong correlation between precipitation and stream fluvial morphologic parameters. Two factors are theorized to have acted simultaneously to produce changes in the fluvial morphology of Little Piney Creek. One factor has been a wave of sand and gravel derived from the drainage basin. This wave was created mostly from an influx of land-use-derived sediment from the basin uplands. The other factor has been the presence of multiple-year climatic anomalies. Discrete multiple-year periods of wet and dry weather have created discrete periods of channel stability and instability superimposed on the wave of land-use-derived sediment.

Aide, M., Moore, K., Nicholas, J., Ravichandren, G. R., and Thompson, J., Department of Geosciences, Southeast Missouri State University. SOIL GENESIS OF RHYOLITE AND GRANITE RESIDUUM IN THE ST. FRANCIS MOUNTAINS. Four Missouri soils, from summit and sideslopes positions on rhyolitic and granitic peaks in the St. Francis Mountains, were studied to determine soil genesis and the clay mineral weathering sequences. Three pedons were ultisols and one pedon was an alfisol, which showed strong evidence for a rhyolitic saprolite. Mineralogy was characterized by x-ray diffractometry (XRD), thermal analysis and potassium fixation. Results demonstrated that the major clay minerals were kaolinite, hydroxy-aluminum interlayered vermiculite (HIV) and hydrous micas. Kaolinite is proposed as forming from K-feldspar weathering, while the presence of vermiculite and hydrous micas are proposed as alteration products of either an aeolian contaminant, the sericitization of the feldspars, or the alteration of primary biotite/chlorite. At two locations, conversion of biotite to chlorite substantially contributed to the presence of vermiculite and hydrous micas.

Roberti, Melanie S. and Laudon, Robert C., Department of Geology & Geophysics, University of Missouri-Rolla. Rolla, MO 65401. VITRINITE REFLECTANCE OF SINKHOLE COALS, EAST CENTRAL MISSOURI FIRECLAY DISTRICT. Vitrinite reflectance measurements on coals from sinkholes found in the East Central Missouri Fireclay District range from 0.7 to 0.8 percent. By using various published regression equations these reflectance measurements correspond to temperatures of 110°C to 125°C. These temperatures are consistent throughout the study area and are higher than would be expected from known burial depths. These temperatures are much more restrictive than those derived from fluid inclusion data in dolomites, but do agree generally with the concept that the whole area may have been heated by some external source. The most likely external source is considered to be fluids that migrated upward from deeper basins surrounding the study area possibly associated with Mississippi Valley Type mineralization events.

Steckel, P. J., Department of Earth Sciences, Southeast Missouri State University. EFFECTS OF SEISMIC AND TECTONIC ACTIVITY ON NATURAL DRAINAGE SYSTEMS IN SOUTHEAST MISSOURI. Over time, the natural drainages of southeast Missouri have responded to seismic and tectonic activity of the New Madrid fault system. Study of evidence of this response may provide insight into the overall geophysical setting of that fault system. The methodology for this study included a review of 30 maps, created in 1924 for the installation of the Little River Drainage District (LRDD), that include evaluation data measured on 500-foot spacings and to a one-tenth-inch vertical accuracy. Elevation profiles of proposed ditches and other lines were then created from this data. This method differs significantly from other profiling studies because it (1) uses data considerably more detailed than other sources and (2) measures natural surface elevations—before changes due to clearing, channelization, drainage, and land-leveling occurred. Results of this study are encouraging and several atypical features have been identified using this method. These features suggest an area of "sunk lands" in south-central Dunklin County and an area possibly affected by active tectonism in northwest Pemiscot and southwest New Madrid counties. A significant, previously overlooked resource of historic engineering elevation data exists in LRDD and other drainage district files. These databases should be developed and used in further studies of the New Madrid fault system.

Thompson, J. R. and Stewart, D., Department of Earth Sciences, Southeast Missouri State University. LANDSLIDES INDUCED BY A 4.7 MAGNITUDE EARTHQUAKE IN THE BENTON HILLS OF MISSOURI. On September 26, 1990, an earthquake of magnitude 4.7 occurred near New Hamburg, Missouri. Several resulting landslides were observed: the largest was less than three miles from the epicenter. The day of the quake, a zone of fissures 2-3' wide and 50-70' long formed transverse to the slope below the property owner's home (Lomax) across the drain field of his septic system. These fissures became a conduit for precipitation to infiltrate the slope. Precipitation for October through March was 28% above normal (27.33" vs. 21.39") (FAA, weather data for Cape Girardeau, Missouri). On April 2, 1991, a catastrophic failure occurred when a large block moved 20' downslope. The block continued to creep with 56' of displacement as of May 21, 1991. The block carried many large trees, several of which were pushed into a pond at the base of the slope. The block measured approximately 125' × 100' × 6', a volume of 75,000 cubic feet. Other landslides were observed 1/4 mile, 6 miles, and 67 miles away from the Lomax property. Numerous older slumps are observed in the Benton Hills, where soil conditions are conducive to such failures. Although the Lomax landslide occurred six months after the New Hamburg earthquake, we conclude that this event was an essential causative factor in the landslide's occurrence.

Vann, Bradley and Cocke, J. M., Geology Department, Central Missouri State University. A CORAL FAUNA FROM THE PENNSYLVANIAN LOWER MISSOURIAN KNOBTOWN SANDSTONE, CASS COUNTY, MISSOURI. A diverse and abundant fauna of rugose corals are noted here from the Missourian Knobtown sandstone of Cass County, Missouri. The accompanying noncorals are rare crinoid stems. Corals include fragments of *Cladochonus*, *Stereostylus*, *Caninia* (= *Pseudozaphrentoides* of some workers), ?*Bothrophyllum*, "*Aman-*

dophyllum, *Kionophyllum*, *Orygmophyllum* and large well developed *Amandophyllum*. *Caninia* is the largest and most abundant coral. It attains lengths and diameters of 32mm and 70mm respectively. All corals are well preserved with epitheca intact and with 60 to 70 percent of caninilids and amandophyllids found in growth position with no attachment area observed in either. The presence of rugose and tabulate corals in crossbedded sandstone has not been reported by earlier workers or observed by us. There is no evidence to support the correlation of the marine Knobtown and the fluvial Warrensburg sandstones.

Vierrether, C. B. and Grant, S. K., Department of Geology and Geophysics, University of Missouri-Rolla. PRIMARY AND SECONDARY MINERALOGICAL ASSEMBLAGES IN THE BOSS-BIXBY Cu-Fe DEPOSIT'S CENTRAL DOME. The Boss-Bixby Cu-Fe deposit lies within the Southeast Missouri Iron Metallogenic Province and is spatially associated with a NE-trending structural lineament. The deposit, part of a caldera complex, is a syenite stock that steeply intrudes felsitic tuffs and flows. The deposit consists of four Precambrian paleotopographic highs that are referred to as the Central Dome, West Dome, North Dome and East Dome. To date, this study has emphasized the detail core logging and petrographic sampling of the Central Dome. The most prominent features of the deposit are the stockwork veining and potassium-rich alteration. The stockwork veining is observable in the overlying volcanics as well as in the syenite; to a lesser extent in andesitic dikes. A polymineralic assemblage heals the stockwork veining and is largely comprised of magnetite, iron sulfides, copper-iron sulfides and fluorite. The potassium-rich alteration is pervasive, but zonal, and projects into the magnetite stockwork veining. Present in all borings logged to date are quartz-potassium feldspar veinlets and a nearly horizontal felsic dike containing secondary biotite and amphibole. Petrographic studies are currently underway to verify the megascopic observations.

Woody, R. E., Keller, D. J., Rasberry, M. A., Furman, F. C., Gammill, B. J., He, Z., and Gregg, J. M., Dept. of Geology and Geophysics, University of Missouri-Rolla. OCCURRENCE OF LOW TEMPERATURE BASSANITE IN SALT POND, SAN SALVADOR ISLAND, BAHAMAS. Bassanite, in association with gypsum, high Mg Calcite, and calcian dolomite, has been observed in an 83 cm sediment core taken from Salt Pond on the east side of San Salvador Island, Bahamas. Samples were analyzed using XRD, SEM-EDS, and optical microscopy. Low temperature (<45°C) orthorhombic bassanite ($\text{CaSO}_4 \cdot 0.48\text{H}_2\text{O}$) rarely occurs in nature as a dehydration product of gypsum in concentrated Na-MgCl solutions. This differs from the high temperature hexagonal variety of bassanite ($\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$) commonly encountered as plaster of Paris. Previous work on the paleosalinity of Salt Pond, using ostracodes, indicates possible fluctuations in salinity during the Holocene (Teeter, *et al.*, 1987). The occurrence of bassanite and gypsum at core depths of 0-5 cm and 55-75 cm corresponds with intervals where ostracodes are absent. This may indicate periods of high hypersalinity and sulfate precipitation.

Geography

Becker, B and May, D., Department of Geography, Geology and Planning, Southwest Missouri State University. THE UNIVERSITY: A REGIONAL RESOURCE. Many universities are attempting to strengthen and enlarge their outreach programs. For geography departments that have planning programs or work closely with planning programs, there are unique opportunities to enhance both their outreach programs and their classroom experiences through a public-public partnership. Many rural regional councils of governments are having financial difficulties as federal assistance is reduced. The establishment of a university administered council of governments opens opportunities for both the university and regional planning organizations. A university driven COG maximizes the opportunities for interrelating teaching, research, and public service. As universities assume a greater role in the growth and development of their regions, geography and planning programs can lead the way in this public-public partnership.

Bradbury, Susan L. and Becker, Barbara. Department of Geography, Geology and Planning, Southwest Missouri State University. WOMEN OWNED BUSINESS: THE FORGOTTEN SIDE OF ENTREPRENEURSHIP. Women owned businesses are the fastest growing segment of the small business population in the country. Women were responsible for 75% of the new firms started in 1985. In 1987 women owned businesses represented 30% of all sole proprietorships. However, despite the growing interest in small firms, overall women entrepreneurs have been neglected. This paper examines the significance and geography of women owned businesses and their contribution to employment and economic growth. Women entrepreneurs differ significantly from male entrepreneurs in terms of the kinds of businesses they create and sources of funding utilized. Furthermore, although women owned businesses employ fewer workers in comparison to industry averages they do contribute significantly to job creation.

Cheek, William H. and Catau, John C., Department of Geography, Geology and Planning, Southwest Missouri State University, and Christopher L. Salter, Department of Geography, University of Missouri-Columbia. ASSESSMENT OF GEOGRAPHY IN MISSOURI STATE UNIVERSITIES: A PROGRESS REPORT. There have been numerous calls for student outcome assessment of higher education in recent years. Institutions, disciplines, and individual departments have responded in a variety of ways. Whereas some have administered nationally normed exams such as the Major Field Achievement Test (MFAT) to assess the exit abilities of their majors, many disciplines, including geography, have no such option. As a result, the geography departments in Missouri's state assisted universities have had to develop their own assessment techniques. Among the methods either in use or under consideration are portfolios, senior capstone courses, exit interviews, and locally developed exams. In an

attempt to provide an outlet for mutual support and cooperation, representatives of the majority of Missouri's state assisted universities began meeting in 1990 to exchange ideas and perhaps develop a common assessment approach. This progress report will describe the status of this effort.

Dodds, C. W., Department of Geology/Geography, Northwest Missouri State University. **NORWEGIAN HYDROELECTRIC POWER: DEVELOPMENT, POLICY DEVELOPMENT, AND PROBLEMS.** Norway's pride in the development of pollution-free hydroelectric power is justifiable, but hardly unmitigatedly so. Throughout the history of the process unanticipated problems have arisen. Early policymakers had to address the rapid depletion of natural features such as waterfalls. From such environmental concerns right up to the present issues, such as inefficient overconsumption of cheap power by the Norwegians themselves, the best of all worlds in energy production has been plagued with crucial and embarrassing problems. Among several other current problems is the inability to market readily its excess production to power-hungry European industrial nations, because the high-tech Norwegian system that makes long distance transmission possible is too sophisticated for potential customers. As a report of the Norwegian experience, this paper provides geographers and planners with insights into the progress and pitfalls of a key alternative to fossil fuel energy production.

Hawkins, R. H., Department of Technology, Southwest Missouri State University. **NATIONAL ENVIRONMENTAL REGULATIONS: A PROTOCOL TO FACILITATE IMPLEMENTATION.** This study investigates federally mandated state programs from a strategic planning perspective. Data gathered in a forty-eight state survey (Underground Storage Tank Regulations) are used to identify the current status of individual state regulations. Pertinent Environmental Protection Agency regulations and petroleum industry publications are used to provide additional insight into the implementation of complex regulations from first a governmental and then an industrial view point. This information is melded using the techniques of advocacy planning and public policy implementation, creating a model which exemplifies strategic planning and problem solving. This model is applicable to any policy which involves discrete special interest groups and is accomplished at an individual citizen level. The protocol derived from this model is relevant to environmental planning and policy as well as other policies which seek to regulate activities that have complex, technical, or environmental facets.

Klein, M. and Johnson, E., Department of Geography, Geology, and Planning, Southwest Missouri State University. **DETECTION AND ANALYSIS OF SELECTED LANDFILLS IN MISSOURI BY USE OF REMOTE SENSING.** The purpose of this research is to assess the feasibility of detecting and monitoring landfills with different physical characteristics in central and southwest Missouri by use of remote sensing. Thematic Mapper data from four spectral bands and NHAP near infrared aerial photography were used to delineate the areal extent of active and inactive landfills. Digital number values from the Landsat data were analyzed by means of digital enhancement procedures. In addition, an unsupervised classification procedure was performed on the Landsat data for each landfill. The enhancement procedures were helpful in identifying bare ground and certain vegetative cover associated with the landfills. The resulting spectral classes representing the landfills closely matched the areal coverages of the landfills as identified on the aerial photographs. For the most part, the landfills classified as separate land cover entities within each subscene. Furthermore, varying portions of several landfills were represented by unclassified pixels relative to the surrounding environment. There were, however, variations in spectral digital number values between landfills.

Meserve, P. H., Geography/Geology, Columbia College. **THE MISSOURI RIVER: NOT MISSOURI'S RIVER.** The Missouri River, like all interstate rivers, is for the most part under federal control since early Supreme Court decisions ruled navigation is commerce. The Missouri state government has a locally significant role in developing Missouri River resources flowing through the state, but must rely on political representation at the national level to affect system-wide aspects of the resource. The legislative and judicial background to state non-control over rivers is reviewed with particular emphasis on the Missouri River. Recent disputes over Missouri River flows—including the upcoming lawsuit between up- and downstream riparian states—are examined from this perspective.

Schroeder, W. A., Department of Geography, University of Missouri-Columbia. **RECALCULATION OF THE 1804 POPULATION OF MISSOURI.** Stoddard's population estimate of 10,350 made in 1804 for the territory that became the state of Missouri has been the only figure available for the time of the Louisiana Purchase. It was an extrapolation from the defective Spanish census of 1800. Analysis of testimony that settlers presented before the U.S. Board of Land Commissioners to validate their land claims, however, indicates a population 25 per cent greater than Stoddard's estimate. Furthermore, the testimony, because it identifies people with specific tracts of land, enables a detailed map of the distribution of the population in 1804 to be made.

Barnes, Taylor C., Department of Geology/Geography, Northwest Missouri State University. **IMPACTS OF BASE CLOSINGS ON THE REDISTRIBUTION OF MILITARY RETIREES.** In 1989, Congress voted to close 86 installations and realign 54 others. One selected closure, Chanute AFB, Rantoul, IL, was examined in this research. Although government assistance is available for the base's 3700 military and civilian employees, no provisions have been made to assess the impact of the closure on the 2000 military retirees residing in the catchment region. With a strength in excess of 1.3 million, the retired military population living in the U.S. represents an important element in regional economies. DoD policies act as catalysts in channeling retirement migration and effect considerable long term social and economic impacts. Through the use of univariate statistics and a probit logistic model, I found that base closures have a considerable impact on a retiree's propensity to also relocate, thereby exacerbating the resultant economic impact of the closure. Because required DoD environmental impact statements resulting from base closures do not address the regional impact retiree's basic income has on the economic well-being of the affected community, I determined the resultant regional multiplier is under-estimated.

Linguistics

Zephir, F., Department of Romance Languages, University of Missouri-Columbia. POSTULATION OF TWO SEPARATE GRAMMARS: EVIDENCE FROM FRENCH AND HAITIAN CREOLE. The striking differences between the Creole languages and their lexifier language, notably in the area of syntax, have led Creolists to conclude that Creole languages possess a separate grammatical system. The present paper seeks to validate this position by offering comparative evidence from Haitian Creole and French. The determiner system of both languages is analyzed in order to justify the postulation of two distinct systems. Furthermore, an in-depth description of the definite article in Haitian Creole reveals that this grammatical category covers a broader syntactic and semantic scope than it does in the lexifier language. In French, the definite article always appears in pre-nominal position, and its function is primarily deictic: it specifies the noun. In Haitian Creole, the article "la" is always post-posed and it can occur (unlike French) in environments other than simple nominals, namely adjectivals, adverbials and prepositional phrases: relative and subordinate clauses. Moreover, it also has a rhetorical and phatic function.

Oncology

Ercal N., Matthews, R. H., Zukowski, J., and Armstrong, D., Department of Chemistry, University of Missouri-Rolla. EFFECTS OF WHOLE ABDOMEN IRRADIATION ON GLUTAMINE IN C57BL MICE. Glutamine may have a particular role as a preferred energy substrate of the gut and be important for its integrity and function. Gut is one of the major body systems which is known to be very sensitive to irradiation. In stress conditions including radiation, surgery, infection, burns etc., glutamine consumption may increase with a decrease of plasma glutamine levels. In the present study, we measured plasma glutamine levels in C57BL male mice by HPLC after whole abdomen irradiation to doses of 0, 1000 and 1500 cGy. Plasma glutamine levels at 0, 1000 and 1500 cGy were respectively 933 ± 131 ($n=4$), 766 ± 56 ($n=4$), 457 ± 65 ($n=6$). Measurements made at 24, 48 and 72 hrs intervals after irradiation were not found to be significantly different. There was a 51% decrease in plasma level at the highest level of irradiation.

Jalandoni, D. J., Kulasekera, K., and Kunze, J. F., Department of Nuclear Engineering/Medical Physics, University of Missouri-Columbia. BORON NEUTRON CAPTURE THERAPY (BNCT) USING A 2 MeV RFQ (PROTON) ACCELERATOR.

BNCT may be a more effective means of treating some types of cancer than conventional radiotherapy methods. BNC reactions produce high LET alpha particles which are less dependent on the oxygen in cells (OER = 1.6). The effect of these particles on cells is also somewhat independent of their position in the cell division process. Previous studies have shown that, for BNCT, an accelerator based neutron facility is administratively more desirable for a hospital, but it appears an accelerator source has inferior performance to a moderated neutron beam from a reactor. This is predominant in the areas of total absorption rates for neutron and gamma rays, the treatment time and the maximum usable depth (MUD). Studies are being done to determine methods to mitigate this disadvantage of the accelerator sources. The current study is performed to establish a benchmark measurement using a 2 MeV RFQ proton accelerator, for the production of the prescribed neutron flux and energies required for BNCT at the patient location. A system will be designed to produce epithermal neutrons in the energy range keV-likeV, and various materials will be tested to characterize the output neutron spectrum of the system. The study assumes that a minimum concentration of 30 micrograms of B-10 per gram of malignant tissue can be achieved in the tumor.

Matthews, R. H. and Ercal, N., Phelps County Regional Medical Center. NODULAR POORLY-DIFFERENTIATED LYMPHOCYTIC LYMPHOMA (NPDL) OF THE THYROID. A 44-year-old, otherwise healthy, white female presented to our institution in December 1989 with enlarging neck mass which on biopsy proved to be NPDL of the thyroid: work-up showed no evidence of disease elsewhere and the patient was staged I-E NPDL of the thyroid. Thyroid lymphomas of the whole are uncommon, but when they do occur they are usually of a type referred to as diffuse histiocytic or diffuse large cell lymphoma (DLC). The case presented is a truly rare disease: should it be treated as thyroid lymphoma, which is usually DLC, or as NPDL as it occurs in other sites? Early stage DLC of the thyroid has been treated by an XRT technique known as thyroid mantle alone with good results. NPDL is slow-progressing, but is uncommonly stage I or II, and laparotomy advances most NPDL patients to stage III in work-up. We elected to treat our patient with combined-modality chemo/XRT, achieving CR. The patient remains free of disease at greater than one year after completion of treatment.

Physics

Anderson, R., Department of Physics, University of Missouri-Rolla. DESIGN PARAMETERS FOR A FRESNEL LENS OR MIRROR. With the development of several new solid state lasers in the infrared and with the development of infrared transmitting fluoride and chalcogenide glasses, there is a need for the development of a Fresnel microlens and in some limited cases a Fresnel micromirror in the spectral region from 1 to 11 μm . There are serious problems in developing these lenses because of the limited number of materials with adequately small water solubility and which are durable. It will be shown that an effective Fresnel microlens can only be designed for

limited range of f-number and this may limit their use where large focal lengths are desired to match the small fiber diameters.

Redd, E., Department of Technology, Southwest Missouri State University. PUDDLE ICE RIDGES. Ridges sometime form on the under side of the ice covering a frozen puddle. They appear as ring patterns in the ice. A ridge forms at the edge of an area where water is in contact with the ice. This area is encircled by a vertically thin, toroidal bubble. The frozen surface and the puddle's draining create the water contact area and the bubble. Two properties of water (surface tension and maximum density at 4°C) then drive ridge formation. The ridge forms by preferential freezing at the three phase intersection (ice, water, and air). Usually the ridges are small (~1 mm in height). In most cases a ridge's growth is self-limiting. This results in multiple ridges on a single puddle. However, after one very rapid temperature fall, I noted a puddle which had frozen completely to its bottom as it drained. This produced small-scale ice caverns with walls textured like the surface of drawn, semiconductor crystal ingots.

Samiullah, M. and Rolnick, P., Division of Science, Northeast Missouri State University. QUANTUM INSTABILITY OF THE CHIRAL SOLITON WITH RESPECT TO VARIATION OF PROFILE PARAMETERS. It has been shown that the simple chiral lagrangian $\frac{1}{4}\text{Tr}(\partial_\mu U \partial_\mu U^*)$ has a soliton-like solution which, for isospin 1/2, has properties similar to those of the nucleon, but which is classically unstable. Jain et al claim that quantum fluctuations in the breathing mode stabilize this solution. Kobayashi et al found that, in the space of profile functions, there exists a path leading to collapse of the soliton to zero size. We investigated this problem in the harmonic approximation and found the explicit dependence of the soliton energy on the parameters of the profile function. We found, as suggested by Jain et al, that, for isospin 0 and physically meaningful values of the parameters, the soliton energy has a minimum. However, by allowing these parameters to vary, this minimum can be made arbitrarily small.

Science Education

Berkland, T. R., Earth Science Department, Central Missouri State University. SUMMER HONORS PROGRAM FOR HIGH SCHOOL STUDENTS AT HOLDREGE, NEBRASKA. A unique program for high school students has been offered to the South Central Nebraska District's students for the last fifteen years. Originally started through a National Science Foundation grant, the program has continued being supported through a self-imposed district tax. A two-week intensive course is offered in natural science, medical science, art, creative writing, logic, computer programming, sociology, statistics, and technology as selections for the nearly 100 students who participated in Summer, 1991. Teachers for the program are selected nationally and internationally from among college and high school faculty. For university faculty, the program offers an excellent chance for interaction with high school students.

Gottfried, S. S., Departments of Biology and Educational Studies, University of Missouri-St. Louis. TEACHER OUTCOMES: A SUMMER RESEARCH EXPERIENCE FOR INNER CITY SCIENCE TEACHERS. A formative evaluation of a summer scientific research/science education program was designed to measure its effectiveness during its first two years of implementation. This report focuses on areas of the study that reflect teacher outcomes: the value of the program as perceived by the teachers, the impact of the program on the ability of the teachers to implement a hands-on lab-oriented curricula, and the change in the teachers' understanding of the nature of science. The quantitative measures used were: *The Test of Integrated Process Skills (TIPS)* and *The Science Classroom Activity Checklist (SCAC)*. The qualitative methods used were questionnaires designed for the study, and classroom observation. In the first year, scores on the TIPS test showed a mean gain of 1.38, which was not statistically significant ($p < 0.05$). The SCAC showed that teachers made 11% and 13% gains in two of the categories indicating gains in the use of lab activities in the classroom, but these gains were not statistically significant ($p < 0.05$). The qualitative data revealed that the teachers highly valued the program and perceived that it substantially impacted their ability to implement a hands-on lab-oriented curricula. Results from the second year of the study are currently being analyzed.

Iverson, P. L., Mares, K. R., and Granger, C. R., The George Engelmann Mathematics and Science Institute, UM-St. Louis. THE GEORGE ENGELMANN MATHEMATICS AND SCIENCE INSTITUTE - Phase II and Phase III.

Phase II (Scholar Research Program) and Phase III (Academic Year Program) are programs that provide Engelmann Scholar with the opportunity to continue their investigation of science and mathematics. The Scholars Research Program enables the students to return to an area university for six weeks to conduct research projects in biology, chemistry, mathematics, physics or psychology under the supervision of a mentor scientist. Scholars are integrated into the dynamics of a working research environment. Each student must present a scholarly paper on their research findings. Classes and research are conducted using the facilities of the University of Missouri-St. Louis, St. Louis University, and Washington University. The activities are augmented by field trips and guest speakers from the community. To reinforce the students' experiences and to ensure year-round exposure to basic scientific disciplines and career opportunities, the Engelmann Institute offers an Academic Year Program during the school year. Students are brought together for monthly seminars to discuss timely scientific topics. These interactions help continue the positive relationships developed between faculty and peers and support the students' sense of confidence in themselves as science scholars.

Jones, J. Michael, Biology Department, Culver-Stockton College. WHY DO COLLEGE STUDENTS LEAVE SCIENCE—MYTHS AND MAYBES. Several recent reports describe the loss of an alarming number of potential scientists who are students at the college level. A survey of approximately 200 students suggests that such reports may not accurately reflect the small liberal arts college. Large numbers of potential science students are not switching to nonscience disciplines. Science majors do not switch because they perceive limited career opportunities, nor because they perceive science as boring, nor because they perceive too much memorization, nor because science is perceived as too difficult. Other factors may influence the science student's decision to switch; these factors include issues of relevance, instructor attitudes, and pedagogy.

Oshima, E. A., Department of Curriculum and Instruction, Central Missouri State University. PROMOTING CRITICAL THINKING SKILLS IN BIOLOGY COURSES. Like the weather, many teachers talk about the importance of critical thinking skills but few attempt to promote their development. The problem is not whether these skills are important, or whether they can be taught; the problem is whether we are willing to make the necessary changes needed to teach them. Materials and teaching strategies that enhance critical thinking were used. For example, a laboratory manual which "presents biology as an investigative, intellectually stimulating experience emphasizing thinking" was adopted; styles of questioning during discussions, test items, etc. were modified. Results from past years' efforts indicate satisfactory gains. Pre- and post-tests normed based on 229 Hoftra University students showed a 9.1% gain in mean scores, significant at the .01 level of confidence. CENTRAL's students showed comparable gains (11.9%). Biology courses can be modified to promote critical thinking skills.

Powers, M. H., Department of Chemistry and Physics, Central Missouri State University. ASSESSMENT-AS-LEARNING IN CHEMISTRY. This paper is a report of a project undertaken as part of Phase III of an on going program of action research on assessment at Central. This project involved designing and implementing three assessment activities for Communication Skills in Chemistry, a course designed to support the capstone research experience for the chemistry major. Assessment activities have been designed in accord with selected student outcomes and criteria for assessing the outcomes have also been designed. Assessment-as-learning projects involving writing, speaking and searching the chemical literature have been implemented. Results from this project are encouraging. For example, 89% of the students indicated that the writing assessment was very effective in helping them become better writers. Similar results were obtained for the speaking and searching components. Results also indicate that there is no reduction in content knowledge, even though lecture time was reduced. Supported by the Office of the Provost and the Faculty Senate Assessment Committee.

Protima, Roy and White, Jayne, Department of Education, Drury College, Springfield, MO 65802. HANDS-ON SCIENCE FOR ELEMENTARY TEACHERS.

A summer course titled "Hands-on Science for Elementary Teachers" was offered through the graduate program in the department of education at Drury College. It was specially designed for both the pre-service and in-service teachers to motivate them to teach science and to alleviate their science anxiety levels.

Nine graduate students were enrolled in this course. Altogether 18 grade school children in the range of grades between 4 to 6 were selected to participate in this summer program.

Course evaluation shows that both the graduate and undergraduate students enjoyed the opportunities to work with the children. Overall, this course helped them to reduce their anxiety level and also they gained confidence in teaching science to the children.

Rushin, J. W. and Nothstine, S., Biology Department, Missouri Western State College. THE JUNIOR DIVISION-MAS: SCIENCE OPPORTUNITIES FOR SECONDARY STUDENTS. This paper summarizes the basic structure of the Junior Division of the Missouri Academy of Science and the various opportunities that this organization provides for high school and middle school teachers at both district and state levels. All of the scholarships, awards, prizes, etc., that are available to outstanding secondary students and teachers through the science paper competitions are described. Other related programs are also described. In addition, an analysis of the participation trends in the state paper competition broken down by grade level, subject category, and gender is also provided for the past three years. Significant results include a higher number of life science and social/behavioral projects over physical science and computer science. There was also a significantly higher percentage of females over males selected to compete in the state paper competitions.

Scism, A. J., Department of Chemistry and Physics, Central Missouri State University. USE OF MICROSCALE CHEMISTRY IN MISSOURI SECONDARY SCHOOLS. The use of microscale techniques in teaching chemistry at the secondary level offers advantages which include lower materials costs, less waste generated, easier manipulation of materials, and improved safety. To what extent are microscale techniques being used in Missouri secondary schools? To answer this question 520 secondary school chemistry teachers (grades 9-12) were surveyed in spring, 1991. The response rate was 34.4%. Of the respondents, only about 31% reported using microscale techniques. Of this group, only about 4% use the techniques exclusively, but about 14% use microscale techniques for as many as half of their labs. Of those using microscale, 96% were moderately to very satisfied. Most teachers thought concepts were learned equally well with microscale or traditional techniques but 23% of the users thought the techniques led to enhanced learning. It appears that many Missouri secondary school chemistry teachers could benefit from the use of microscale techniques.

Thomas, William E., INQUIRY PHYSICS: BRIDGING THE GENDER GAP. Department of Physics & Astronomy, Southwest Missouri State Univ. The analysis of nearly 1500 student responses to questions involving two-dimensional motion has uncovered strong and wide-spread differences with respect to gender. These

differences, in favor of males in all cases, were independent of academic major, science and mathematics background, class standing, and reasoning ability. An additional 200 questionnaires were given as posttests in both traditional lecture-discussion-laboratory physics courses and inquiry-based physics classes. The analysis of these responses, along with the pretest results, showed that (1) the pretest mean scores for men were significantly higher than those for women in both types of classes, (2) in the traditional courses the prepost gains for men were greater than those for women, and (3) in the inquiry-based classes the pre-post gains for women were greater than those for men, producing the only instance of no significant differences between genders.

Collegiate Division

Biology

Deering, P. and Schaffer, K. L., Dept. of Biology, Northwest Missouri State University. THE USE OF SHREDDED NEWSPAPER AS A SOIL AMENDMENT FOR MARIGOLD, TOMATO AND WINTER WHEAT SEEDLINGS. Old newspapers (ONP) account for 7;15% of the total paper volume in municipal solid waste systems. New recycling markets are sought as a lack of demand for ONP has resulted in an over supply. This experiment was to determine whether the use of ONP as a soil amendment is a viable recycling alternative. Marigold, tomato and winter wheat seedlings were subjected to one of the following: 1) control, soil only; 2) soil amended with water soaked ONP; 3) soil amended with urea (2.3g/l) soaked ONP; 4) soil amended with fertilizer soaked ONP. Chlorosis and/or anthocyanin formation in leaf veins, petioles and stems first occurred in plants grown in soil with ONP. Nitrogen deficiencies were attributed to the high carbon content of ONP. The use of scanning electron microscopy confirmed greater ONP decomposition in groups 3 and 4. These results suggest that plant growth was inhibited due to the high C/N ratio in ONP and further research is needed before ONP amended soils can be used as a tool for recycling. Supported by Northwest Undergraduate Research Program.

Johnston, R. L., Department of Biology, Missouri Southern State College. THE EFFECTIVENESS OF A GRASSLAND MANAGEMENT PLAN BASED ON MORTALITY STUDIES IN ENGLAND. The purpose of this study was to determine the merit of a program developed by Dr. James Jackson for Crickley Hill Country Park. The plan was enacted in 1991 to help protect the park turf from visitor and archaeological damage. Moisture and mortality measurements were taken at regular intervals on sections of disturbed and undisturbed turf plus mortality rates were kept for four indicator species on the same areas of turf to determine the effectiveness of the program. The results were subjected to descriptive statistics in which the mean and standard deviation within a known confidence interval were determined. Both sets of data indicated that the plan was successful. Further studies are planned to continue to record the effectiveness of the plan and to make improvements.

Moseley, L. G. and Kaps, M. L., Department of Biology, Southwest Missouri State University. THE EFFECTS OF LEAF REMOVAL ON COLORATION OF RELIANCE GRAPES. Under southern Missouri environmental conditions, Reliance table grape develops an uncharacteristic poor red berry color. This experiment was designed to ascertain the effects of leaf removal in the fruit zone as a means of improving red color. Using a completely randomized design of 5 replications for each of 2 training systems, Umbrella Kniffen and High Cordon, 4 leaves per fruit zone of each shoot were removed 2 weeks after bloom. No leaves were removed from the control replicates. Light penetration into the fruit zone, as measured with LI-COR quantum light sensors, was greater in the leaf removal treatment for 1 of three light readings. Color differences, as measured by a Minolta Chromameter programmed with the Hunter "L a b" system, showed a higher Hunter "a" value (red color) in the leaf removal treatment. Leaf removal improved the coloration of Reliance table grapes, but not to such a significant level to suggest this as a standard viticultural practice for all training systems.

Paige, T. B., Missouri Southern State College, Joplin, MO.

The root of *Cimicifuga racemosa*, more commonly known as the herb, black cohosh, has been reported in herbal lore to have estrogenic properties. Some have said that black cohosh contains estrogen itself. Black cohosh is used by many women in place of estrogen for estrogen replacement therapy.

Rats were assigned to four different groups. Group 1 had intact ovaries and no injections. Groups 2 through 4 were ovariectomized. Group 2 did not receive any injections. Group 3 received estrogen injections, and group 4 received black cohosh solution injections. After 5 sets of injections to groups 3 and 4, all rats were sacrificed, and their uteri were immediately removed, trimmed, and weighed. The main hypotheses were that group 4's uterine weights would be not significantly different from the uterine weights of groups 1 and 3, and significantly greater than group 2's uterine weights.

The data indicated that, contrary to hypothesis, the uterine weights of group 4 were significantly less than uterine weights of group 1. Overall, the uterine weights of group 4 were less than uterine weights of all other groups, a result different than what was predicted.

These data also indicate that black cohosh does not have estrogenic effects in regard to increasing uterine weight. It may be important to determine whether black cohosh has any other estrogenic effects that have been claimed.

Davis, Brent, Drury College, Springfield, MO, and **Sullivan, L. P.**, Kansas University Medical Center, Kansas City, KS. TECHNIQUES FOR STUDYING FLUID TRANSPORT BY CULTURED EPITHELIAL CELLS.

A subtype of the Madin-Darby canine kidney (MDCK) cell line forms fluid-filled cysts when the cells propagate within collagen gel. The cyst wall consists of a single cell layer with the apical surface of the cell forming the inner cyst wall. Cysts grow by cell propagation and by fluid secretion into the cyst. We are developing techniques for studying the mechanisms involved in fluid secretion by single cysts. A microscopic video technique is used to measure the rate of increase in cyst volume. Micro-epifluorimetric techniques have been adapted to measure changes in cell pH and in membrane potentials. Fluid secretion is stimulated by agents that increase cyclic AMP levels and is inhibited by ouabain. Vasopressin and isobromomethyl xanthine increased fluid secretion from $-0.22 \pm .27$ (SE) to 3.85 ± 1.1 nL/min/cm² inner cyst surface area in cysts with a diameter of 103 ± 24 μ m. The

onset of secretion is accompanied by a transient hyperpolarization of the membrane potential followed by a long-lasting depolarization. Amiloride dropped cell pH from 7.04 to 8.84 in 3 expts and reduced fluid secretion from 5.04 to 0.58 nL/min/cm². This suggests that the Na-H exchanger may play a role in fluid secretion.

Pearson, Tara M., Lord, Pamala, and Roy, Rabindra N., Department of Chemistry, Drury College, Springfield, MO 65802. ESTIMATION OF LIQUID JUNCTION POTENTIAL AND THE DETERMINATION OF THE PH FOR THE BIOCHEMICAL BUFFER MOPS AT 25°C.

Electromotive force measurements have been made on the cells:



The second ionization constants for Mops [3-(N-morpholino) propanesulfonic acid] were calculated from the first cell. The pH and liquid junction potentials were calculated for MOPS in order to compare corrected pH (using δE_j) values with those found by use of a glass electrode system. The results will be discussed with relation to the application to body fluids [isotonic saline solution, 0.16 m].

Smith, Blair M. and Scottgale, T. Nelson, Department of Biology, William Jewell College, THE *SERRATE* GENE AND IT'S EFFECTS ON ECTODERMAL DEVELOPMENT IN *DROSOPHILA MELANOGASTER*. During *Drosophila* embryonic development, cells in the ventral ectoderm differentiate into precursors of the central nervous system (CNS) or the ventral epidermis. This development decision is under genetic control. The neurogenic loci, six zygotically acting genes, if mutant cause only neural development from ventral ectoderm resulting in lethality. Lack of *Serrate* gene function causes embryonic lethality, but does not cause neural overgrowth; rather, the CNS is disorganized and both dorsal and ventral epidermis are disrupted. My study involved asking whether the neurogenic loci and *Serrate* are involved in the same developmental pathway, and I approached this by seeing if genetic interactions between *Serrate* mutations and neurogenic mutations exist. I found that *Serrate* mutations appear to enhance the phenotype of *Delta* mutations, when both are heterozygous in a fly. Flies hemizygous for certain *Notch* mutations and heterozygous for a *Serrate* mutation display a novel wing phenotype. Both observations suggest that these 2 neurogenic loci may be interacting with *Serrate* during CNS and epidermal differentiation. Supported by NSF grant #NSF-9108071 and a grant from MAS.

Blair, S. D., Department of Biology, Central Methodist College. RETINOIDS AND THEIR EFFECTS ON THE MOUSE PROSTATE RECONSTITUTION MODEL. Previous studies have shown that various retinoids, most recently 4-hydroxyphenyl retinamide (4-HPR), have chemopreventative effects on a variety of carcinomas. This study was conducted to compare the growth of prostate reconstitutions in experimental and control specimens of the *Mus musculus*, C57 strain. The experimental groups were maintained on 4-HPR and 13-cis retinoic acid (RA) diets. All animals were fed their diets, with or without the retinoid, for a duration of five weeks. After the first week, the urogenital sinuses of 14 day mouse fetuses were inoculated with ras/myc oncogenes and grafted under the renal cortex of the adult males. These 'reconstituted prostate tissues' were then allowed to grow for a total of four weeks. At the end of this time, the graphs were removed, weighed, assayed for infections, and frozen for future study. A total of 8-RA, 7-RA control, 4-HPR, and 9-HPR control mice were used. The food concentrations were 586 mg/kg food of 4-HPR and 200 mg/kg food of RA. In previous studies, the use of ras/myc was demonstrated rather well, showing approximately a 14-fold increase in weight of the prostate reconstitution. Both retinoids produced promising results. The average weights for the experimental groups were 152.1 mg for RA and 109.58 mg for 4-HPR. The average weights of the control groups were 478.34 mg for RA and 350.4 mg for 4-HPR. These vast differences in wet weights point strongly in the direction of the therapeutic value of these retinoids, as there was definite inhibition of growth.

Dunbar, Amy D., Department of Biology, William Jewell College. A COMPARISON STUDY OF *Uvulifer ambloplitis* (BLACK SPOT DISEASE) IN FISHES IN NORTHERN AND SOUTHERN MISSOURI STREAMS. A survey was conducted to determine if there was a statistically significant difference in the number of fish infected with the parasite *Uvulifer ambloplitis* in northern and southern Missouri streams. The intermediate host for this parasite is the snail, *Helisoma* spp. Fish samples were seined on May 20-21 and October 5, 1991 from Clear Creek and Bull Creek near Springfield, MO. Seining in Rush Creek near Liberty, MO occurred on September 23, and November 21, 1991. Streams in northern Missouri are turbid and slow moving with mud or sand bottoms. Southern streams are swift, clear and have rocky bottoms. A total of 569 fish were collected of unequal numbers from each stream type, including 24 species representing six families. The species showing the greatest number of infected fish was the Red Shiner, *Notropis lutrensis*. In the southern collection, 83.6% of fish were unaffected while 16.4% were affected with at least one spot. In the northern collection, 44.2% were unaffected while 55.8% were affected with at least one spot. Although no population counts of snails were obtained, one possible explanation for the results could be the population levels of the intermediate host, *Helisoma* spp. and its habitat preference for the stream type in northern Missouri. Supported by MAS.

Johnson, Mark W. and Smith, D., Dept. of Biology, Northwest Missouri State University, THE EFFECTS OF ELECTROMAGNETIC FIELDS ON FETAL DEVELOPMENT OF RATS. Rats were exposed to two environmental conditions. Twenty female Sprague-Dawley rats were placed in each experimental condition: 1) High electric field, low magnetic field; 2) Low electric field, high magnetic field. Studies have indicated that EMF's have an effect on the fetal development and the female reproductive tract. In this study, general observation of most animals exhibited surplus caruncles within the uteri, with necrotic tissue resembling cotyledons. A statistically significant difference was seen in size and weights of animals exposed to the magnetic field as compared to the control

animals. Mortality rate for the electric field animals, during the nurturing stage was above normal. Several litters did not live to weaning.

Jordan, R. and Kirk, M. D., Division of Biological Sciences, University of Missouri-Columbia. NEUROMUSCULAR ORGANIZATION OF FEEDING MUSCULATURE OF THE SEA HARE *APLYSIA CALIFORNICA*. In *Aplysia* feeding behavior, the intrinsic muscles of the buccal mass work together to produce rhythmic protractions and retractions of the radula. In our previous studies we found several motoneurons that control the buccal musculature and innervate multiple, nonhomologous muscles. We used intracellular and extracellular recording techniques to further characterize innervation by one motoneuron B11 and to determine its neuromuscular plasticities on these muscles. We found that B11 innervates all of the major intrinsic buccal muscles, and from experiments using antagonists to acetylcholine (ACh) receptors we found strong evidence that B11 uses acetylcholine as its neurotransmitter. By characterizing motoneurons involved in producing feeding behavior, especially those that innervate more than one muscle, we hope to be able to use this system as a model to study neuromuscular control of behavior. Supported by DHHS grant NS24662 and the Howard Hughes Medical Institute.

Kouba A. and Smith, D., Dept. of Biology, Northwest Missouri State University, SEMEN ANALYSIS BY RECTAL EJACULATION OF RATS EXPOSED TO EMF FORCES. In previous experiments post-coital collection of sperm by the removal of the copulatory plug did not produce usable results in male rats exposed to EMF forces. The development of a rectal probe to collect sperm via electroejaculation enabled the research to routinely collect viable sperm for semen analysis. A bipolar rectal probe was used to collect semen from male rats by a successive series (5 V) of electrical stimuli with 2 sec. durations. Alternating current proved the most effective (85%) with an ejaculate collected near 3.5 to 4.0 volts, with a maximum voltage of 5. Semen was collected for examination and diluted with saline solution. Motility and sperm counts were used to determine amount of viable semen in those rats exposed to EMF forces compared to the control.

Kramer, Pamela, Department of Biology, Missouri Western State College. THE EFFECT OF VARIOUS CONCENTRATIONS OF RETINOL PALMITATE ON THE HEAD FREQUENCY REGENERATION OF 1/6 POST-CEPHALIC SEGMENTS OF THE PLANARIAN, *DUGESIA TIGRINA*. This study was done to determine the effect of retinol palmitate, an analog of Vitamin A, on the head development of 1/6 post-cephalic segments of the brown planarian, *Dugesia tigrina*. A head frequency was calculated for segments exposed to 25 IU/ml, 2.5 IU/ml, 0.25 IU/ml and 0.0 IU/ml concentrations of retinol palmitate. The head frequency index was plotted as the ordinate against the post-cephalic body segment and the resultant curves were compared using an analysis of variance test. The planarian life cycle was found to have a profound effect on the regeneration process, therefore the study was replicated three times during different seasons of the year. Trial I (March 91) results showed significantly higher head frequency averages for body segments three and four in the retinol palmitate concentration of 2.5 IU/ml and segment four in the 0.25 IU/ml concentration when compared to the same segments of the control. Trial II (July 91) results were insufficient to calculate head frequency indices due to a high mortality rate for all segments. Trial III (December 91) results supported the results obtained in Trial I by affirming the effect of retinol palmitate on segments three and four in the planaria.

Morgan, H. A., Department of Biology, William Jewell College. A DETERMINATION OF WINTERING AVIAN SPECIES IN A TALLGRASS PRAIRIE AT THE MARTHA LAFITE THOMPSON NATURE SANCTUARY. A banding study was conducted from November 1991 through March 1992 in an 8-acre seeded tallgrass prairie to identify fall and winter residents. No previous survey of wintering species had been conducted at the sanctuary. Birds driven into mist nets were banded, weighed, and released. Of the 74 birds caught and banded, 83.8% were American Tree sparrows, *Spizella arborea*, 6.7% were Slate-colored Juncos, *Junco hymelis*, 5.4% were Song sparrows, *Melospiza melodia*, and 4.1% were Swamp sparrows, *Melospiza georgiana*. Average weight of the birds was 15.6g for Tree sparrows, 18.3g for Juncos, 20.0g for Song sparrows, and 17.0g for Swamp sparrows. Supported by MAS.

Nack, J. A., Hoffman, L. M., Bergey, M. A., and Sexton, W. L., Kirksville College of Osteopathic Medicine. EFFECTS OF EXERCISE TRAINING IN DIABETIC RATS. The purpose of this study was to investigate the effects of exercise training in diabetic rats. Male Sprague-Dawley rats (n = 69) were randomly divided into control (C) and diabetic (D; streptozotocin 65 mg/kg iv) groups and subdivided into sedentary (SC and SD) and exercise trained (ETC and ETD) groups. ETC and ETD rats ran on a treadmill 60 min/d for 13 wks at 45 ft/min on a 20% incline, while SC and SD rats were cage-confined. Under halothane anesthesia, a catheter was surgically implanted into the right carotid artery and exteriorized, and fasting plasma glucose concentration (mg/dl) was measured. Mean arterial pressure (MAP; mmHg) and heart rate (HR; b/min) were measured at rest (R) and during exercise (E).

	N	Weight, g	(Glucose)	R-MAP	E-MAP	R-HR	E-HR
SC	21	451 ± 8	161 ± 6	129 ± 2	137 ± 3	416 ± 10	516 ± 7
SD	18	260 ± 16*	488 ± 19*	105 ± 3*	129 ± 2*	330 ± 14*	440 ± 13*
ETC	16	429 ± 8	170 ± 7	131 ± 1	137 ± 3	423 ± 6	513 ± 5
ETD	14	315 ± 21*#	371 ± 14*#	116 ± 3*#	125 ± 4*	360 ± 14*	440 ± 14*

(*P ≤ 0.05 vs. SC and ETD; # P ≤ 0.05 vs. SD)

Exercise training resulted in higher body weights and lower plasma glucose levels compared to age-matched SD. Exercise training also attenuated the diabetes-induced reduction in resting MAP. These data suggest that exercise training may attenuate some of the deleterious effects of diabetes.

Scott, S. L., Department of Biology, William Jewell College. THE IMPORTANCE OF BODY COMPOSITION IN WEIGHT MAINTENANCE. Previous research has shown a direct correlation between body composition and determining overweight or obese individuals. This study was conducted to further investigate the effect of a combined exercise and diet regimen on body composition. The study is based on the hypothesis that a combined exercise and diet regimen would decrease body fat more efficiently than exercise or diet alone. Research was conducted on 25 individuals ranging in age from 18-22 years. The method used to calculate the total body composition was bioelectrical impedance. Using electrodes, this method measures the amount of conductive tissue the body presents to a current. Using a computer program the percent body fat can be calculated using the individuals height, weight, frame size, and sex. Four experimental groups were studied: Exercise and Diet, Exercise, Diet, and a Control group. From the data collected in this study the diet group had the highest total fat loss at -3.5%, the exercise group had a gain of 4.6% and the exercise and diet group also gained 6.7% body fat overall. These results do not support the original hypothesis.

Zigelhofer, C. and Scottgale, G., Department of Biology, William Jewell College. THE EFFECTS OF EXERCISE ON APPETITE, BODY WEIGHT AND RESTING METABOLISM IN MALE MICE. Previous studies have been inconsistent in their results about the effects of exercise on appetite and resting metabolism. This study was done in order to determine what type of effects could be seen in mice that exercised regularly. The experimental mice were run in rodent wheels 4 days a week for 30 minutes each day. The control mice were caged throughout the experiment. Body weight, resting metabolism, and food intake were measured once weekly for 18 weeks. All mice were fed regular mouse chow. Resting metabolism was measured in the morning using a small metabolism chamber. Over the 18-week period, the average weight gain was 13.9g for the control mice and 13.7g for the running mice. Food consumption was somewhat higher in the runners; the controls averaged 32.3g/week and the runners averaged 35.7g/week. Resting metabolism measurements were variable because the mice were awake and somewhat restless. Supported by a grant from the Missouri Academy of Science

Chemistry - Sections I & II

Jaskiewicz, K. K., Division of Science, Northeast Missouri State University. CONFIDENCE LIMITS FOR LINEAR TITRATIONS: THE PROBLEM OF CORRELATION. Earlier workers have proposed a number of different methods for obtaining confidence intervals for equivalence point volumes of titrations in which the endpoint is indicated by intersecting line segments. Several of these methods were first presented without mutual comparison. We compare the results from Fieller's theorem (which has a firm basis in mathematical statistics) with results from two methods proposed by D. Ceausescu and V. Eliu-Ceausescu. The first of their methods treats the independent variable as insignificantly affected by error, and treats the slope and intercept of the regression line as statistically independent, which is not true. The method gives results significantly different from those obtained by Fieller's theorem. Their second method purports to address these deficiencies by modelling each branch of the curve as a closely correlated bidimensional normal distribution. The mathematics of this latter approach has some aspects in common with Creasy's method, but avoids the difficult numerical integration.

Moore, C. Porter, Roy, Rabindra N., and Pearson, Tara, Department of Chemistry, Drury College, Springfield, MO 65802 and **Johnson, David A.**, Department of Chemistry, Spring Arbor College, Spring Arbor, MI 49283. THE SECOND DISSOCIATION CONSTANT OF CARBONIC ACID IN SEAWATER MEDIA.

The second thermodynamic dissociation constant, K_2 , of carbonic acid in synthetic seawater of a salinity of 35 was determined at temperatures ranging from 273.15 to 318.15K using the electromotive force method, without liquid junction:

Pt: H_2 (g, 1 atm.) | Na_2CO_3 (m_1), $NaHCO_3$ (m_2) in seawater | AgCl; Ag was measured at each temperature and the apparent values of pK_2 were calculated using the Nernst equation, and will be compared with the values from the literature in pure as well as synthetic seawater.

Vogel, Kathleen M., Pearson, Tara M., and Roy, Rabindra N., Department of Chemistry, Drury College, Springfield, MO 65802. THERMODYNAMICS OF CARBONIC ACID-CARBONATE EQUILIBRIA IN RELATION TO GREENHOUSE EFFECT.

The standard potential of the ($AgCl(s) + \frac{1}{2}H_2(g) = Ag(s) + HCl(aq)$) cell has been determined in synthetic sea water of salinity 35. Electromotive force measurements were made on the cell without liquid junction:

Pt: $H_2(g, 1 atm)$ | $HCl(m_1)$, synthetic sea water | AgCl; Ag. The concentrations of HCl ranged from 0.0025 to 0.0400 mol/kg. These results were used to determine the pK and pK' of carbonic acid as a function of temperature. The Nernst expression was rearranged and the results extrapolated to pure ionic media using least-squares regression techniques to establish the standard potential of the cell. The results will be presented for the temperature range 273.15 to 318.15 K and will be compared with the results of other researchers. The results will be discussed in terms of the greenhouse effect and global warming.

Williamson, Becky, Roy, Rabindra N., Roy, Lakshmi N., and Hagerty, Patrick, Department of Chemistry, Drury College, Springfield, MO 65802 and **Johnson, David A.**, Department of Chemistry, Spring Arbor College, Spring Arbor, MI 49283. THE FIRST DISSOCIATION OF CARBONIC ACID AND PH STUDIES IN OCEAN WATER.

Electromotive force measurements were made on the cell without liquid junction:

Pt: $H_2(g, 1 atm)$ | $Na_2CO_3(m_1)$, $NaHCO_3(m_2)$ in seawater | AgCl; Ag were measured at 298.15 K. The values of

pK_1 were calculated using the Nernst equation. The extrapolation method of Harned and least-squares regression techniques were used to determine thermodynamic pK_1 values. The results of pK_1 and pH will be discussed and compared with the literature data.

Willard, Demara and Davis, William, Department of Chemistry, Drury College, Springfield, MO 65802. THE THERMODYNAMIC BEHAVIOR OF HYDROGEN BROMIDE IN AQUEOUS SOLUTIONS OF BARIUM BROMIDE.

Electromotive-force measurements were made on the cell without liquid junction:

Pt | H₂ (g, $p = 101.325$ kPa) | HBr (m_A), BaBr₂(m_B)/AgBr(s)/Ag(s). Activity coefficients of HBr were calculated from the observed electromotive-force values using the Nernst expression. The activity coefficients of HBr were analyzed using the treatment of Harned and also the comprehensive ion-interaction model of Pitzer. Activity coefficients for HBr in the salt mixture follow Harned's rule at ionic strength values up to 2.01 mol/kg. The Pitzer mixing parameters both including and excluding higher-order effects and their temperature derivatives have been determined and are compared with the results of similar systems.

Geology

Reeves, Sean M., Department of Geology/Geography, Northwest Missouri State University. TRANSGRESSIVE-REGRESSIVE CYCLES IN THE CHERRYVALE FORMATION (PENNSYLVANIAN, MISSOURIAN), MISSOURI AND IOWA. The Cherryvale is composed of the Fontana, Block, Wea, and Westerville Members. Lithologic and micro-paleontologic samples collected from exposures in Missouri and Iowa were used to determine the development of depositional cycles. The occurrence of poorly fossiliferous blocky mudstone with thin discontinuous coals in the basal Fontana Shale Member indicates regression and paleosol development. The upper Fontana is composed of fossiliferous shale and represents the initial phase of the Cherryvale transgression. The overlying Block Limestone Member is composed of dense, dark skeletal calcilitite suggesting continued Cherryvale transgression and deposition offshore below effective wave base. The Wea Member is composed of a basal section of conodont-rich shale and thin limestones overlain by a section of conodont-poor shale with abundant quartz grains. This succession suggests regression at the end of Wea deposition. The shallowing-upward limestone sequence in the overlying Westerville Member suggests a later transgressive-regressive cycle.

Zurbuchen, Brian, Department of Geology and Geography, NWMSU. NITRATES IN WELL WATER, NODAWAY COUNTY, MO. Nodaway Co. has a history of high nitrate content in rural well water. Health Department reports and well owner concerns indicated the need for identification of possible nitrate source(s). The tests of well water made in this study include wells in upland glacial alluvium and alluvial valley fill. None of the wells was considered to be deep enough to reach the pre-glacial river channels. A total of 80 wells were tested for nitrates and water samples were analyzed for bacteria. The study found a positive correlation between high nitrate levels and wells which were near hog lots which had uncollected wastes and wells which had surrounding land fertilized with hog waste. The study found a negative correlation between high nitrate levels and land which was fertilized with nitrates other than hog waste, wells near hog lots with collected wastes, wells closer than 100 feet from septic tanks, wells in unfertilized areas, and coliform bacteria levels. Of wells tested, 39% had nitrogen as nitrate concentrations above the MDH standard of 10 mg/l. Study supported by NWMSU Applied Research Funds and Student Research Funds.

Physics

Davis, William B., Hagerty, Patrick, Good, Katherine, and Roy, Rabindra N., Chemistry Dept., Drury College, Springfield, MO 65802 and **Johnson, David A.**, Chemistry Dept., Spring Arbor College, Spring Arbor, MI 49283. HIGHER ORDER ELECTROSTATIC EFFECTS ON THE SYSTEM HC1-ThC1₄-H₂O USING PITZER'S EQUATION.

The activity coefficients of HC1 in HCL-ThC1₄-H₂O mixtures have been calculated from electromotive force measurements of the cell:

Pt; H₂(g, 1 atm) | HC1 (m_A), ThC1₄ (m_B) (aq) | AgC1; Ag.

The data have been treated with Pitzer's formalism. The contributions arising from the higher order electrostatic terms based on cluster integral theory will be discussed. A variety of numerical integration techniques including Gauss-Legendre Method will be compared in terms of the thermodynamic properties.

Thilker, D. A., Fox, J. R., and Selinger, M. L., Department of Physics, University of Missouri-Rolla. PROPERTIES OF BUCKMINSTERFULLERENE: ANALYTIC PHYSICAL METHODS FOR VERIFICATION OF TRUNCATED ICOSAHEDRAL MOLECULAR STRUCTURE. Aspects pertinent to the confirmation of a specific molecular structure - buckminsterfullerene (C₆₀), the truncated icosahedral form of carbon - are examined. Absorption spectroscopy, nuclear magnetic resonance, quantum microscopy, and x-ray scattering are each covered. Nuclear magnetic resonance revealed a single peak, implying a truncated icosahedral structure. X-ray diffractometry of the sample yielded a scattering pattern with sharp peaks. The XRD data loosely fit to an hcp lattice with lattice parameters $a = 10.12$ Å and $c = 16.65$ Å. Infrared spectroscopy revealed peaks indicative of the presence of two varieties of fullerite, C₆₀ and C₇₀. Ultraviolet spectroscopy yielded the characteristic "camel"

spectra. Visible spectroscopy measurements also agreed with previously reported observations. Auger analysis yielded no discernable difference from carbon graphite. STM/AFM analyses showed directly how our sample exhibited only a short ranged packing order. A procedural description of buckminsterfullerene purification is given in detail.

Weeks, Matthew D., Department of Physics and Astronomy, Southwest Missouri State University AC BEHAVIOR OF POLYANILINE POLYMER. Previous studies (Epstein, et. al.) have theorized that the conductivity of the emeraldine polymer can be given in terms of Mott's theory of conduction in amorphous materials. We set out to verify this theoretical model. We measured the values of conductivity for the polyaniline (PANI) polymer. Samples of the PANI polymer were created in film form by Brewer Scientific Inc. Metallic contacts were then evaporated onto the samples for the resistivity measurements. We measured the A.C. resistivity of the samples in the frequency range (20 Hz – 1 MHz). Since the conductivity has been shown to vary with temperature and humidity, the measurements were made in a controlled environment. When I present this paper, I will compare our results with Mott's theory.

Computer Science

Peterson, Brian, Stephens, Darin, Smeltzer, Jim F., Dept. of Chemistry/Physics; **Heeler, Phillip J.**, Dept. of Computer Science/Information Systems; Northwest Missouri State University, Maryville, MO 64468. CLASS-ROOM APPLICATIONS USING NASA CD-ROM IMAGERY.

NASA data sets in CD-ROM format with accompanying software for Macintosh and IBM-PC platforms are available to universities for use in research and classroom applications. In order to implement research projects and classroom demonstrations in earth science and physics, it is necessary to customize the software for our specific hardware. When the project is completed, the users will be able to call up imagery from the following:

1) Magellan mission to Venus, 2) Voyager mission to the outer planets, and 3) Viking mission to Mars. In addition the project will produce a manual specific to the hardware and software locally available for use in earth science, physics, mathematics, and computer science.

Social & Behavioral Sciences

Ballard-Paige, Julie Ann, Missouri Southern State College, Joplin, MO 764801. LOCUS OF CONTROL AND GAMBLING BEHAVIOR IN COLLEGE VERSUS NONCOLLEGE STUDENTS. Gambling activities have been linked to variables such as gender, age, and some personality traits. Previous research has studied, but not clarified, the relationship between locus of control and gambling behaviors. The present survey attempted to determine if locus of control had any relationship to gambling activities in an 18 to 20 year old population. It was hypothesized that internals and externals would gamble differently, and that college students would be more internal and their gambling more skill-oriented, whereas those not attending college would be more external and would gamble more in luck situations. The contention was made that males would report a greater participation in gambling activities than females. Findings were equivocal for the most part, perhaps due to small sample size and non-representative sample composition.

Morgan, Rhonda, Missouri Southern State College, Joplin, MO 64801. THE RELATIONSHIP BETWEEN LUNAR CYCLES AND HUMAN BEHAVIOR HAS LONG BEEN A FASCINATING AND CONTROVERSIAL ISSUE. The belief that human behavior is somehow influenced by the phases of the moon has existed for thousands of years. For example, many people believe that a full moon make people behave strangely. The purpose of this study was to investigate the relationship between the variables of frequency of crisis intervention calls, gender of caller, time of day and day of the week calls come in, and the variable of moon phases. A Box-Jenkins time series analysis was attempted on the daily calls. There seemed to be no simple model that would describe the values in this series. This could be due to low frequencies of calls per day, and would be more suitable to use in a larger urban setting. The data were analyzed by using a NPAR Test Chi Square. The results revealed a significant difference due to days of the week, gender and lunar month. However, the results dealing with the phases of the moon exposed a non-significant value. From the results of this study, it would appear, at present, that there is no justification for a belief in a lunar influence on human behavior.

Schneider, Julie, Missouri Southern State College, Joplin, MO 64801. PERCEIVED IDEAL VERSUS ACTUAL CHARACTERISTICS OF CRISIS INTERVENTION HELPERS. During a personal crisis, people often turn to crisis helpers. What traits should crisis helpers have? In this study, a Likert-style questionnaire was administered to 53 subjects (28 students, viewed as potential crisis service users, and 25 paraprofessional crisis helpers) to answer this question. Results indicate that the characteristics of "responsive," "listens," "understanding," and "concerned" were ideally preferred traits for crisis helpers. Significant differences were discovered between students' and paraprofessionals' perceptions of ideal characteristics. Significant differences were found for gender and between respondents who have received services from a professional counselor and those who have not. The information from this study can aid crisis centers during paraprofessional selection procedures. With the ability to select more effective crisis helpers, crisis intervention centers will be able to serve the public more effectively at the moment of crisis.

Social & Behavioral Sciences - Section II

Bullimore, Nancy J., Department of Biology, Missouri Western State College. THE MODIFICATION OF FARMING PRACTICES AFTER A WELL WATER EVALUATION AND AN EDUCATION PROGRAM. Phase I of this project uses information obtained from a Farm-A-Syst survey involving five (5) counties in Northwest Missouri: Caldwell, Clinton, Gentry, Harrison and Nodaway. The survey evaluated current farming practices, site structures, and how farmers prioritize farm management techniques. An attempt is made to correlate current farming practices and structures with various types of well water pollution. Phase II will evaluate the effects of an information/education program on these farming practices.

Burger, P. R and Goudge, T. L., Department of Geography, Northwest Missouri State University. GEO-MARKETING: THE POTENTIAL OF COMPUTER MAPPING. Few business procedures at present make maximum use of geographical applications to enhance the marketing, sales, and distribution operations. This study was designed to incorporate computer mapping and geographic information systems software into the day-to-day operations of a small business. This business has nationwide distribution and future decisions demand an increased understanding of marketing, sales, and distribution trends. The software had to be Macintosh compatible: 1) in order to be consistent with current computer systems of the firm; and 2) it provides a preferred learning curve for the management of the firm. Several interactive maps were created. These maps and related databases were used to target marketing and sales efforts, establish balanced sales territories, and track sales performance.

Hill, A. L., McGrail, T. E., and Goudge, T. L., Department of Geography, Northwest Missouri State University. PROPOSITION B: WHAT CAN WE LEARN FROM IT DEFEAT? The failure of Proposition B has left the future of higher education in Missouri in uncertainty. A geographer's initial reaction was to ask: "What was the spatial distribution of the vote?" The purpose of this study was to determine if regional patterns existed within the state of Missouri on the outcome of the Proposition B vote, November 5, 1991. The resulting map indicated distinct regional variations within the state. Statistical correlations on variables that may have had a relationship to the vote outcome were performed. These variables included age groups of the population, unemployment, per capita income, educational levels, and the percent of school age children, among others. Statistical analysis indicated that the higher the percentage of the county's population that possessed college degrees the higher the tendency to vote yes. Other factors that correlated with yes votes were higher per capita incomes and the higher the percentage of high school graduates. Thus, education and income were major factors that tended to be in support of Proposition B. Variables that were highly correlated with a greater percentage of no votes included: the higher the percentage of manufacturing employees per county, an increased unemployment rate and the greater the percentage of population over the age of 65. These findings may be helpful in constructing a new legislation to support education in Missouri.

McGrail, T. E., West, J. R., and Goudge, T. L., Department of Geography, Northwest Missouri State University. THE GEOGRAPHY OF TOP COLLEGE FOOTBALL RIVALRIES. Traditional rivalries have arisen as a function of distance and regional competition. Rooney has documented the shift over the last twenty years in the production of superior football talent. This shift has been from the 'Northern' (PenWevO) emphasis to the southern game (Pigskin Cult). Have the intensity of the traditional rivalries shifted as well? Traditional rivalries draw considerable attention to the media and fans. Yet, little research has been conducted. The purpose of this study was to determine which college football rivalries were viewed as the most significant by the college football coaches who vote for the nation's outstanding teams. Questionnaires were sent to each of the NCAA Division I Head Football Coaches. This input, along with other variables, was used to establish a rating system. Numerous maps were generated. In an attempt to explain the results it was concluded that regional bias plays a significant role in the outcome of the study.

TRANSACTIONS OF THE MISSOURI ACADEMY OF SCIENCE



Vol. 26, 1992



About the Academy

Scientists of the State of Missouri organized in 1934 to form the Missouri Academy of Science. By April 6, 1934, a Constitution and By-Laws were prepared and on August 14, 1934, the organization was incorporated.

The purposes of this Academy were presented in the fourth "article of agreement" as follows:

"This corporation is organized, not for profit but for the purposes of promoting the increase and the diffusion of scientific spirit, and of promoting cooperation between the scientific interests of Missouri. It proposes to accomplish these purposes:

- a. By holding meetings for the presentation of scientific papers embodying the results of original research, teaching experience, or other information of scientific interest.
- b. By fostering public interest in scientific matters, through open meetings, press releases, and in such other ways as seem feasible.
- c. By encouraging local scientific organizations in every possible way.
- d. By promoting acquaintance in harmonious relationships between scientists in Missouri, and among all who are interested in science.
- e. By supplying, so far as finances permit, a medium for the publication of results of original work, particularly those of special interest in this state.
- f. By concerning itself with legislation on scientific matters, and providing opportunity for discussion of such legislation.
- g. By working in any and all other ways which may prove feasible, for the advancement of science in Missouri."

The Academy held its organizational meeting on April 13-14, 1934 with 250 people attending. At the December, 1934, meeting, more than 400 people registered and by May, 1935, there were approximately 750 members of the Academy. Statewide interest at a high level continued until activities made necessary by World War II caused disruption of Academy affairs except for some activity in the College Section.

Post-war revival of Academy activities started at a meeting on April 20, 1963 at Drury College. From the group of twelve persons who initiated the reactivation of the Academy in 1963, the membership has grown steadily to more than 800. Activities of the Academy have expanded to include the awarding of modest grants for projects proposed by high-school and college students, and to sponsor the establishment of a Junior Academy of Science.

Since its re-activation in 1963, the Missouri Academy of Science has regularly held annual meetings at 16 different sites around the state. The refereed publication, the *Transactions of the Missouri Academy of Science*, has been published consistently since 1967. Six Occasional Papers have also been released.

Presently, 49 colleges and universities around the State of Missouri hold an Institutional Membership status. Many industries and other private businesses are supporting the Academy with Corporate Memberships.

Membership into the Academy is a year-round opportunity for everyone and runs from January 1 to December 31. Benefits include four quarterly newsletters, one annual *Transactions*, and annual meeting lower pre-registration fee.

The Missouri Academy of Science is a non-profit organization and is supported solely by membership dues and donations. That is why we appreciate each new member and the current members who renew so faithfully each year. And it is because of their interest that the Academy continues its success as a fine scientific organization.

Information For Authors

Manuscripts

1. *Editorial Policy.* Authors must pay \$25 per printed page for publication costs. Transactions publishes several types of original contributions from the disciplines within the Academy: research papers, research notes, reviews, and annotated bibliographies. Manuscripts must be authored or co-authored by a member of the Academy. Each manuscript is subject to peer review. The Editor has final authority for acceptance or rejection. Manuscripts should be submitted prior to May 15 to the Editor:
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2. *Manuscript Preparation.* Type all material double spaced, on one side of standard sized bond paper. Submit 4 copies of the manuscript with illustrations for review purposes. Retain the original typescript and illustrations in your files. If accepted for publication, the final copy of the text and original art work will be requested.

Each paper must include an informative abstract which records succinctly the essential findings, followed by a short list of key words for abstracting purposes.

Each table must be typed on a separate page and be suitable for direct reproduction. Number tables consecutively and provide a short title at the top of each page.

All illustrations must be high contrast black and white and reproducible. Handwritten or typewritten lettering or symbols are normally not acceptable. The manuscript is to be assembled in the following order: title, authors names and affiliations, abstract, key words, text, acknowledgments, literature cited, tables, figure legends, figures. Number all pages.

Authors should refer to current Transactions and a style manual appropriate to the discipline for details on style, format, and citation of references. Use the common and binomial Latin name of an organism when first mentioned. Subsequently the genus or common name may be used. Names of taxa should be underlined.

Abstracts for Annual Meeting:

1. *Editorial Policy.* Authors must pay \$10 per abstract for publication costs. Abstracts are to be submitted to the appropriate section chairperson by January 31 for the Senior Division and March 1 for the Collegiate Division of the year of the meeting.
2. *Abstract Preparation.* Type the abstract as one single-spaced paragraph within a 6½ × 3 inch space using a fresh ribbon. Type the name of the author(s), *not* underlined, and the affiliated institution, using appropriate capital and lower case letters. If co-authors have different institutional affiliations, follow each author's name with their affiliation. Type the title in all capital letters. Continue the paragraph with the main body of the text. Underline generic and specific names. Acknowledgment of support may be included as the last sentence of the text.

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