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Effects of Elevated Ambient Temperature on White Crappie (*Pomoxis annularis*) Feeding and Growth

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Abstract: Age 3 white crappie (*Pomoxis annularis*) from two small Missouri impoundments (Busch Lake 33 in St. Charles Co., and Little Dixie Lake in Callaway Co.) grow to markedly different sizes. This study was initiated to assess whether the higher summer water temperatures that Lake 33 experiences might be responsible for the evident reduction in crappie growth there. Fish were obtained from Lake 33 in November, transferred to laboratory holding facilities, raised gradually to elevated maintenance temperatures, and fed fathead minnows (*Pimephales promelas*) in abundance. Fish raised to 32°C temperatures died, indicating that this was their incipient lethal temperature. However, fish maintained at 30 and 25°C fed actively and suffered no mortalities which we could associate with thermal stress. In addition, fish held at 30°C exhibited higher post-experimental condition than did Lake 33 fish caught at either 30°C temperatures in June, July, and August, or in mid-October. These findings indicate that heightened temperatures in Lake 33 alone are insufficient to explain the slow growth of white crappie there, and point to the need to additionally consider the effects of lake oxygenation levels and predator-prey habitat partitioning.

Key Words: Missouri, white crappie, *Pomoxis annularis*, growth, size, condition, relative weight, LSI, temperature, upper incipient lethal temperature, transport, maintenance.

Introduction

It was recently observed (Fischer 1994) that white crappie (*Pomoxis annularis*) from two small Missouri impoundments showed markedly different growth rates: at age 3, those in Little Dixie Lake (Little Dixie Conservation Area, Callaway Co.) averaged 230.7 mm total length (TL), while those in Lake 33 (August A. Busch Memorial Conservation Area, St. Charles Co.) averaged 173.1 mm TL (Fig.1). In Missouri, attaining 230 mm TL by age 3 is considered by managers as evidence of good crappie growth (Colvin and Vasey 1985).

The size differences noted above appear to be associated with differences in fish foraging. In general, young crappie begin feeding on zooplankton (Colvin 1989, Reeves 1989), switch mainly to macroinvertebrates, and then become primarily piscivorous as adults after attaining about 160 mm TL (Ball and Kilambi 1972, O'Brien et al. 1984). Consistent with this scenario, adult crappie stomach samples collected during the summers of 1993 and 1994 from Little Dixie Lake indicated that age 0 gizzard shad (*Dorosoma cepedianum*) and bluegill sunfish (*Lepomis macrochirus*) were utilized as prey (Fischer, unpublished data). In contrast, the stomachs of adult Lake 33 crappie collected during the same months were either conspicuously empty or contained only a few invertebrates or zooplankton, despite trawl sample evidence that optimal sized age 0 gizzard shad were available in abundance as prey during this period.

The occurrences of these between-lake differences in feeding and growth may relate to the higher summer water temperatures that Lake 33 experiences each year (>30°C, vs. ca. 27-30°C in Little Dixie Lake; Fischer 1994). This suggestion is consistent with literature evidence that the upper lethal temperature for juvenile white crappie acclimated to 29°C is 33°C, and that the species' optimal growth temperature is 25°C (Brungs and Jones 1977). A recent laboratory study of adult white crappie held at between 18 and 27°C has likewise shown that the species' consumption rates peak at 24°C and decline at temperatures above this level (Hayward and Arnold 1996). Together, these data suggest that ambient summer temperatures in Lake 33 may exceed the optimal feeding temperature range for adult white crappie.

Given these indications, the primary objective of the present study was to examine the feeding and growth responses of adult Lake 33 white crappie to maintenance temperatures that mimicked summer field maxima in Lake 33 and Little Dixie Lake, respectively. A subsidiary objective was to refine methods for successfully transporting field-caught white crappie and for maintaining them at elevated temperatures.

Materials and Methods

Study Area: The trophic status of Little Dixie Lake (83 ha) and Lake 33 (74 ha) was measured during a 1989-1990 state-wide survey (MDNR 1992). Although both lakes are considered eutropic, the levels of total phosphorus, chlorophyll a, and total nitrogen were higher in Lake 33 than in Little Dixie Lake, respectively (92.5 vs. 66.0 mg/L; 35.7 vs. 17.4 mg/m^3; 1190 vs. 860 mg/L).

Field Collections: Fish mortalities (described below) necessitated making three separate field collections of specimens destined for the laboratory. Collection 1 was made using four trapnets set overnight in Lake 33 on September 27, 1994 (water temperature 16.5°C; dissolved oxygen level 4.7 mg/l). At mid-day on September 28, the 102 captured adults were trucked the ca. 160 km to Columbia, Missouri, in a mechanically aerated 1300 L hauling tank medicated with 1% NaCl and terramycin as prophylactics. No mortalities occurred en route. On arrival, ten fish each were placed in six laboratory holding tanks (described below) at ambient temperatures, while the reminder were transferred to raceways maintained at the Little Dixie Conservation Area.

Collection 2 from Lake 33 was made on October 3, 1994, via boat electroshocker (1300 to 1530 h; water temperature 20.8°C at 1 m; dissolved oxygen level 8.5 mg/l). We transported the fish to Columbia following the methods outlined above, and no mortalities were sustained en route. However, on arrival (ca. 1800 h), only five fish were placed in each of the six holding tanks, while the remainder were again allocated to the raceways.

Collection 3 was made on November 1, 1994, via boat electroshocker (1200 to 1300 h; surface water temperature 13°C). After mortality-free transportation as before (arrival time ca. 1530 h), five fish were again placed in each tank and additional fish were transferred to the Little Dixie raceways. Using a mix of lake water and

electrical chillers, we were able to attain holding tank temperatures as low as 17°C on the day the fish were brought in. However, overnight tank temperatures rose to 22-23°C, resulting in some mortalities. Thus, on November 3, additional fish were moved back from the raceways to bring the totals in each holding tank to 10. Cold weather prevented any subsequent collections from Lake 33.

For comparison, three reference collections of 10 white crappie adults each were obtained from Lake 33 trapnettings conducted on summer dates (June 15, July 13, and August 18, 1994) when temperatures were 30°C.

Laboratory Holding Facilities: Six laboratory holding tanks (375 L each) were used to maintain our specimens. Each tank was separately wrapped in, and rested upon, a single layer of Reflectix Insulation. Each tank was provided aeration via a 30 cm airstone, and temperatures were maintained using Ebo-Jager model LZ submersible heaters. A 12 h light: 12 h dark photoperiod was maintained using overhead fluorescent lights, and half of each tank was kept covered to provide shaded shelter.

Water quality (temperature, dissolved oxygen, pH, and ammonia levels) was assessed in each holding tank every morning. Temperature and dissolved oxygen levels were measured using a Yellow Springs Instrument (YSI) model 57 meter, while pH and ammonia were measured using Aquarium Pharmaceuticals colormetric test kits. Partial water changes were executed weekly (10% volume, dechlorinated city tap water).

Two weeks before conducting Collection 3, we added biofiltration units to each tank: these employed Performance model 600 water pumps that cycled water through elevated 20 L reservoirs containing activated charcoal and crushed clam shell substrates inoculated with Bacta-Pur Bacteria (BN-1). Towards the end of the study, the pH and ammonia tests were needed on alternate days only. The initial allocation of fish to each tank was never allowed to exceed 0.0015 kg/L.

Temperature/Feeding Experiments: After arriving in the laboratory, fish from each collection were held at ambient temperatures for one week to acclimate and to monitor post-capture survivorship. Thereafter, water temperatures in replicate tanks were raised 1 C°/d (Busacker et al. 1990) towards target temperatures of either 25, 30, or 35°C. Live prey (fathead minnows, *Pimephales promelas*; 30-50 mm total length, a size range across which the crappies apparently exhibited unhampered consumption) were provided every afternoon at approximately 3% of the fish's summed initial body weights, a level which yielded growth in another recent study (Read and Triplett 1994; NCRAC 1994). Tank-wise consumption rates were monitored daily. Due to crappie mortalities, we had to vary the number of minnows that each tank was provided each day. In addition, all dead minnows found in a tank the morning after a feeding were removed, leaving any remaining live minnows (counted twice for accuracy) to be factored into the calculation of that day's ration.

Growth Assessment: At the end of the experimental period, fish deriving from Collection 3 were killed to obtain total length (cm, to nearest 0.1), total weight

(g, to nearest 0.1), and liver weight (g, to nearest 0.001) measurements. Identical data were obtained at the time of sampling from 10 individuals from each of the three reference collections, respectively, selected to match the sizes of those fish that had undergone testing. These data were used to calculate four indices of fish growth or condition: (1) Fulton's condition factor (K=g total body weight/cm total length^3 x 100; see Bagenal and Tesch 1978, Bolger and Connolly 1989), (2) relative weight (W_r=W/W_s x 100, where W represents an individual's weight in g, and W_s (standard weight in g) is calculated as log W_s = -5.642 + 3.332 log L, where L is an individual's total length in mm; see Wege and Anderson 1978, Neumann and Murphy 1991), (3) liver-somatic index (LSI=g liver weight/g total body weight x 100; see Bulow et al. 1978, Adams and McLean 1985), and (4) relative liver weight (L_r=g liver weight/W_s x 100, where W_s is again the standard weight in g calculated for an individual fish; see Legler 1977). These indices were selected because of their potential to reflect short-term changes in fish biomass (growth) as a function of recent thermal and feeding history.

Results

Collection and Maintenance: Fish from Collection 1 exhibited immediate mortalities, culminating in >50% losses during the first week in captivity and a halt in experimentation. These mortalites likely reflected the stressed condition of the fish at capture, given that trapnetting was used and that Lake 33 was then experiencing its fall overturn. In addition, ammonia levels in our holding tanks ranged between 0.5 and 1 ppm during this time.

Fish from Collection 2 experienced parallel first week mortality rates, despite having been collected via electroshocking under more stable lake conditions. In this case, rising ammonia levels in our holding tanks (0.5 to 2 ppm) forced us to terminate the experiment after two weeks. This situation prompted us to install the biofiltration units described above.

For fish from Collection 3, no mortalities occurred between days two and six of initial holding, allowing us to proceed with our temperature elevations and feeding/growth assessments.

Temperature Effects on Survivorship: After five days of no mortalities in our Collection 3 fish, we began raising temperatures 1 C°/d in our holding tanks towards the desired target temperatures.

Complete mortality occurred in the first tank targeted for 35°C over two days once temperatures exceeded 32°C. Due to a faulty heater, the first tank targeted for 30°C also attained 32°C temperatures, likewise resulting in complete mortality. Evidence of disease was not apparent in either case. These results suggest that the incipient upper lethal temperature of fall-caught white crappie is 32°C. Early mortalities in the second tank targeted for 35°C were attributed to too rapid an initial temperature increase, forcing us to exclude consideration of this replicate.

In the second tank targeted for 30°C, we achieved 100% survival across the November 9 to December 13, 1994, period that followed them attaining 30°C. This

outcome indicates that the incipient upper lethal temperature for fall-caught white crappie was above 30°C.

Poor survival in the two 25°C tanks due to an unidentified disease and/or delayed initial mortality resulted in the survival of only four specimens in one tank. The mortalities showed no evidence of thermal origin, and the four survivors both fed and behaved normally between November 6 and December 13, 1994, during which 25°C temperatures were maintained. The resulting limited sample size prevented us from making statistical comparisons between the 25 and 30°C treatments.

Feeding Effects: Despite prior literature indications, we observed fairly consistent feeding behavior in our surviving fish over a water temperature range of 23-30°C. On December 2, 1994, four of 10 of the 30°C fish were placed separately in the four tanks that had become unoccupied (each pre-elevated to 30°C) so that their individual feeding behavior could be monitored. Over the remaining 11 days of experimentation, the two lone fish that survived the transfer consumed between 0 and 2 fathead minnows per day, averaging 1.40 and 1.50, respectively, a difference that was not significant (ANOVA, 1 and 18 df, F=0.10, p=0.754). In contrast, the remaining six fish held together at 30°C consumed an average of 1.97 minnows/fish/d, while the remaining four fish held together at 25°C consumed an average of 1.3 minnows/fish/d. This difference was also non-significant (ANOVA, 1 and 18 df, F=0.17, p=0.682). In contrast, a comparison of the pooled lone fish and pooled grouped fish did prove significant (ANOVA, 1 and 38 df, F=10.80, p=0.002), indicating that the latter consumed significantly more prey (1.34 times as many) and suggesting that some social feeding facilitation had occurred. Since the eight 30°C fish were all between 160 and 171 g total weight, and the prey were all of consistent sizes, neither predator nor prey size differences were likely to have accounted for the variance in foraging rates. Instead, latent transfer-related stress may have affected the two lone fish.

Consumption: Using Carlson's (1967) two-sex regression for 1966 and 13% correction for preservation-related weight increases, we calculated the weight of an average 40 mm fathead minnow to be 0.68 g. Using our measured mean crappie weight (53.2 g), this information indicates that our two lone 30°C fish consumed 1.79 and 1.92 g prey/g fish/day, respectively, and that our group-held 25°C and 30°C fish consumed 1.67 and 2.52 g prey/g fish/day, respectively.

Growth Effects: Analyses of variance and Duncan's multiple range tests (Zar 1974) indicated that our experimental fish exhibited significantly greater K and W_r values than did fish from our reference collections obtained from Lake 33 during the summer months, despite being of comparable sizes (Table 1). While our experimental fish exhibited the highest L_r and the second highest LSI values, these differences proved non-significant (Table 1).

Discussion

Collection and Maintenance: Our experience with trapnetting and

electroshocking white crappie suggests that the latter capture technique results in superior survivorship. The Read and Triplett (1994) and NCRAC (1994) results confirm this contention, and additionally suggest that using night transportation and bottled air for aeration represent additional improvements. Increased survivorship in the laboratory was achieved when we maintained ammonia levels at low levels (<0.5 ppm), suggesting that particular attention should be paid to this water quality parameter when maintaining or culturing this species.

Temperature Effects on Survivorship: Our induction of mortalities when 32°C was attained provides evidence for this temperature being the incipient upper lethal temperature for fall-caught white crappie, a temperature appropriately higher than the species' upper avoidance temperature (Coutant 1977).

Feeding Effects: In contrast to previous reports that the rate at which individual white crappie consumed fathead minnows declines at temperatures exceeding 24°C (Hayward and Arnold 1996), our 25 and 30°C fish were observed to feed consistently and relatively predictably. This difference may reflect seasonal differences in fish metabolism, Hayward and Arnold's fish having been August-caught whereas ours were fall-caught. The fact that our fish actively fed at 30°C suggests that the summer temperatures experienced in Lake 33 were unlikely to be the sole cause of the lack of feeding observed therein.

Another interesting observation stems from the differences observed in crappie feeding when held singly or in groups. The latter fed at a 34.5% greater rate, and did so more predictably, suggesting that there may be some social facilitation of feeding of piscine prey (enhanced prey location or capture efficiency) in white crappie. Further investigation of this tendancy seems warrented.

Consumption: Our consumption estimates for fish at 25 and 30°C exceed what would be expected given Hayward and Arnold's (1996) results for August-caught Little Dixie Lake adults of #344 g average size (range 164-532) tested at temperatures between 18 and 27°C. While it is generally true that younger fish display heightened consumption rates, the high consumption rates of our Lake 33 fish cannot be attributed to youth since all were 3-year-old adults. Note, however, that our Lake 33 adults were very small for their ages (53.2 g mean weight), suggesting that the consumption rates of such "stunted" individuals may more favorably compare with "normal" fish of similar size rather than similar age. In addition, the possibility that Lake 33 fish have undergone selection for higher temperature tolerances cannot be dismissed.

Growth Effects: For fish obtained from Lake 33, those maintained in the laboratory at 30°C exhibited significantly greater condition index values (K, W_r) and heightened liver indices (LSI and L_r) relative to comparably-sized field-caught specimens (Table 1). To assess whether this difference simply reflected a natural autumn increase in fish condition, the W_r values were calculated for an additional reference

collection of 17 fish (160-174 mm TL) obtained October 12 and 13, 1994, from Lake 33. The resulting mean ($\bar{X}$=82.68, SE=7.4) was both similar to the three summer reference collections and substantially different than for the lab-reared specimens (Table 1). Together, this evidence of growth and improved condition under the heightened temperatures we maintained in the laboratory suggests that high temperatures alone cannot be reponsible for the slow growth that Lake 33 fish experience. While significant condition increases due to additions of somatic tissue did appear after the 36 days of laboratory feeding, the lack of significance in the liver index differences suggests that greater time may be necessary for augmentation in liver sizes to occur, at least during this time of year.

Summary: In review, Lake 33 fish held in the lab at 30°C suffered neither mortalities nor impaired feeding, and exhibited significantly better condition indices than did Lake 33 specimens collected at identical temperatures in June, July, and August. Given these indications, we may therefore conclude that elevated ambient temperature alone is not the cause of the poor white crappie growth observed in Lake 33. This outcome forces us to consider the possible synergistic effects of summer temperatures and dissolved oxygen levels in Lake 33. As summer surface water temperatures rise in the lake, white crappie may be forced lower into the water column to seek thermal refuge. White crappie may avoid waters where dissolved oxygen concentrations decline below 3.3 ppm (Grinstead 1969). Given that dissolved oxygen levels typically decline with depth in Lake 33 (Fischer 1994), white crappie there may thus find themselves "squeezed", and forced to inhabit areas of higher temperatures or lower oxygenation than they prefer, inducing stress and a decline in active feeding despite an abundance of prey. Investigating the effects of temperature elevations and varying oxygenation levels on feeding and growth would be an appropriate follow-up study. In addition, juvenile gizzard shad may exhibit temperature and/or oxygenation tolerances different than do white crappie, the thermal LD_{50} for young shad in summer being 28.5°C (Cvancara et al. 1977), allowing them to segregate spatially and reducing potential predation levels. In contrast, the depths of Little Dixie Lake likely allow fish in summer to seek thermal refuge below the thermocline while still avoiding the hypoxic conditions near the bottom. Between-lake differences in biotic community composition are likely of lesser relative importance.

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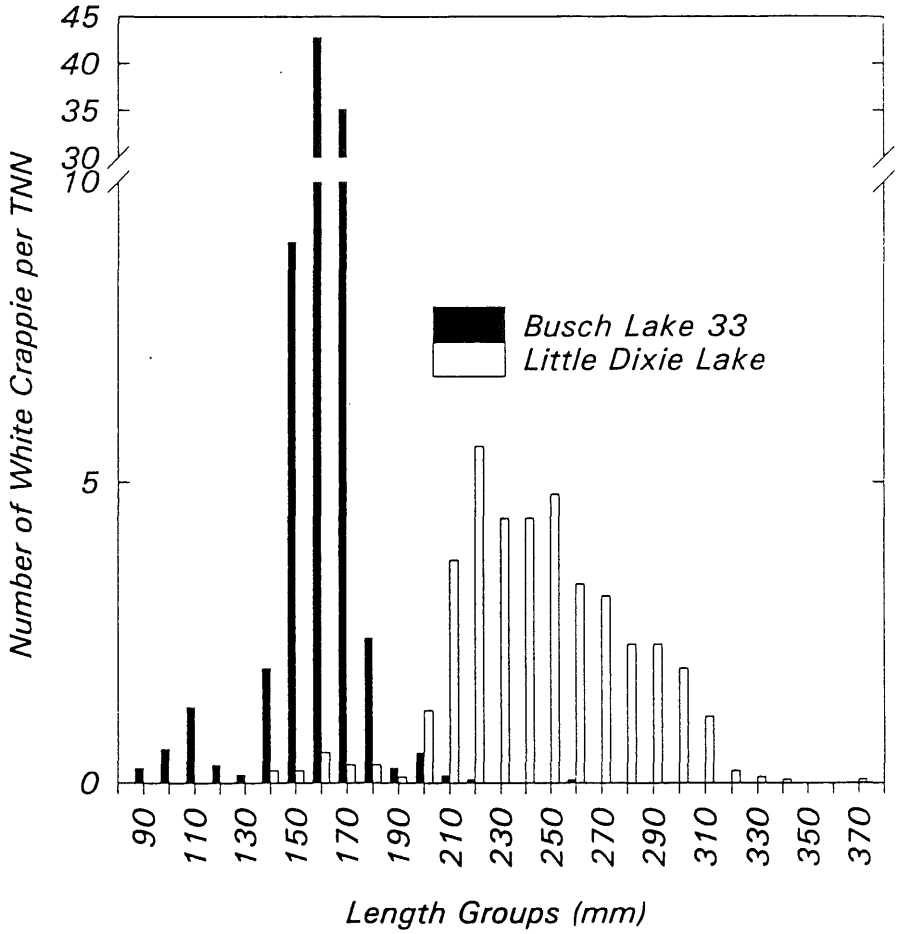

Figure 1. Distribution of spring-caught white crappie collected from Little Dixie Lake, Little Dixie Conservation Area, and Lake 33, August A. Busch Memorial Conservation Area. TNN = trap net night.

Table 1. ANOVA and Duncan's Multiple Range Test results comparing four indices of white crappie condition between laboratory and wild-caught specimens maintained or captured at 30°C, respectively. TL = total length (mm); TW = total weight (g); LW = liver weight (g); FCF = Fulton's condition factor; RW - relative weight; RLW = relative liver weight; LSI = liver-somatic index; SE = standard error. Means with same letter within index columns are not significantly different.

Sample	N	Mean TL (± 1 SE)	Mean TW (± 1 SE)	Mean LW (± 1 SE)	Mean FCF (± 1 SE)	Mean RW (± 1 SE)	Mean RLW (± 1 SE)	Mean LSI (± 1 SE)
June	10	168.7 (1.5)	48.4 (2.5)	0.415 (0.027)	1.003[b] (0.034)	80.163[b] (2.621)	0.860[a] (0.044)	0.689[a] (0.039)
July	10	167.6 (2.0)	48.0 (2.6)	0.425 (0.042)	1.014[b] (0.037)	81.249[b] (2.907)	0.883[a] (0.062)	0.725[a] (0.068)
August	10	170.1 (0.7)	49.1 (0.7)	0.476 (0.050)	0.998[b] (0.017)	79.546[b] (1.410)	0.965[a] (0.094)	0.766[a] (0.076)
Lab	8	167.6 (1.5)	53.2 (1.42)	0.472 (0.029)	1.34[a] (0.017)	90.887[a] (1.407)	0.888[a] (0.054)	0.806[a] (0.049)
ANOVA	--	p=0.554	p=0.295	p=0.591	p=0.009	p=0.006	p=0.588	p=0.705

Spiders of Missouri: An Annotated Checklist

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Abstract: Using published papers, unpublished faunistic surveys, and preserved specimens, we found 480 species of spiders distributed among 29 families in Missouri. We provide additional information, whenever possible, regarding the collection, identification, and natural history of each spider. This represents the first statewide listing of the spider fauna.

Key Words: spider, Araneae, Arichnida, Missouri, diversity, checklist, distribution

Introduction

Spiders comprise the order Araneae, the seventh most diverse taxonomic order on earth (18). About 34,000 species of spiders have been described and grouped into approximately 100 families (18, 33) and spider densities in forests or fields sometimes exceed 500 individuals per square meter (33, 38, 42). Although they do not possess powered flight, the propensity for long distance dispersal by "ballooning" on air currents, which is commonplace in immature individuals, allows spiders to colonize very isolated or inhospitable localities, such as remote mountain tops and distant oceanic islands (33).

Because spiders are major secondary consumers and relatively conspicuous invertebrates, assessment of their populations is an important tool for comparing and assessing the integrity of all types of terrestrial ecosystems. Hence, spiders in a sense are bioindicators of overall habitat quality, the health of entire terrestrial invertebrate communities, and the extent or nature of habitat disturbances (11, 89, 93, 94). Spiders present biologists with observable models of speciation and adaptation (18). For example, spider silk, long admired by engineers for its extraordinary strength and resilience, is now used by molecular geneticists to investigate evolutionary histories and trends. Finally, spiders are widely known to be essential, natural controllers of insects without being significantly detrimental to human health (33).

Thus, an awareness of what spiders species exist in a given area not only provides the foundation for future ecological and evolutionary studies, but it also may give us insight into the health of entire ecosystems. This project, therefore, serves as a starting ground for future studies of spiders and other components living in the natural and disturbed habitats of Missouri.

Until now, no one has prepared an exhaustive list of spider species found in Missouri. Furthermore, there are only a few localized studies of Missouri spider populations that have been published. Peck's survey of spiders in the environs sur-

rounding the city of Warrensburg in Johnson Co. is the most significant, resulting in the collection of 202 different species (68). His study, unlike most, was designed to survey the entire spider fauna, and consequently he employed a number of different collecting methods. By contrast, Bultman (11), using pitfall traps, found 55 species of cursorial spiders in three different types of Ozark fens and a surrounding oak-hickory forest in south-central Missouri. Also using pitfall traps, Haskins and Shaddy (41) collected 63 species of cursorial spiders in a set of old-fields in Adair Co. Weaver (93) recorded 47 spider species by sweeping with a net and searching by hand at Tucker Prairie in Callaway Co., Missouri, to study succession patterns after managed burning. Gardner (34) lists 36 species collected from various Missouri caves. Finally, Banks (2) identified spiders collected casually by a friend, "mostly near Springfield."

There are, however, a number of unpublished works on spiders in Missouri. Two manuscripts, one by W. R. Enns, entitled "Bibliography of Missouri Spiders", and the other by H. Exline-Frizzell, entitled "Catalog of Spiders of Missouri and North Arkansas", remain elusive; we have been unable to obtain copies of them. However, much of Enns' material no doubt is included in the University of Missouri spider collection. W. B. Peck informed us that his manuscript "Spiders from Missouri Pitfall Traps" (69) involved a 3-year long pitfall trap study conducted in Knob Noster State Park in Johnson Co. in the west-central region. Weaver's ongoing study (94) focuses on the arthropod community in leaf litter found on the soil in forests located in Carter, Reynolds, and Shannon Counties, which is part of the Missouri Ozark Forest Ecosystem Project (MOFEP) conducted by the Missouri Department of Conservation in the south-central part of the state. All spiders from Weaver's study were extracted using Tullgren funnels from quantitatively obtained leaf litter samples.

Materials and Methods

We obtained many records for spiders in some regions of Missouri from the faunistic studies mentioned in the introduction (2, 11, 34, 41, 68, 69, 93, 94). In addition , we included data on the spider collection in the Wilbur R. Enns Entomology Museum (WEM) at the University of Missouri-Columbia. We also thoroughly searched all available literature of spider systematics. The material found in published revisions of spider taxa held added significance since many of them contain the only accessible records of the late Harriet Exline-Frizzell's extensive collection and, therefore, insight into her unpublished catalog. The sixty-thousand specimen Exline-Peck Collection, one of the largest in the nation, is now held at the California Academy of Sciences in San Francisco. The collection contains a number of type specimens and is routinely used as reference for taxonomic studies.

Results and Discussion

The checklist of spiders in this paper is organized using the higher level taxonomy published by Coddignton and Levi (18). For instance, the first branching point separates all spiders into either of two suborders, the Mygalomorphae or

Araneomorphae. Mygalomorphs include the "tarantulas." They typically live in silk-lined burrows or tube retreats and differ from Araneomorphs mainly in spinneret and male genitalia structure (18). They are also characterized by having two pairs of lungs and possessing chelicerae that are parallel to each other, which move in a vertical plane. Araneomorphs differ by having their chelicerae opposing - at right angles to the body's longitudinal axis - and most share the transition of posterior book lungs into tracheae (33, 38).

The araneomorphs, known as the "true" spiders that most people encounter in their daily lives, represent about 32,000 of the 34,000 known species (33). In our checklist, araneomorph family divisions are arranged by trophic guild and not according to any particular cladistic order. We did this because knowledge of guild type and associated predatory habit often is used as the first step in spider identification in the field, whereas cladistic relationships often are not readily apparent and some remain in a state of flux.

For all spiders, there are generally three types of guilds based on how the spider acquires its food. The first type of guild, the *active hunters*, are spiders that use silk mostly for draglines, retreats, or construction of cocoons, and not for building webs. As the name suggests, they typically wander in search of prey. The *passive hunters* are similar in that they often construct silk-lined retreats and not webs. However, these spiders lie hidden in the retreat usually until they sense the mechanical vibrations from nearby prey. It then seizes the insect with its large, powerful forelegs. The passive hunters and active hunters are often grouped together as the "wandering spiders." The third type of guild are the *web-builders*. These are species like the common orb-weaving garden spider, *Argliope aurantia*, that spin sometimes large, elaborate webs to capture food. It is important to remember that guild associations are generalizations that in many cases might apply to the female of a particular species, but not to the male. Methods of prey capture can at once be very specialized and also common across the species level, depending on the circumstance and species of prey. For instance, most spiders with the exception of about three families (including the salticids and the lycosids) rely on vibrations to locate prey, due to insufficient eyesight (33).

We found a total of 480 spider species distributed among 29 families in Missouri. This is considerably higher than the estimate of "more than 300 species of spiders" reported 15 years ago for the state (95). In addition, our results are similar to the outcomes of spider surveys for two nearby states. Dorris (30) recorded 435 species of spiders in Arkansas, and Beatty and Nelson (6) reported that the total spider fauna in Illinois is 500 species in 27 families. Species names and classifications that we use here reflect up-to-date taxonomic works. In most cases, synonymies have been noted within the list.

For each spider species in the checklist, we present the following information whenever it was available: (1) the county, the particular locality, and the date on which the species was collected; (2) the name of the collector; (3) the name the person who identified the specimens and the date when the identification was recorded; (4) brief description of the species' natural history and distribution; and (5) reference

to reports in the taxonomic literature or specimens in the Wilbur Enns Collection (WEM) at the University of Missouri-Columbia.

Our results clearly indicate that the present state of knowledge of spiders in Missouri is very fragmentary. Most species are recorded to occur in one or a few counties. In contrast, only several species have been documented to occur in more than ten or more counties in the state. Furthermore, counties in the southeastern and southwestern regions of the state are underrepresented because few archnologists have collected there. To remedy this, one of us (JS) recently spent several weeks collecting spiders at representative natural areas in these two regions and his results will be reported in the near future.

In conclusion, our checklist provides the first, good measure of the spider fauna in the entire state of Missouri. But we cannot now render an informed opinion about the current ecological status of any spider in Missouri and, thus, about the possible change in the geographic distribution or abundance of any spider in the state. Yet, one must wonder if the widespread alteration and fragmentation of Missouri's natural habitats in the past 150 years might have significantly affected some spider species. For example, has the suppression of periodic fires and consequent invasion of woody vegetation on many small, patchy glade habitats in the south-central counties resulted in localized extinction of *Dugesiella hentzi*, the common tarantula? Perhaps it is appropriate to consider conducting a county-based survey of the spiders in Missouri, one that emphasizes collections made in the many natural areas held in the public domain.

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Family	Species	County	Locality, (Collector/Collection)	Identified	Natural History and Distribution	Published
Mygalomorphae	**(The "Tarantulas")**					
Avicularidae	Dugesiella hentzi (Girard)				open, dry glades in south and central MO	95
	Sphodros niger (Hentz)	Boone	Columbia, (WS Craig)	WS Craig		WEM
	(syn.: Atypus milberti Kaston)					
	sp?	Polk	Morrisville, (Mrs. F. Wallace)			WEM
Antrodiaetidae	Antrodiaetus hadros Coyle		Montauk State Park, 1968, Current River bank in mixed hardwood forest, (Coyle)	Coyle	burrows in moist reddish clay loam with very little surface litter	21
	Antrodiaetus lincolnianus Worley	Johnson	Warrensburg, (WB Peck)	Gertsch		68
	Antrodiaetus stygius (Coyle)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
		Dallas	Bennett Springs State Park, Sept. 4 1961, burrows near edge of stream, heavy shade and dense leaf litter, (Coyle)	Coyle		21
		Johnson	Warrensburg, Oct 10, 1962, stream in mixed deciduous forest, (Peck)			21
Ctenizidae	sp?	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (WB Peck & J. Peaslee)	F. Coyle 1981		69
Araneomorphae	**(The "True Spiders")**					
Active Hunters						
Amaurobiidae	Titanoeca americana Emerton	see note	(Van Ingen)			2
		Johnson	Warrensburg, (R.L.)		egg sacs laid June and early July and covered lightly with debris; under logs, bark and rocks	43
		Vernon	Walker, (Mus. Comp. Zool.)			43
	Titanoeca brunnea Emerton		"Tucker's Creek," (H. E. -Frizzell)		males appear April - Aug., females appear Feb. - July; leaf litter in woods	43

		Franklin	Washington, (Am. Mus. Nat. Hist.)	AMNH		WEM	
		Washington	Cove Creek, 15 mi. south of Prairie Grove (H. E. -Frizzell)			WEM	
Anyphaenidae	Anyphaena celer Banks	Johnson	Warrensburg, (W. B. Peck)	Peck			66
	Anyphaena celer (Hentz)		2 MO records: east of Kansas City; Ozarks/Rolla region		mature males taken every month except June, mature females taken year round; "...taken in houses, deciduous forests, on leaves, flowers, treesides, in pitfalls and in footprints in snow		70
	Anyphaena fraterna	Johnson	Warrensburg, (W. B. Peck)	Peck			68
	A. fraterna? Hentz	MOFEP	(J. C. Weaver)	Weaver	Leaf litter		94
	Anyphaena gracilis Hentz	see note	(Van Ingen)				2
	Anyphaena maculata (Banks)		1 MO record: Poplar Bluf fregion		mature males from late Sept. to early Feb., mature females from mid-Oct. to mid-April; "...taken by sweeping in bottomland pine and hardwood forests, by sifting leaves, and by Malaise traps."		70
	Aysha gracilis	Johnson	Warrensburg, (W. B. Peck)	Peck			68
		Boone	Columbia, (V. H. Owens)	Gertsch		WEM	
		Newton	(P. K. Moore)	Davis		WEM	
	Aysha (Hentz) sp?	St Louis	Kirkwood, (Neal)	Davis			41
	Wulfila saltabunda Hentz	Callaway	Tucker Prairie, (J. C. Weaver)	Peck			93
		Johnson	Warrensburg, (W. B. Peck)	Peck			68
Clubionidae	Agroeca pratensis C.L. Koch	Chariton		Davis		WEM	
	Castianeira amoena (C.L. Koch)		3 MO records: Nevada region; Columbia region; Rolla region		under rocks & stones and on stone outcrops, wanders on paths and very active, in woods or unfrequentec places; Southeastern U.S.		80
	Castianeira cingulata (C.L. Koch)	Johnson	Warrensburg, (W. B. Peck)	Peck			68
		Wright	Bill Dyer Lead Mine Cave entrance, (J. E. Gardner)				34

		3 MO records: St. Louis; Rolla region; Poplar Bluff region		forest litter, beneath logs & stones and among leaves; resembles large carpenter ants; Eastern and Midwestern U.S. & Canada	80
C. cingulata Hentz?	MOFEP	(J. C. Weaver)	Weaver	Leaf litter	94
Castianeira crocata (Hentz)		1 MO record: west of Columbia		houses, hiding in cracks, under boards; possibly a mutiliid wasp mimic; southern NJ to MO & south to TX	80
Castianeira descripta Kaston	Johnson	Warrensburg, (W. B. Peck)	Peck		68
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen, (T. L. Bultman)			11
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (W. B. Peck & J. Peaslee)	Peck 1979		69
Castianeira gertschi Kaston	Callaway	Tucker Prairie, (Weaver)	Weaver		93
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
		1 MO record: Columbia region		habits unknown; Southern New England to southeast U.S.	80
Castianeira longipalpus (Hentz)	Johnson	Warrensburg, (Peck)	Peck		68
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
	Reynolds	Grasshopper Hollow Fen: prairie fen; oak-hickory forest, (Bultman)			11
		2 MO records: Columbia region, Rolla region		usually under dead leaves, beech-maple forests	80
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979		69
C. longipalpus Gertsch?	MOFEP		Weaver	Leaf litter	91
Castianeira trilineata (Hentz)		1 MO record: Rolla region; one		ground stratum of sandy forests; Eastern U.S.	80

		specimen collected with carpenter ant worker (*Formica pallidefulva*).				
Castianeira variata C.L. Koch	Johnson	Warrensburg, (Peck)	Peck			68
C. Variata Gertsch	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Reynolds	Grasshopper Hollow Fen: seep fen, (Bultman)				11
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
		1 MO record: Warrensburg region		found in drier types of woodland and open areas (Filch 1963); Northeastern U.S. to KS & LA		80
Castianeira sp. A	Reynolds	Grasshopper Hollow Fen:seep fen, (Bultman)				11
Clubiona abbotii Gertsch	Johnson	Warrensburg, (Peck)	Peck			68
Clubiona johnsoni Gertsch	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Clubiona kastoni Hentz	Callaway	Tucker Prairie, (Weaver)	Weaver			93
Clubiona mixta Emerton	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Clubiona obesa Emerton	Johnson	Warrensburg, (Peck)	Peck			68
Clubiona tibialis	Johnson	Warrensburg, (Peck)	Exline			68
Clubiona C.L. Koch sp?	Monroe	(P. K. Moore)	Davis		WEM	
Clubionoides excepta	Johnson	Warrensburg, (Peck)	Exline			68
C. excepta (C.L. Koch)	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; forested fen, (Bultman)				11
C. excepta Banks?	MOFEP	(Weaver)	Weaver	Leaf litter		94
Gayenna saltabunda Hentz	see note	(Van Ingen)				2
Micaria elizabethae Gertsch	Reynolds	Grasshopper Hollow Fen: prairie fen, (Bultman)				11
Meriola decepta Hentz	Johnson	Warrensburg, (Peck)	Exline			68
Phrurotimpus alarius	Johnson	Warrensburg, (Peck)	Exline			68
P. alarius (Hentz)	Reynolds	Grasshopper Hollow Fen:forested fen; oak-hickory forest, (Bultman)				11

	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979, Peaslee 1979			69
P. alarius Emerton?	MOFEP	(Weaver)	Weaver	Leaf litter		94
Phrurotimpus borealis Chamb. & Gertsch	Johnson	Warrensburg, (Peck)	Exline			68
P. borealis (Emerton	Reynolds	Grasshopper Hollow Fen: forested fen; oak-hickory forest, (Bultman)				11
Phrurotimpus kentuckyensis	Johnson	Warrensburg, (Peck)	Exline			68
Phrurotimpus minutus Banks?	MOFEP		Weaver	Leaf litter		94
Scotinella formica Banks	Johnson	Warrensburg, (Peck)	Exline			68
Scotinella fratella (Gertsch)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979, 1980			69
Scotinella similis (Banks)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Thargalia trilineata Hentz	see note	(Van Ingen)				2
Thargalia longipalpis Hentz	see note	(Van Ingen)				2
Trachelas deceptus Hentz	Callaway	Tucker Prairie, (Weaver)	Weaver			93
Trachelas tranquillus (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68
	Boone	Columbia, (Pickett)	Enns&Wingo		WEM	
	see note	(Van Ingen)				2
	Greene	Springfield		mature males from mid June to early November, mature females year-round except for Feb. and March; common in houses, pine & hardwood forests, under boards, in leaf rolls, and in Malaise traps; Eastern U.S. & Canada		71
	Johnson	Warrensburg				71
	Newton	Newtonia				71
	Phelps	Rolla				71
	St. Louis	Valley Park				71
Trachelas Hentz sp.	Ste Genevieve	Weingarten, (J. Leach)	Davis		WEM	

Gnaphosidae	Callilepis imbecilla (Keyserling)	Reynolds	Grasshopper Hollow Fen: prairie fen; oak-hickory forest, (Bultman)				11
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979, Peaslee 1979			69
	Callilepis pluto Banks	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Cesonia bilineata (Hentz)	Wayne	(Exline-Peck Collection?)		Mature males year-round except Feb. & March, mature females year-round; pitfall traps in pine stands, woods, and prairies, in Malaise traps, in houses & greenhouses; Manitoba to MA south to NM & FL		76
	Drassodes auriculoides	Johnson	Warrensburg, (Peck)	Peck			68
	D. auriculoides Barrows	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Drassodes saccatus (Emerton)	Phelps			elevations to 10,000 ft; mid-May to mid-Sept.; pitfall traps in grasslands, under rocks and bark		74
	Drassodes Banks sp.	Livingston	Chillicothe, (J. House)	Exline		WEM	
	Drassylus aprilinus (Banks)	Johnson	Warrensburg, (Peck)	Exline			68
		MOFEP	(Weaver)	Ovtsharenko	leaf litter		94
		Reynolds	Grasshopper Hollow Fen: prairie fen, (Bultman)				11
		Cole			Mature males and females year-round; Various traps, under ground cover, oak-hickory and pine forests; MI & MA to San Luis Potosi & FL		78
		Miller					78
		Newton					78
		Phelps					78
		St. Louis					78
	Drassylus covensis Keyserling	MOFEP	(Weaver)	Ovtsharenko	leaf litter		94

D. covensis (Banks)	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)			11
Drassylus creolus Chamb. & Gertsch	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; forested fen, (Bultman)			11
	Dent			Mature males from late Feb. to June, mature females from March through Aug.; pitfall and Berlese traps, fields, prairies, under boards, pine and oak-hickory forest	78
	Johnson				78
	Phelps				78
Drassylus depressus (Emerton)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
	Boone	Exline-Peck Collection?		Mature males late April through late Sept., mature females Jan., March, May through late Aug.; vacuum and pitfall traps, under boards, rocks, and debris, in fields, forests, gravel pits, in houses; British Columbia to Nova Scotia, south to AZ, AR, & VA	78
Drassylus dixinus Chamberlin	Reynolds	Grasshopper Hollow Fen: seep en; prairie fen, (Bultman)			11
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, May 23 - July 24, 1978-80, 39 males, 46 females, (Peck & Peaslee, EPC)		southeastern U.S	78
	Johnson	Warrensburg, June 1, 1963, 1 male, (Peck, EPC)			78
Drassylus eremitus Chamberlin	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; oak-hickory forest, (Bultman)			11

	Crawford	E-PC?		Mature males Feb.-Aug, Oct., mature females March-Aug, Dec.; pitfall traps and Berlese samples, in bogs, and in bottomland, hardwood, pine, and sand-pine forests		78
Drassylus fallens Chamberlin	Adair	2 mi. south of Kirksville,(Haskins & Shaddy)	Peck/Dondale			41
Drassylus gynosaphes	Johnson	Warrensburg, ground, openroadway, May 5, 1963, 1 male, (Peck)		KS & MO, to Southern TX.		78
Drassylus lepidus (Banks)	Johnson	(Peck?)		Mature males and females year-round; pitfall traps and houses, under rocks, associated with crop fields, grass; UT & SC to southern Mexico		78
Drassylus nannellus Chamb. & Gertsch	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/ Dondale			41
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, June 11 - July 24, 1978 - 1980, 1 female, (Peck & Peaslee)		Oregon to Ohio		78
Drassylus neglectus Banks		Kohler City, (Pickard)	Pickard		WEM	
Drassylus niger	Callaway	Tucker Prairie, (Weaver)	Weaver			93
D. niger (Banks)	Reynolds	Grasshopper Hollow Fen: prairie fen, (Bultman)				11
Drassylus novus	MOFEP	(Weaver)	Ovtsharenko	leaf litter		94
D. novus (Banks)	Reynolds	Grasshopper Hollow Fen: forested fen; oak-hickory forest, (Bultman)				11
	Phelps	(Exline?)		Mature males from April to June and Nov., mature females from May through Sept.; pitfall traps and leaf litter in pine and oak-hickory forests, under stones; eastern deciduous forest		78
Drassylus rufulus (Banks)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41

	Boone	Columbia, Oct. 30, 1904, 2 females		CO & TX to NH & NC		78
Drassylus sp	Genlry	(Burchett)	Exline		WEM	
	Worth	Allendale, (House)	Exline		WEM	
Gnaphosa fontinalis C.L. Koch	MOFEP	(Weaver)	Ovtsharenko	Leaf litter		94
G. fontinalis Keyserling	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
	Oregon	Shawnee National Forest, (Peck?)		mature males from April through July, mature females from April through October; maple-basswood and pine-oak forests, on bean plants, and in pitfall traps in leaf litter		72
	St. Charles	St. Charles				72
Gnaphosa sericata (C. Koch)	Reynolds	Grasshopper Hollow Fen: forested fen; oak-hickory forest, (Bultman)				11
	Boone	Columbia		elevations b/w 1000 and 6000ft, in pitfall traps at pond edges, fields, sandy roads; NY to UT, south to Gualemala and Cuba		72
	Phelps	Rolla				72
	St. Louis					72
Haplodrassus bicornis (Emerton)	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
Haplodrassus signifer (C.L. Koch)	Johnson	Warrensburg, (Peck)	Peck			68
	Lawrence	(Hughes)	Exline		WEM	
	Linn	Laclede, (Mueller)	Exline, Davis		WEM	
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Reynolds	Grasshopper Hollow Fen: prairie fen, (Bultman)				11
	Cole			taken year round between 1000 and 13,800 ft; pitfall traps, under stones		73
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Phelps					73

H. signifer?	MOFEP	(Weaver)	Weaver	Leaf litter		94
Haplodrassus Walckenaer sp.	Cedar	(Garrison)	Exline		WEM	
Herpyllus ecclesiasticus Hentz	Bates	(E-PC?)		Mature males and females year-round; elevations up to 8050 ft., in houses, under rocks and logs, in Malaise traps, associated with oak, maple, pine, basswood, cottonwood, sycamore, locust; Alberta east to Nova Scotia, south to Tamaulipas and FL.		75
	Johnson					75
	Phelps					75
Herpyllus vasifer	Johnson	Warrensburg, (Peck)	Peck			68
	Boone	Columbia, (Ferris)	Gertsch		WEM	
	Livingston	Chillicothe, (House)	Exline		WEM	
H. vasifer Chamberlin	Boone	Columbia, (Enns)	Zach,Thewke		WEM	
H. vasifer (Walckenaer)	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
Litopyllus repicolens Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
Litopyllus temporarius Chamberlin	Johnson	Knob Noster State Park, under stone, April 30, 1964, 1 male				77
		Warrensburg in house or on wooded terrace, May 6 - Aug. 11, 1961 - 1964, 4 males, 3 females, (Peck, E-PC)				77
Micaria agilis nov. sp.	see note	(Van Ingen)				2
Micaria elizabethae (Gertsch)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Nodocion floridanus (Banks)	Wayne	Williamsville, malaise trap, June 1970, 1 male, (J.T. Becker)	R.E. Leech	Eastern U.S. west to southeastern AZ		77
Prosthesima ecclesiastica Hentz	see note	(Van Ingen)				2
Rachodrassus exlineae	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
Platnick & Shadab	Cole	Jefferson City, May 10, 1961, 1 female, (Dowdy)	Exline/Peck			74
	Jefferson	outside Pleasant Valley Cave, June 10 - 24, 1965, carrion trap, 2 males, (S. Peck)	AMNH			74

	Ripley	Doniphan, Sept. 30, 1941, 1 female	AMNH			74
	Washington	Washington State Park, May 16, 1941, 1 female, (C. M. Goodnight)	AMNH			74
Sergiolus capulata Hentz	Callaway	Tucker Prairie, (Weaver)	Weaver			93
Sergiolus decoratus Banks	Bates	(Shannon)	Davis		WEM	
	MOFEP	(Weaver)	Ovtsharenko	Leaf litter		94
Sergiolus variegatus (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Sosticus insularis (Banks)	Johnson	Warrensburg, (Peck)	Peck			68
	Johnson	Warrensburg, June 22-25, 1962, in house, 1 female, (Peck)	Peck			74
Talanites exlineae Barrows	MOFEP	(Weaver)	Weaver	Leaf litter		94
Zelotes aiken, new sp.	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, May 23-June 5, 1980, 1 male, (Peck & Peaslee)		Southeastern U.S.		79
	Johnson	Warrensburg, May 10, 1964, 1 male, (D. L. Frizzell & W. Peck)				79
Zelotes duplex Chamberlin	Reynolds	Grasshopper Hollow Fen: prairie fen; oak-hickory forest, (Bultman)				11
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Cole			Mature males April through Oct., mature females Feb. through Oct.; pitfall traps in hickory, oak, and pine forests, pastures, prairies, and buildings; Eastern U.S. & Canada		79
	Dent					79
	Johnson					79
	Phelps					79
Zelotes hentzi	Johnson	Warrensburg, (Peck)	Peck			68
	Cedar	(Garrison)	Exline		WEM	

	Z. hentzi Koch	Cass		Exline		WEM	
	Z. hentzi Barrows	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
		Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
		Johnson	(E-PC?)		Mature males year-round, mature females year-round except Jan.; Berlese, malt, molasses, and pitfall traps, in coniferous forests, sandstone outcrops, meadows and prairies; Southern Canada and the U.S., except for the Southwest		79
	Zelotes Inheritus Kaston	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Zelotes laccus (Barrows)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, June 4 - Aug. 16, 1978 - 1980, 83 males, 25 females, (Peck & Peaslee)	Peck 1979	Eastern U.S. & Canada	69;79	
	Zelotes subterraneus	Johnson	Warrensburg, (Peck)	Exline			68
	Zelotes tuobus Chamberlin	Johnson	Knob Noster State Park, pitfall, brushy prairie, Sept. 6-19, 1980, 1 female , (Peck & Peaslee)		British Columbia south to NM, east to KY & TN		79
	Zelotes sp	Bates	Passard, (Shannon)	Davis		WEM	
	Zelotes sp	MOFEP	(Weaver)	Weaver	Leaf litter		94
	Zelotes Emerton sp.	St Louis	(Hartshorne)			WEM	
Hahniidae	Hahnia cinerea Villiers	Cass	(Lathrop)	Davis		WEM	
	H. cinerea Emerton			Opell & Bealty	from Cape Girardeau region north to Iowa		67
	Hahnia ononidum (Simon)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41

	Neoantistea agilis (Keyserling)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
			Columbia region; Rolla region; Ste Genevieve region	Opell & Beatty			67
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978, 1979, 1980			69
	Neoantistea magna (Keyserlig)	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; oak- hickory forest, (Bultman)				11
	Neoantistea riparia (Keyserling)		Springfield region	Opell & Beatty			67
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Leptonetidae	Leptoneta sp	Ozark	Goat Cave, (Gardner)				34
Lycosidae	Allocosa funerea (Hentz)	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; oak-hickory forest, (Bultman)				11
			1 MO record: central MO (Columbia?)		most common species of its genus; grassy fields, meadows, lawns, gardens and pine forests; April - Sept.		27
	Allocosa sublata (Montgomery)		1 MO record: north of St. Louis		soil and litter in moist woods		27
	Arctosa funerea	Johnson	Warrensburg, (Peck)	Exline			68
	A. funerea Walckenaer	Boone	Columbia, (Enns)	Exline		WEM	
	Arctosa virgo (Chamberlin)	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
	Geolycosa fatifera (Hentz)	Jackson	Kansas City, Aug., 1931, female, (Macy)	AMNH; possible misidentification (no males found)	mesic in habitat selection, "scarce where shade is marked or leaf fall heavy"; resembles G. missouriensis (Banks).		91
	Geolycosa missouriensis (Banks)	Boone	Columbia, June 7, 1938, 1 female, (Peterson)		mature males from Sept. through Nov., and April, mature females year-round; wide variety of habitats excluding forests; from the Central lowlands to the Rockies		91

[syn: Lycosa missouriensis nov sp.]	*	(Van Ingen)				2
Gladicosa gulosa (Walck.), comb. nov.	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Boone			mature females from September, through winter, to June (Kaston, 1948); dead leaves and leaf litter on the forest floor; southern Canada in the northeast to eastern TX in the southwest. Not recorded from FL and a single specimen from CO.		10
	Greene					10
	St. Charles					10
	St. Louis	St. Louis City				10
[syn.: Lycosa gulosa Walckenaer]	Johnson	Warrensburg, (Peck)	Exline			68
Gladicosa pulchra (Keyserling), comb. nov.	Pulaski	Richland, 20 April, 1962, female (W. Ivie)		trunks of deciduous and pine trees, silk-lined burrows under stones in TX; from Long Island, NY, along the East Coast to TX in the southwest. Limited in its northern range inland to the southern parts of KS and MO and northern KY.		10
Hogna antelucana (Montgomery)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Hogna carolinensis (Walckenaer)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslec)	Peck 1979			69
Hogna helluo (Walckenaer)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Lycosa avara Keyserling	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Lycosa babingtoni Blk.	*	(Van Ingen)				2
Lycosa belluo Walckenaer	Boone	Columbia, (Owens)	Gertsch		WEM	

Lycosa carolinensis	Johnson	Warrensburg, (Peck)	Peck			68
L. carolinensis Walckenaer	Boone	Columbia, (Wood)			WEM	
L. carolinensis Hentz	*	(Van Ingen)				2
Lycosa helluo Chamberlin	Johnson	Warrensburg, (Peck)	Peck			68
L. helluo Walckenaer	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen, (Bultman)				11
Lycosa permunda Hentz	Johnson	Warrensburg, (Peck)	Exline			68
Lycosa punctulata	Johnson	Warrensburg, (Peck)	Peck			68
	Phelps	Rosati, (Strange)	Enns		WEM	
L. punctulata Walckenaer	St Louis	Florissant, (Strange)	Davis		WEM	
L. punctulata (Hentz)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Lycosa rabida Emerton	Johnson	Warrensburg, (Peck)	Peck			68
L. rabida Walckenaer	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen, (Haskins & Shaddy)				41
Lycosa scutulata Hentz	*	(Van Ingen)				2
Lycosa sp. A	Reynolds	Grasshopper Hollow Fen: forested fen; oak-hickory forest, (Bultman)				11
Pardosa lapidicina Hentz	Johnson	Warrensburg, (Peck)	Peck			68
Pardosa milvina	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Columbia, (Enns)	Enns		WEM	
P. milvina Hentz	Boone	Easley, (Enns)	Exline		WEM	
		5 MO records: Kansas City region; Johnson Co. region; Vernon Co. region; Barry Co region; Butler Co region		Mature males from Feb. to Aug., mature females from Feb. to Nov.; reaches high densities in moist habitats such as swamps and edges of ponds, but also in deciduous woods, lawns,and various crops; northern MI & southern Canada to ME, south to TX & FL.		28
Pardosa moesta Banks	Reynolds	Grasshopper Hollow Fen: prairie fen, (Bultman)				11
Pardosa obsoleta Banks?	*	(Van Ingen)				2
Pardosa saxatilis (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68
	Callaway	Tucker Prairie, (Weaver)	Brady			93
	Ste Genevieve	Ste Genevieve, (Enns et. al.)	Davis		WEM	
	Boone	Columbia, (Enns)	Davis		WEM	

	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen, (Bultman)			11
Pardosa Wallace & Exline sp	Boone	Hog Lot Cave, (Gardner)	Gardner		34
Pirata alachuus Gertsch & Wallace	Crawford			open woods, ground litter, along streams and ponds	92
	Johnson				92
	Phelps				92
	Ripley				92
	Stoddard				92
	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; forested fen; oak-hickory forest, (Bultman)			11
Pirata arenicola Emerton	Reynolds	Grasshopper Hollow Fen: prairie fen; forested fen, (Bultman)			11
Pirata hiteorum Emerton	Callaway	Tucker Prairie, (Weaver)	Brady		93
P. hiteorum Wallace & Exline	Adair	2 mi. of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
Pirata indigenus, n. sp.	Crawford	Meramec River, (Exline-Frizzell & Frizzell)	Exline		92
Pirata insularis Emerton	Johnson	Warrensburg, (Peck)	Exline		68
	Crawford				92
	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; forested fen; oak-hickory forest, (Bultman)			11
Pirata maculata Montgomery	Johnson	Warrensburg, (Peck)	Peck		68
Pirata minutus Emerton	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
Pirata montanoides Banks	•	(Van Ingen)			2
Pirata sedentarius (Simon)	Johnson	Warrensburg, (Peck)	Peck		68
	Boone	near stream			92
	Crawford				92
	Dent				92
	Jefferson				92
	Osage				92
	Phelps				92
	Ste. Genevieve				92
	Saline				92

Pirata seminola Gertsch & Wallace	Newton	Newtonia, (Peck)	Exline			92
	Dent	Hobson Heights, (H. Exline-Frizzell)	Exline			92
Pirata spiniger Chamberlin & Ivie	Carter	Blue spring Cave, (Gardner)	Gardner	very rare – otherwise known only from FL and adjoining states		34
Pirata sylvanus	Johnson	Warrensburg, (Peck)	Exline			68
Pirata sp nov	Johnson	Warrensburg, (Peck)	Exline			68
Pirata sp?	Camden	Macks Creek, (Wood)			WEM	
	Boone	Columbia, (Enns)	Exline		WEM	
Pirata sp?	Carter	various caves, (Gardner)	Gardner			34
Pirata Emerton sp.	Franklin	Hidden Room Cave				34
Schizocosa avida (Walckenaer)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
		2 MO records from the Lower Missouri River region and the Ozarks		fields & meadows; construct shallow burrows for moulting or egg-laying		26
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peaslee 1978			69
[syn.: Lycosa erratica Hentz]	•	(Van Ingen)				2
Schizocosa bilineata (Emerton)	Johnson	Warrensburg, (Peck)	Peck			68
	Callaway	Tucker Prairie, (Weaver)	Brady			93
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; oak-hickory forest, (Bultman)				11
		2 MO records: Warrensburg region?		open fields, meadows, vegetated beaches; mature in spring		26
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
S. bilineata Walckenaer	Boone	Columbia, (Bishop & Crosby)			WEM	
Schizocosa crassipes	Johnson	Warrensburg, (Peck)	Peck			68
	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
S. crassipes Hentz?	MOFEP	(Weaver)	Weaver			94

Schizocosa duplex Chamberlin	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Schizocosa ocreata (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
	Ste Genevieve	Ste Genevieve, (Enns et. al.)	Davis		WEM	
	Boone	Columbia, (Enns)	Davis		WEM	
	Howell	Ralph Ridge Pit Cave, (Gardner)	Gardner			34
	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen; forested fen; oak-hickory forest, (Bultman)				11
		9 MO records from Lower Missouri River region and the Ozarks		forest glades and meadow-forest interface; often confused with S. crassipes		26
S. ocreata Keyserling	Ozark	Bear Cave				34
Schizocosa retrorsa (Banks)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
		3 MO records: 2 from south central MO/ Ozarks region; St. Louis-IL border vicinity		habitat not reported		26
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Schizocosa saltatrix (Hentz)	Johnson	Warrensburg, (Pek)	Peck			68
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Reynolds	Grasshopper Hollow Fen: prairie fen; oak-hickory forest, (Bultman)				11
		4 MO records from Lower Missouri River region		hardwood forests; adults appear in spring		26
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Trabea aurantiaca (Emerton)	Reynolds	Grasshopper Hollow Fen: forested fen, (Bultman)				11
Trochosa avara Keyserling	Johnson	Warrensburg, (Peck)	Peck			68
	Callaway	Tucker Prairie, (Weaver)	Brady			93

		Boone			Mature males from Sept. to mid-Nov., mature females from mid-March to mid-Nov.; beneath stones and along the edges of wooded areas; from southern Quebec and ME in the northeast to eastern NE, KS, and TX in the southwest		9
		St. Louis					9
	Trochosa terricloa Hentz?	MOFEP	(Weaver)	Weaver			94
	Varacosa acompa (Chamberlin)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Varacosa avara (Keyserling)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979, 1980			69
Mimetidae	Ero furcata Hentz	Johnson	Warrensburg, (Peck)	Exline			68
	Ero leonia Ivie & Barrows	Callaway	Tucker Prairie, (Weaver)	Weaver			93
	Ero pensacolae Emerton	Johnson	Warrensburg, (Peck)	Exline			68
	Ero sp	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Mimetus epeiroides	Callaway	Tucker Prairie, (Weaver)	Peck			93
	M. epeiroides Chamberlin	Greene	(Leach)	Davis		WEM	
	M. epeiroides Emerton	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Mimetus puritanus Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
Oxyopidae	Oxyopes apollo sp. n.	Phelps	Rolla, (R. H. Crandall)				8
	[syn.: O. helius Bryant]						8
	Oxyopes salticus	Johnson	Warrensburg, (Peck)	Peck			68
		Ste Genevieve	Ste Genevieve, (Enns)	Enns		WEM	
		Boone	Rocheport, (Strange)	Enns		WEM	
		Butler	Fisk, (Enns & Wood)	Enns		WEM	
		Butler	Poplar Bluff, (Enns & Wood)	Davis		WEM	
		Callaway	Tucker Prairie, (Strange)	Enns			93
	O. salticus Barrows	Vernon	Nevada, (McReynolds)	Enns		WEM	
	O. salticus (Hentz)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
		Boone			common in tall grass and herbaceous vegetation		8
		Carter					8
		Dent					8
		Jackson					8

		Phelps					8
		*	(Van Ingen)				2
	Oxyopes scalaris Hentz	?	(Tugmon et. al.)	Tugmon et al			87
		Cole, Phelps			pine trees, deciduous trees, shrubs		8
Pisauridae	Dapanus mirus Hentz	Johnson	Warrensburg, (Peck)	Peck			68
	Dolomedes scriptus Hentz	Johnson	Warrensburg, (Peck)	Peck			68
	Dolomedes sp., aff. scriptus Hentz	Crawford	Jagged Canyon Cave, (Gardner)	Gardner			34
	Dolomedes tenebrosus	Johnson	Warrensburg, (Peck)	Exline			68
	D. tenebrosus Hentz	Oregon	Two Entrance Cave, (Gardner)	Gardner			34
	Dolomedes sp., aff. tenebrosus	Carter	Mitchell Hollow Cave, (Gardner)	Gardner			34
	D. sp., aff. tenebrosus Walckenaer	Phelps	Hanley Cave				34
	Dolomedes triton	Mercer	Princeton, (Hoberect)	Gertsch		WEM	
		Boone	Columbia, (Owens)	Gertsch		WEM	
	D. triton Hentz	Boone	Ashland, (Wood)	Wood		WEM	
	Dolomedes urinator	Johnson	Warrensburg, (Peck)	Peck			68
	Dolomedes sp?	Barry	various caves, (Gardner)	Gardner			34
		Boone	various caves, (Gardner)				34
		Callaway	Spaghetti Cave, (Gardner)				34
		Carter	Fern Lip Cave & FS Cave 165, (Gardner)				34
		Crawford	Bat Cave & Bear Cave, (Gardner)				34
		Franklin	Camper Spring Cave & Hidden Room Cave, (Gardner)				34
		Madison	Marsh Creek No 1, (Gardner)				34
		Oregon	various caves, (Gardner)				34
		Pulaski	Peninsula Cave, (Gardner)				34
		St Louis	Woods Cave, (Gardner)				34
		Washington	Camp Branch Cave, (Gardner)				34
	Dolomedes Walckenaer sp?	Wright	Bill Dyer Lead Mine Cave, (Gardner)				34

	Pisaurina brevipes (Emerton)		Kansas City region		Mature males found in May, mature females from March through November; collected from prairies; eastern North America from Ontario, MI, & MA south to LA and central FL and westward to KS and AR		12
	Pisaurina dubia (Hentz)		4 MO records: 2 from Kansas City region; Columbia; St. Louis		Mature males from May through July, mature females from March through June; from grass, litter, and pine; southern coastal plain, lower Piedmont of eastern North America from MD south to southern FL and west to KS & TX.		12
	Pisaurina mira Walckenaer	MOFEP	(Weaver)	Weaver			94
	Pisaura undata Hentz	•	(Van Ingen)				2
		Boone	Rocheport, (Enns)	Davis		WEM	
		Butler	Poplar Bluff	?		WEM	
		Camden	Stover, (Enns)	Enns		WEM	
			5 MO records: St. Louis region; Columbia region; 2 from Rolla region; south of Rolla, (E-PC?)		Mature males in May and June, less in April and July, mature females March through September; females usually found in grass and shrubs, males more commonly wander; very common in eastern North America west to TX, MN, KS, and OK.		12
	Thanatidius tenius Hentz	Johnson	Warrensburg, (Peck)	Peck			68
Salticidae	Agassa cyanea (Hentz)	Callaway	Tucker Prairie, (Weaver)	Edwards			93
		Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	A. cyanea Peckham	Butler	Poplar Bluff, (Enns & Wood)	Davis		WEM	
	Attus concolor nov sp	•					2
	Corythalia delicatula (Gertsch & Mulaik)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Cutler 1979			68

Dendryphantes octavus Hentz	*	(Van Ingen)				2
Epiblemum scenicum Clerck	*	(Van Ingen)				2
Eris aurantia (Lucas)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Eris marginatus Hentz	Johnson	Warrensburg, (Peck)	Peck			68
Eris militaris (Hentz), new comb.		2 MO records: Kansas City; Branson region		Habitat varied, common on trees and shrubs; widely distributed throughout U.S., more common in the northern states and less in the southwest.		60
Evarcha hoyi (Peckham)	Johnson	Warrensburg, (Peck)	Exline			68
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
E. hoyi (Peckham & Peckham)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peaslee 1979			69
hoyi Hentz?	MOFEP		Weaver	Leaf litter		94
Gertschia noxiosa Hentz	Johnson	Warrensburg, (Peck)	Peck			68
Habrocestum cristatum Hentz	*	(Van Ingen)				2
Habrocestum coecatum Hentz	*	(Van Ingen)				2
Habrocestum pulex	Johnson	Warrensburg, (Peck)	Exline			68
H. pulex Walckenaer	Boone	Columbia, (Strange)	Davis		WEM	
H. pulex (Hentz)	St. Louis	St. Louis				81
	St. Louis	St. Clair				81
Habronattus coecatus (Hentz)	Boone	Columbia, 1 male (N. Banks, MCZ)		Habronattus species are typically terrestrial and are found in open, sunny places on bare ground, rocks, ground cover, or low vegetation; eastern U.S. from NY south to northern FL and west to the edge of the Great Plains, south into northeastern Mexico.		40
	Jackson	Ft. Osage State Park, June 26, 1975, 1 male (C. Griswold, UCB)				40
Habronattus coronatus	Johnson	Warrensburg, (Peck)	Exline			68
H. coronatus Hentz		Shockelford, (Enns)	Gertsch		WEM	
Habronattus viridipes	Carter	Fremont, (Enns)	Davis		WEM	
Hentzia ambigua Hentz	Callaway	(S. Swedener)	Zepp		WEM	

Hentzia mitrata Hentz	Johnson	Warrensburg, (Peck); shrubs and oak trees, (E-PC)	Peck		68;82	
	Phelps					82
Hentzia palmarum (Hentz)	Johnson	(E-PC)				82
	Newton					82
	Phelps					82
	Vernon					82
Icius elegans (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68
I. elegans Emerton	Boone	Columbia, (Zepp)	Zepp		WEM	
Icius hartii (Emerton)	Johnson	Warrensburg, (Peck)	Exline			68
Icius mitratus Hentz	*	(Van Ingen)				2
Maevia inclemens Hentz?	MOFEP	(Weaver)	Weaver	Leaf litter		94
Maevia vittata (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68
Maevia Koch sp.	Howard	New Franklin, (Zepp)	Zepp		WEM	
Marpissa formosa (DeGeer)	Johnson	Warrensburg, (Peck)	Exline			68
Marpissa lineata	Callaway	Tucker Prairie, (Weaver)	Weaver			93
M. lineata G. & E. Peckham	Johnson	Warrensburg, (Peck)	Exline			68
M. lineata (C. L. Koch)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	St. Louis	St. Louis, May 13, 1950, 1 female, (W. Dowdy)		common in leaf mold in forest and shrub communities, common member of the litter population of the prairie grass communities; widely distributed over the eastern half of the U.S., but displaced by *Marpissa sulcosa* in FL and along the southern coast		4
[poss. syn.: Onondaga lineata (C.L. Koch)]	Reynolds	Grashopper Hollow Fen: seep fen, (Bultman)				11
[poss. syn.: Onodaga lineata Peckham]	MOFEP	(Weaver)	Weaver	Leaf litter		94
Marpissa mucosa (Clerck)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Marpissa pikei DeGeer	Callaway	Tucker Prairie, (Weaver)	Peck			93
Marpissa undulata	Jackson	Sibley, (Strange)			WEM	
	Perry	(C. W. Wingo)	Thewke		WEM	
Menemerus bivittatus DeGeer	MOFEP	(Weaver)	Weaver	Leaf litter		94
Metacyrba undata Walckenaer	Johnson	Warrensburg, (Peck)	Peck	common throughout the eastern half of the U.S. (Barnes 1958)		68

[poss. syn.: Marpissa undata]	Jackson	Sibley, (Strange)	Davis		WEM	
[poss. syn.: Marptusa familiaris Hentz]	•	(Van Ingen)				2
Metaphidippus canadensis (Banks)	Callaway	Tucker Prairie, (Weaver)	Edwards			93
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Metaphidippus exiguus [poss. syn.: Pelegrina exigua (Banks)]	Johnson	Warrensburg, (Peck)	Peck			68
M. exiguus Peckham	Boone	Columbia, (Davis)	Davis		WEM	
Metaphidippus flavipedes Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
Metaphidippus galathea	Johnson	Warrensburg, (Peck)	Exline			68
	Callaway	Tucker Prairie, (Weaver)	Peck			93
	Boone	Columbia, (Davis)	Davis		WEM	
	Boone	Columbia, Rollins Farm, (Davis)	Davis		WEM	
M. galathea (Walckenaer)	Boone	Columbia, (Davis)	Davis		WEM	
	Boone	(Voucher & McRae)	McRae		WEM	
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Metaphidippus sp	Boone	Rocheport, (Strange)	Davis		WEM	
	Butler	Poplar Bluff, (Enns & Wood)	Davis		WEM	
	Boone	Columbia, (Strange)	Davis		WEM	
	New Madrid	Lilbourn, (Wood)	Davis		WEM	
Metaphidippus Banks sp.	Carter	Fremont, (Enns)	Davis		WEM	
Marpissa sp	Callaway	Reform, (Yonke & Kopp)	Thewke		WEM	
Peckhamia americana Hentz	Johnson	Warrensburg, (Peck)	Exline			68
Peckhamia picata	Johnson	Warrensburg, (Peck)	Peck			68
Pelegrina exigua (Banks, 1892)	Boone			Usually found on conifers, known from pines, junipers, and occasionally on other plants such as oak and walnut; eastern U.S., except far north		61
	Cole				WEM	
Pelegrina galathea (Walckenaer)	Barry			sunlit places, such as old fields; widespread throughout eastern North America north to southern Ontario, west to the Rockies, south to FL and Costa Rica		61
	Boone					61
	Jackson					61

	Vernon					61
	St. Charles					61
	St. Louis					61
Pelegrina proterva (Walckenaer)	Boone					61
	Cole					61
	Jackson					61
	Johnson					61
	St. Louis			Found on various trees and shrubs, usually in or near forests; across much of Canada and northeastern U.S., south in the east to FL & TX		61
[syn: Metaphidippus protervus]	Johnson	Warrensburg, (Peck)	Exline			66
Pellenes coecatus (Hentz)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Pellenes sp	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Paraphidippus sp. A	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
Phidippus apacheanus Hentz	Boone	Columbia, garden, (Marston)	Hennessey		WEM	
Phidippus audax	Johnson	Warrensburg, (Peck)	Peck			68
	Callaway	Tucker Praire, (Weaver)	Edwards			93
	Boone	Columbia, (Owens)	Gertsch		WEM	
	Cedar	(Garrison)	Davis		WEM	
	Vernon	Nevada, (McRoy)	Davis		WEM	
	Crawford	Steelville, (F. St. Aubin)	Davis		WEM	
P. audax Hentz	•	(Van Ingen)				2
Phidippus cardinalis Keyserling	Christian	(Zepp)	Zepp		WEM	
	Johnson	Warrensburg, (Peck)	Peck			68
Phidippus clarus	Johnson	Warrensburg, (Peck)	Peck			68
P. clarus (Keyserling)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Phidippus flavipedes Peckham	Boone	Columbia, Research Park, (Hennessey)	Hennessey		WEM	
Phidippus mc cooki (Peckham)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
Phidippus princeps Keyserling	Johnson	Warrensburg, (Peck)	Peck			68
P. princeps (Peckham)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69

Phidippus purymiratus(?)	Jasper	Webb City	Davis	WEM	
P. purymiratus Keyserling ?	Lafayette	Lexington, (Strange)	Davis	WEM	
Phidippus rimator	Callaway	Tucker Prairie, (Weaver)	Edwards		93
	Buchanan	Rushville, (O. Sonnenmoser)	Hennessey	WEM	
P. rimator Peckham	Boone	Columbia, Research Park, (Hennessey)		WEM	
Phidippus whitmanii	Johnson	Warrensburg, (Peck)	Peck		68
	Phelps	Rosati, (Enns)	Davis	WEM	
	Ste Genevieve	Bloomsdale, (Enns, Wood)	Davis	WEM	
Phidippus Clerck sp.	Cass		Davis	WEM	
Philaeus militaris Hentz	•				2
Phlegra fasciata (Hahn)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979		69
Plexippus putnami Peckham	•	(Van Ingen)			2
Saitis pulex Hentz	•	(Van Ingen)			2
Salticus scenicus (Banks)	Johnson	Warrensburg, (Peck)	Peck		68
Sarinda hentzi Peckham	Callaway	Reform, (Yonke & Kopp)		WEM	
S. hentzi Banks	Johnson	Warrensburg, (Peck)	Peck		68
	Ste Genevieve	Bloomsdale, (Enns & Wood)	Davis	WEM	
	?	Woodoych(?), (Strange)	Davis	WEM	
	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
Sassacus papenhoei	Johnson	Warrensburg, (Peck)	Exline		68
S. papenhoei Walckenaer	Boone	Columbia, (Zepp)	Zepp	WEM	
Sitticus cursor Barrows	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
Sitticus striatus Emerton	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
Sitticus sp. A	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen, (Bultman)			11
Synageles scorpiona Hentz	•	(Van Ingen)			2
Synemosyna formica Hentz	•	(Van Ingen)			2
Synemosyna lunata Walckenaer	Boone	Columbia, (Craig)		WEM	
Talavera minuta (Banks)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Cutler 1979		69
Thiodina iniquies Hentz	Boone	Columbia, (Davis)	Davis	WEM	
Thiodina sylvana	Johnson	Warrensburg, (Peck)	Exline		68
T. sylvana Peckham	Callaway	Tucker Prairie, (Weaver)	Peck		93

	Thiodina sp.	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978			69
	Tutelina elegans (Hentz)	?	(Tugmon et. al.)	Tugmon et al			87
	Zygoballus bettini Peckham	Johnson	Warrensburg, (Peck)	Exline			68
	Zygoballus nerviosus	Johnson	Warrensburg, (Peck)	Exline			68
		Monroe	(Snider)			WEM	
		Cooper				WEM	
Passive Hunters							
Dysderidae	Ariadna bicolor (Hentz)	Boone	Columbia, (Hennessey)			WEM	
		Boone	Columbia, (Zepp)	Spellerberg		WEM	
		Boone	Columbia, (Zepp)	Zepp		WEM	
		Boone	Columbia, (Thewke)	Thewke		WEM	
		Boone	Columbia, (Enns)	Enns		WEM	
		St Louis	St Louis, (Spellerberg)	Spellerberg		WEM	
		Taney	(Exline?)		ME to FL and west to Southern CA		5
		Wayne					5
	Dysdera crocata	Pettis	Sedalia, under porch, (Enns)	Zack			34
		St Louis	St Louis, (Koch)	Koch		WEM	
		St Louis	St Louis, (Spellerberg)	Spellerberg		WEM	
Philodromidae	Ebo Keyserling sp.	Johnson	Warrensburg, (Peck)	Peck			68
	Ebo latithorax	Butler	Poplar Bluff, (Enns & Wood)	Davis		WEM	
	E. latithorax Walckenaer	Boone	Columbia	Neal		WEM	
	E. latithorax Keyserling	Boone	Columbia		mature males collected mid-March to late June, mature females collected from mid-April to mid-August; obtained by sifting, pitfall traps in fields and at field-forest junctions, under logs; leaves of coniferous and deciduous forests; houses		85
		Johnson	Warrensburg				85
		Phelps	Rolla				85
	Philodromus abbotti	Cooper		Davis		WEM	
		Boone	Columbia, (Davis)	Davis		WEM	
	P. abbotti Gertsch	Cooper	Pilot Grove, (S. E. Moore)	Davis		WEM	
	Philodromus barrowsi Keyserling	Johnson	Warrensburg, (Peck)	Peck			68
	Philodromus cespitum (Walckenaer)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69

	Philodromus infuscatus Keyserling	Vernon	Nevada vicinity, (Dondale & Redner)	Dondale & Redner			23
	Philodromus keyserlingi Marx	Franklin	St. Albans				25
	Philodromus marxii Banks	Johnson	Warrensburg, (Peck)	Peck			68
	Philodromus placidus Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
	Philodromus pratariae (Scheffer)	Vernon	2 mi. south of Nevada, tallgrass prairie, (Dondale & Redner)	Dondale & Redner			23
	Philodromus rufus Keyserling	Johnson	Warrensburg, (Peck)	Peck			68
	Philodromus satullus	Johnson	Warrensburg, (Peck)	Exline			68
	Philodromus vulgaris (Hentz)	?					25
		*	(Van Ingen)				2
	Philodromus sp. A	Reynolds	Grasshopper Hollow Fen - prairie fen, (Bultman)				11
	Thanatus formicinus	Cass	(P. K. Moore)	PP Standlea		WEM	
		?	Henery(?)	LJ Bayer		WEM	
		Cooper		PP Standlea		WEM	
		Lafayette		PP Standlea		WEM	
		Boone	Columbia, (F. Stubbs)			WEM	
		Lawrence	(J. Hughes)	Davis		WEM	
		St Louis	Weldon Springs, fence posts, (Enns)	PP Standlea		WEM	
		Gentry	(P. Sayer)			WEM	
	Thanatus rubicellus Hentz	Johnson	Warrensburg, (Peck)	Dondale			68
	Thanatus rubicellus Mello-Leitao	Phelps	Rolla				29
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Thanatus striatus Mello-Leitao	Boone	Columbia, (W. R. Spellerberg)	WRS		WEM	
	Tibellus duttoni (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
		Cooper		Davis		WEM	
		Cooper		Kaston		WEM	
		Greene		Davis		WEM	
		?	Henery(?)	Davis		WEM	
	T. duttoni (Walckenaer)		Bartun	Davis		WEM	
	Tibellus oblongus	Callaway	Tucker Prairie, (R. K. Strange)	Enns			93
		Lawrence		LJ Bayer		WEM	
		Hickory		R Zack		WEM	
		Hickory	(J. McMeley)	PP Standlea		WEM	
		Callaway	Reform, (T. R. Yewke & D. D. Kopp)			WEM	
		Platte		Bayer		WEM	
		Greene		Bayer		WEM	
Thomisidae	Callilepis sp?	MOFEP	(Weaver)	Weaver	Leaf litter		94
	Coriarachne versicolor	Boone	Columbia, (Owens)			WEM	

C. versicolor Brez	Phelps	Rolla, (Exline-Frizzell)			WEM	
C. versicolor Keyserling	Greene	Springfield				35
	Boone	Columbia	Crosby			35
	*	(Van Ingen)				2
Misumena oblonga Keyserling	*	(Van Ingen)				2
Misumena rosea Keyserling	*	(Van Ingen)				2
Misumena vatia Hentz	Phelps	Rosati, (Enns)			WEM	
Misumenoides aleatorius (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Columbia, (Strange)	Davis		WEM	
	Lawrence	Mt Vernon, (R. Williams)			WEM	
	St. Louis	St. Louis, (Crosby)	Crosby			35
	Carter	Hunter, (Crosby)	Crosby			35
	Jefferson	Valley Park, (Meiners)	Meiners			35
M. aleatorius (Walckenaer)	Boone	Centralia - bean field, (M. Hennessey)	M Hennessey		WEM	
[syn.: M. formosipes]	Ste Genevieve	Ste Genevieve, (Enns, Wood, St. Aubin, Strange)			WEM	
	Boone	Columbia			WEM	
	Callaway	Tucker Prairie, (Weaver)	Peck			93
	Boone	Boonville - Bell Orchard, (Enns)			WEM	
	Boone	Columbia, (Zepp)	Zepp		WEM	
	Butler	10 mi. northwest of Poplar Bluff, (Enns & Wood)	Kaston		WEM	
Misumenoides Hentz sp (imm)	Carter	Van Buren, (Enns)	J Bregner		WEM	
Misumenops asperatus (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
	Callaway	Tucker Prairie, (Weaver)	Peck			93
	Boone	Columbia	?			35
	St Louis	St Louis	?			35
Misumenops celer Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
M. celer (Hentz)	Boone	Columbia	Crosby			35
	Jefferson	Valley Park	Meiners			35
Misumenops oblongus	Johnson	Warrensburg, (Peck)	Exline			68
	Callaway	Tucker Prairie, (Weaver)	Peck			93
	Butler	Poplar Bluff, (Enns & Wood)	Davis		WEM	
M. oblongus (Keyserling)	Boone	Columbia, (Crosby)	Crosby		WEM	
	St Louis	St Louis, (Emerton)	Emerton		WEM	
	Boone	Boonville, Bell Orchard, (Enns & Wood)	PP Standlea		WEM	
Misumenops sp. A	Reynolds	Grasshopper Hollow Fen: seep fen; prairie fen, (Bultman)				11
Misumenops Scheffer sp?	MOFEP	(Weaver)	Weaver	Leaf litter		94
Oxyptila sp. A	Reynolds	Grasshopper Hollow Fen: prairie fen, (Bultman)				11
Ozyptila modesta Keyserling	Johnson	Warrensburg, (Peck)	Exline			68

	Boone	Columbia				24
O. modesta (Scheffer)	Johnson	Columbus	Crosby			35
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Ozyptila monroensis Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
	St Louis	St Louis				24
	Boone	Columbia				24
	St Louis	St Louis	Meiners			35
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
O. monroensis Walckenaer	Howard	Fayette, (Neal)			WEM	
Synema bicolor Hentz	Callaway	Tucker Prairie, (Weaver)	Peck			93
Synema parvulum (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Boonville, (Enns)	Davis		WEM	
	St Louis	St Louis	Emerton			35
	Johnson	Columbus	Ivie			35
S. parvulum Walckenaer	Callaway	Reform, (T. R. Yonke & D. D. Kopp)			WEM	
Tmarus angulatus (Walckenaer)	Johnson	Warrensburg, (Peck)	Peck			68
	Callaway	Tucker Prairie, (Weaver)	Peck			93
	Boone	Columbia, (Crosby)	Crosby		WEM	
T. angulatus Keyserling	Buchanan	Rushville			WEM	
Tmarus minuta Banks	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Tmarus sp. A	Reynolds	Grasshopper Hollow Fen: prairie fen, (Bultman)				11
Xysticus auctificus Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Columbia, (R. K. Strange)	Davis		WEM	
Xysticus bicuspis Keyserling	Boone	Columbia	Crosby			35
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
Xysticus elegans Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
	MOFEP	(Weaver)	Weaver	Leaf litter		94
	Boone	Columbia residence, (Enns)	PP Standlea		WEM	
	Boone	Columbia, (H. Hartshorn)	CE Mason		WEM	
	Mercer		PP Standlea		WEM	
	St Louis	Creve Coeur Lake	Meiners			35
	St Louis	St Louis	Meiners			35

	Johnson	Knob Nosler State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
X. elegans Hentz	Boone	Columbia, (D. L. Harrison)	Mason		WEM	
Xysticus emertoni Keyserling	Reynolds	Grasshopper Hollow Fen: ak-hickory forest, (Bultman)				11
Xysticus ferox (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Columbia residence, (H. Hartshorn)	CE Mason		WEM	
	Boone	Columbia, (Enns)	Davis		WEM	
	Boone	Columbia residence, (Hartshorn)	CE Mason		WEM	
	Boone	Columbia, (V. H. Owens)	Gertsch		WEM	
	Cape Girardeau	Cape Girardeau, rotten wood	Davis		WEM	
	Lincoln	Troy, (H. Hartshorn)	Mason		WEM	
	Reynolds	Grasshopper Hollow Fen: oak-hickory forest, (Bultman)				11
	St Charles	St Charles	Brown			35
	Boone	Columbia	Brown			35
X. ferox (Banks)	Johnson	Knob Nosler State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978			69
Xysticus fraternus Banks	Reynolds	Grasshopper Hollow Fen: forested fen; oak-hickory forest, (Bultman)				11
	Greene	Springfield	Banks		WEM	
Xysticus fraternis Keyserling?	MOFEP	(Weaver)	Weaver	Leaf litter		94
Xysticus funestus Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
	Phelps	Dry Fork Creek, Rolla, Sept. 23, 1950, 2 males, 1 female, (D. L. & H. E. Frizzell)	Gertsch	Eastern U.S. and Canada		36
	Boone	Columbia, (V. H. Owens)	Gertsch		WEM	
	Boone	Columbia, (Enns)	Davis		WEM	
	Boone	Columbia buildings	Mason		WEM	
	Boone	Columbia, (V. H. Owens)	Gertsch		WEM	
	Cedar	(Garrison)	Davis		WEM	
	Hickory		PP Standlea		WEM	
	Reynolds	Grasshopper Hollow Fen: prairie fen; oak-hickory fen, (Bultman)				11
	Greene	Springfield	Banks			35

		Boone	Columbia	Hayhurst			35
		Barry	Cassville				35
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Xysticus gulosus Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
		Boone	Columbia	Crosby			35
		*	(Van Ingen)				2
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
		St. Louis	Oct. 1, 1940, 2 males, (W. Gordon)		Most of the U.S. and southern Canada, southward into AL and GA in the east and into TX and northern Mexico in the west		36
	Xysticus luctans Keyserling	Callaway	Tucker Prairie, (Weaver)	Peck			93
	Xysticus nervosus Banks	*	(Van Ingen)				2
	Xysticus ontariensis Emerton	Boone	Columbia	Crosby		WEM	
	Xysticus pellax O.P.-Cambridge	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
	Xysticus quadrilineatus	Boone	(K. Hall)	Davis		WEM	
	X. quadrilineatus Keyserling	Nodaway	Maryville, (P. K. Moore)	Davis		WEM	
	Xysticus triguttatus Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
		Callaway	Tucker Prairie, (Weaver)	Peck			93
		Boone	Columbia, (Enns)	Davis		WEM	
		Butler	Poplar Bluff, (Enns & Wood)	Davis		WEM	
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979			69
		Phelps	10 mi. south of Rolla, June 24, 1950, 2 males, 1 female, (H. E. & D. L. Frizzell)		U.S. and Canada east of the Rockies		36
Web-builders Agelenidae	Agelenopsis emertoni Chamberlin & Ivie	Johnson	Warrensburg, (Peck)	Peck			68
		Howell	Jim Ridge Cave, leaf litter, (Gardner)				34
	Agelenopsis kastoni Chamberlin &	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale			41

	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978		69
Agelenopsis naevia (Walckenaer)	Johnson	Warrensburg, (Peck)	Peck		68
	Boone	Rocheport, (Neal & Enns)	Exline	WEM	
	Warren (?)	14 mi. east of Wright City, July 22, 1935, 1 female	Ivie		16
(syn: Agalena naevia Hentz]	see note	(Van Ingen)			2
Agelena naevia (Walckenaer)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978		69
Agelenopsis pennsylvanica C.L. Koch	Boone	Columbia, (Owens)	Gertsch	WEM	
	Phelps	St James, (Enns, St. Aubin, & Strange)	Enns	WEM	
Agelenopsis potteri Blackwall	Johnson	Warrensburg, (Peck)	Peck		68
Celotes medicinalis Emerton	see note	(Van Ingen)			2
Cicurina arcuata Keyserling	see note	(Van Ingen)			2
	Boone	Columbia			15
	Boone	Rocheport, (Exline)		WEM	
	Johnson	Warrensburg, (Peck)	Exline		68
	Callaway	Tucker Prairie, (Weaver)	Peck		34
C. arcuata?	Pulaski	Wilson Cave No 1, under stone, in darkness, (Gardner)			34
Cicurina brevis Emerton	Johnson	Warrensburg, (Peck)	Peck		68
	Crawford	Stairstep Cave, under stone, (Gardner)			34
Cicurina cavealis (Bishop & Crosby)	Adair	2 mi. south of Kirksville, (Haskins & Shaddy)	Peck/Dondale		41
	Boone	Rocheport Cave (W 92 32': N 39), 1 female			15
	?	Fisher Cave, 2 females			15
	Barry	Sweet Potato Cave, beneath objects, twilight or total darkness, (Gardner)			34
	Crawford	Cathedral Cave			34
	Pulaski	Kerr Cave			34
	Boone	Rocheport		WEM	
	Benton	various caves			34

	(placed in Dictynidae)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1980, Peaslee 1980		69
	Cicurina ludoviciana (Simon)	Adair	Kirksville - 2 mi south, (Haskins & Shaddy)	Peck/Dondale		41
	(placed in Dictynidae) Simon	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979, Peaslee 1980		69
	Cicurina robusta Simon	Reynolds	Grasshopper Hollow Fen - seep fen, (Bultman)			11
	Coras lamellosus Keyserling	Johnson	Warrensburg, (Peck)	Exline		68
	Coras medicinalis Hentz	Phelps	St James, (Enns & Strange)	Davis	WEM	
		Buchanan	St Joseph, (House)	Davis	WEM	
		Boone	Little Dome Cave, (Gardner)			34
		Miller	McDowell Cave & Potato Cave, (Gardner)			34
		Crawford	various caves, (Craig)			34
	Coras aff montanus Emerton	Johnson	Warrensburg, (Peck)	Exline		68
	Cicurina minima Simon	Johnson	Warrensburg, (Peck)	Ivie		68
	C. minima Clerck	Christian	Rattlesnake Cave, in wet, rotting leaves near entrance, (Gardner)			34
	Tegenaria domestica	Boone	Columbia, (Wood)	Exline	WEM	
		Mercer	Princeton, (House)	Enns	WEM	
	T. domestica Emerton	Randolph	Moberly, (House)	Enns	WEM	
Araneidae						
Araneids	Acacesia hamata Hentz	Johnson	Warrensburg, (Peck)	Exline		68
	Acrosoma rugosa Hentz	see note	(Van Ingen)			2
	Acrosoma spinea Hentz	see note	(Van Ingen)			2
	Acanthepeira stellata Walckenaer	Johnson	Warrensburg, (Peck)	Peck		68
		Ste Genevieve	Ste Genevieve, (Enns)	Enns	WEM	
		Boone	Columbia, (Enns)	Enns	WEM	
		Carter	Fremont, (Enns)	Enns	WEM	
	A. stellata Marx	Callaway	Tucker Prairie, (Weaver)	Peck		93
	Araniella displicata Hentz	Callaway	Tucker Prairie, (Weaver)	Peck		93
	Araneus bonsallae (McCook)		2 MO records: 1 from St Louis region, 1 from Nevada region; "most collections were made by wasps."			51

Araneus cingulatus (Walckenaer)		3-4(?) MO records: 1 just eastof Kansas City, 1 from Rolla region, 1 from St Louis region, 1 just west of St Louis; " most collections come from wasp nests."		males mature in May to July, females are found from May to Sept.		51
Araneus gemmoides Chamberlin & Ivie		Columbia region	Levi	eaves of houses, on barns, in cave entrances		50
Araneus marmoreus Clerck		2 MO records: Columbia region; Springfield region	Levi	webs in grasses and low shrubs in tallgrass meadows		50
[syn.: Epeira insularis Hentz]	see note	(Van Ingen)				2
Araneus niveus (Hentz)		4 MO records: Columbia region; Jefferson City region/ just south of Columbia; just east of Jefferson City; Poplar Bluff region		males are mature in June and July, females from June to Sept; woods and wasp nests		51
Araneus pratensis Emerton	Callaway	Tucker Prairie, (Weaver)	Peck			93
		2 MO records: Warrensburg region; east of Rolla		; males are mature in May and June, mature females are found until August; "...moist meadows in the open, on alfalfa, and swept from fields with mixed populations"		51
[syn: Singa pratensis Emerton]	Johnson	Warrensburg, (Peck)	Peck			68
Araneus ravi new sp.	St Charles	Wentzville, July 9, 1929; "presumably from a wasp nest"; 4 female paratypes				51
	St Louis	Kirkwood, mud dauber; female paratype, (P. Rau)	(MCZ)			51
Araneus thaddeus (Hentz)		2 MO records: 1 from Columbia region, 1 from Nevada region		males mature from late summer to early fall, females from summer to early winter		51
[syn: Epeira thaddeus Hentz]	Johnson	Warrensburg, (Peck)	Peck			68
Argiope aurantia Lucas	Johnson	Warrensburg, (Peck)	Peck			68
Argiope transversa Emerton	*	(Van Ingen)				2
Argiope trifasciata Forskal	Johnson	Warrensburg, (Peck)	Peck			68
Carina directa			Exline		WEM	
Cyclosa turbinata Walckenaer	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Rocheport, (Enns)	Exline		WEM	

C. turbinata?	Texas	Unnamed Cave No 15, leaf litter at entrance, (Gardner)				34
Drexelia directa Hentz	Carter	Fremont, (Enns et. al.)	Enns		WEM	
Epeira patagiatus Clerck	Johnson	Warrensburg, (Peck)	Peck			68
Epeira cornutus Clerck	Johnson	Warrensburg, (Peck)	Peck			68
Epeira domiciliorum Hentz [poss. syn.: N. hentzii]	see note	(Van Ingen)				2
Epeira pegnia Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
Epeira marmoreus Clerck	Johnson	Warrensburg, (Peck)	Peck			68
Epeira trifolium Hentz	see note	(Van Ingen)				2
Eustala anastera Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
Kaira alba	?	(Exline?)	?			58
Larinia borealis Banks	Johnson	Warrensburg, (Peck)	Peck			68
	Callaway	Tucker Prairie, (Weaver)	Peck			93
Leucage venusta (Walckenaer)		14 MO records: 2 northwestern MO; 2 St. Louis area; southwest of St. Louis; Columbia region; southeast of Columbia; 2 Nevada region; Rolla region; 3 Poplar Bluff region; Springfield region.		webs in low bushes in wooded areas; males found only from late May to early July; distributed throughout eastern US and from NH to southeastern SD to central TX.		56
	Johnson	Warrensburg, (Peck)	Peck			68
[poss. syn.: Argyropeira hortorum Hentz]		(Van Ingen)				2
Mahadeva verrucosa Hentz	see note	(Van Ingen)				2
Mangora gibberosa (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68
	Callaway	Tucker Prairie, (Weaver)				93
		8 MO records: widespread except northern MO and the Bootheel		Herbs in deciduous forest, low brush, more common in fields than woods; males mature from June-July, adult females are found from June to September		53
Mangora maculata (Keyserling)	Johnson	Warrensburg, (Peck)	Exline			68
		At least 5 MO records: KC region; 3 from Rolla/Ozarks region; north of Bootheel/Stoddard Co area		often mislabeled M. gibberosa in collections; from deciduous forest, woods and shrubs; adults found from June and July to Sept and Oct		53
Mangora placida (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68

		9 MO records: KC region; 2 Columbia region; St Louis region; 4 Rolla/Ozarks region; southeastern Ozarks		woods and deciduous forest; males mature from May-June, adult females appear from May through summer		53
Mangora spiculata (Hentz)		southeastern Ozarks west of Poplar Bluff		found in woods, tall grass, low brush; males mature between May and June		53
Mastophora archeri Gertsch	?			FL, AL, KS, and MO		90
Mastophora hutchinsoni Gertsch	Clay	Liberty	Exline			37
Mecynogea lemniscata (Walckenaer)		just north of the Bootheel in the Stoddard County region		dome-shaped web made in shrubs, usually in deciduous forest; adult males have been collected in various habitats in June and July; spiderlings hatch at the end of March; MD to MO and FL to Mexico.		56
Meta menardi Latreille		3-4 MO records: Atchison Co.: "cave near Rock Port;" Rolla region; 1-2 from Ste. Genevieve region		Found deep within or around caves, old mines and wells, and sometimes cellars; mature in all seasons		56
	Boone	Columbia, (St. Aubin)	Brezner		WEM	
	Camden	Gar Cave, (Gardner)				34
	Miller	McDowell Cave, (Gardner)				34
	Oregon	Everett Chaney Cave, (Gardner)				34
	Texas	Unnamed Caves 14 & 15, (Gardner)				34
	Perry	various caves, (Gardner)				34
Micrathena gracilis Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
Micrathena mitrata (Hentz)	Johnson	Warrensburg, (Peck)	Peck			68
		9 records distributed throughout state	Levi	deciduous forest, woodland, under trees, sometimes in shrubs and usually in shade		55
[syn.: Micrathena reduviana Comstock]			Spangler		WEM	
Micrathena sagittata (Walckenaer)		12 records distributed throughout state	Levi	on shrubs in deciduous forest and woods		55
	Phelps	St James, (Enns et. al.)	Enns		WEM	
Neoscona arabesca (Walckenaer)	Johnson	Warrensburg, (Peck)	Exline			68
	Ste Genevieve	Ste Genevieve, (Enns et. al.)	Davis		WEM	

		Callaway	Tucker Prairie, (Weaver)	Peck			93
			4 MO records: St Louis southwest to Nevada region	Berman & Levi	shrubs, meadows, sunny but moist situations		7
	[syn.: N. minima F.O.P.- Cambridge]	Johnson	Warrensburg, (Peck)	Peck			68
	[syn.: Epeira trivittata Keyserling]	see note	(Van Ingen)				2
	Neoscona domiciliorum Hentz	Phelps	St James, (Enns et. al.)	Enns		WEM	
	Neoscona hentzii (Keyserling)		9 MO records: St Louis west to Kansas City and Nevada region	Berman & Levi	open woods, seldom in grass		7
	Neoscona sacra Walckenaer [poss. syn.: N. hentzii]	Johnson	Warrensburg, (Peck)	Peck			68
	Nephila clavipes			Zack		WEM	
	Nuctenea cornuta Clerck	Callaway	Tucker Prairie, (Weaver)	Peck			93
	Singa truncata Banks	Johnson	Warrensburg, (Peck)	Exline			68
		Boone	Boonville, (Enns)	Davis		WEM	
	Singa variabilis Emerton	Boone	Columbia, (Davis)	Davis		WEM	
	Verrucosa arenata McCook	Johnson	Warrensburg, (Peck)	Peck			68
		Boone	Pinnacles, (St. Aubin)	Davis		WEM	
		Jackson	Sibley, (Strange)	Enns		WEM	
		Camden	Slover, (Enns)	Enns		WEM	
Tetragnathids	Glenognatha foxi (McCook)	Barry	Sweet Potato Cave, (Gardner)	Gardner			34
		Johnson	Warrensburg, (Peck)	Exline			68
			4 MO records: KC region; Warrensburg region; Rolla region; Cape Girardeau region		" a ground crevice in a dry lake in MO, and between stones on the bank of a stream 'but did not notice an orb-web.'"		56
	Pachygnatha autumnalis Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
			Kansas City region		distributed from NE south to Cuba and west to MO and AR; collected using pitfall traps in low woods and old fields		56
	Pachygnatha tristriata C. L. Koch	Callaway	Tucker Prairie, (Weaver)	Coddington			93
			Rolla region		found in vegetation, under stones, meadows, grass pastures, pitfall traps		56
	Tetragnatha elongata Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
		Phelps	St James, (Enns & Strange)	Enns		WEM	
		Boone	Columbia, (Wood)			WEM	
			18 MO records distributed from KC to St Louis and south throughout the state		from large nearly horizontal webs placedover small streams, often in woods or shaded branches		57

	Tetragnatha guatemalensis O. P. -Camb.		3 MO records: east of KC; Warrensburg region; Poplar Bluff region		from herbs, vegetation along marsh trail, and pine trees; all habitats probably near the edge of rivers, lakes, and other water		57
	[syn: Tetragnatha seneca Seeley]	Johnson	Warrensburg, (Peck)	Peck			68
	Tetragnatha laboriosa Hentz	Johnson	Warrensburg, (Peck)	Exline			68
		Callaway	Tucker Prairie, (Weaver)	Peck			93
							2
			13-14 MO records: from KC to St Louis and south, throughout the state		from grass, often dry fields some distance from water and agricultural crop fields		57
	Tetragnatha pallescens F. P. -Camb.		6 MO records: Columbia region; St Louis region; Rolla region; Springfield region; Branson region; west of Poplar Bluff		found in trees, tallgrasses, vegetation near water, rice fields in AR		57
	Tetragnatha versicolor Walckenaer	Johnson	Warrensburg, (Peck)	Peck			68
Dictynidae	Dictyna annulipes Blackwall		Columbia region?	Chamberlin & Gertsch			14
	Dictyna bellans Chamberlin	Johnson	Warrensburg, (Peck)	Exline			68
			4 MO records: St. Louis region; Columbia region; Springfield region; Rolla region	Chamberlin & Gertsch			14
	Dictyna cruciata Emerton	Phelps	Beaver Creek, 10 miles south of Rolla, June 11, 1950, (D. L. & H. E. Frizzell)	Chamberlin & Gertsch			14
	Dictyna foliacea Hentz	Johnson	Warrensburg, (Peck)	Exline			68
			2 records from central MO	Chamberlin & Gertsch			14
	Dictyna longispina	Boone	Columbia, (Hennenssey)	Hennessey		WEM	
	Dictyna sublata Hentz	Johnson	Warrensburg, (Peck)	Exline			68
		see note					2
			2 MO records: Columbia region; Rolla region	Chamberlin & Gertsch			14
	Dictyna volucripes Keyserlin	Johnson	Warrensburg, (Peck)	Exline			68
		Boone	Columbia, (R. K. Strange)	Enns		WEM	
		Butler	Fisk, (Wood)	Enns		WEM	

		see note				2
			2 MO records: Columbia region, Kansas City region	Chamberlin & Gertsch		14
	Dictyna sp. A	Reynolds	Grasshopper Hollow Fen - forested fen, (Bultman)			11
	Dictyna sp	Boone	Columbia, (Enns)	Enns	WEM	
Linyphiidae	Alopogyna cornuipalpis O. P. - Cambridge.					84
Subfam. Linyphiinae	Centromerus cornupalpis O. P. - Cambridge.	Johnson	Warrensburg, (Peck)	Exline		68
		Pulaski	Peninsula Cave, (Gardner)			34
		Crawford	Bear Cave, (Craig)			34
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1980		69
	Centromerus latidens Emerton	Johnson	Warrensburg, (Peck)	Exline		68
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978, 1980		69
		Boone	Rockbridge Cave entrance, at twilight and total darkness, (Gardner)			34
		Christian	Infant Maze Cave, (Gardner)			34
		Franklin	Panther Cave, (Gardner)			34
		Jefferson	Reiter Cave, (Gardner)			34
		Oregon Co	Turner Spring Cave & Whites Creek Cave, (Gardner)			34
			Bat Cave, Crawford Cave & Lookout Cave, (Craig)			34
		Jefferson	Pleasant Valley Cave, (Gardner)			34
	Centromerus sp	Madison	Marsh Creek Cave No 2, (Gardner)			34
	Frontinella communis Hentz	Johnson	Warrensburg, (Peck)	Exline		68
		St Louis	Kirkwood, (Neal)	Davis	WEM	
	Linyphia marginata C. L. Koch	Johnson	Warrensburg, (Peck)	Peck		68
		Phelps	St James, (Enns et. al.)	Enns	WEM	
		Ste Genevieve	Ste Genevieve, (Enns et. al.)	Enns	WEM	

		Big Spring State Park, (Enns et. al.)	Enns & Davis		WEM	
	see note	(Van Ingen)				2
Linyphia phrygiana C. L. Koch	see note	(Van Ingen)				2
Lepthyphantes sabulosa Keyserling [syn.: L. appalachia Chamb. & Ivie, 1944]	Johnson	Warrensburg, (Peck)	Exline			68
	?					84
Meioneta micaria Emerton	Johnson	Warrensburg, (Peck)	Exline			68
Meioneta serrata (Emerton)	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979, 1980			69
Meioneta sp	Johnson	Warrensburg, (Peck)	Exline			68
Nereine clathrata Sundevall	Callaway	Tucker Prairie, (Weaver)	Milledge			93
	?					84
Nereine marginata C. L. Koch	Barry	Bannister Cave, Moonshine Cave, & Shelter Cave, (Gardner)				34
	Camden	Robbers Cave				34
	Texas	various caves				34
Nereine radiata	?					84
Porhomma cavernicola Keyserling						84
Stemonyphantes blauveltea Gertsch	Callaway	Tucker Prairie, (Weaver)	Coddington			93
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1980			69
Stemonyphantes lineatus Linnaeus	Boone	Harrisburg, (Hall)	Davis		WEM	
Tapinopa bilineata Banks	Johnson	Warrensburg, (Peck)	Peck			68
Tennesseellum formicum Emerton	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Columbia, (Enns)	Enns		WEM	
Troglophantes cavernicola Keyserling	Barry	various caves in detritus, (Gardner)				34
	Boone	various caves, (Gardner)				34
	Howell	Mud Spring Cave, (Gardner)				34
	Lawrence	Turnback Cave, (Gardner)				34
	Shannon	Powder Mill Creek Cave, (Gardner)		Adult males and females were collected during January, February, March and August; most often associated with decaying organic		34

Subfam. Erigoninae	Ceraticelus bryantae Kaston	Johnson	Warrensburg, (Peck)	Exline	68
	Ceraticelus creolus Chamberlin	Johnson	Warrensburg, (Peck)	Exline	68
	Ceraticelus emertoni O. P. - Cambridge	Johnson	Warrensburg, (Peck)	Exline	68
		?			84
	Ceraticelus fissiceps O. P. - Cambridge	Johnson	Warrensburg, (Peck)	Exline	68
		?			84
	Ceraticelus laetabilis (Hackman)	?			84
	Ceraticelus laticeps Emerton	Johnson	Warrensburg, (Peck)	Exline	68
		?			84
	Ceraticelus micropalpis (Emerton)	?			84
	Ceraticelus minutus (Chamberlin & Ivie)	?			84
	Ceratinella brunnea Emerton	Johnson	Warrensburg, (Peck)	Exline	68
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979	69
		?			84
	Ceratinella toslor Chamberlin	Boone	Columbia, type locality		90
	Ceratinops crenatus (Emerton)	?			84
	Ceratinops latus (Emerton)	?			84
	Ceratinops rugosus (Emerton)	?			84
		Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979	69
	Ceratinopsis interpres (O. P. - Cambridge.)	?			84
	Ceratinopsis purpurescens Keyserling	Johnson	Warrensburg, (Peck)	Exline	68
		?			84
	Cornicularia minuta Emerton	Johnson	Warrensburg, (Peck)	Exline	68
	Dietrichia? sp nov?	Johnson	Warrensburg, (Peck)	Exline	68
	Eperigone maculata (Banks)	Johnson	Warrensburg, (Peck)	Exline	68
		Taney	Zoo Cave, (Gardner)		34
		Texas	various caves, (Gardner)		34
		?			84
	Eperigone tridentata (Emerton)	Johnson	Warrensburg, (Peck)	Exline	68
		?			84
	Eperigone trilobata Emerton	Johnson	Warrensburg, (Peck)	Exline	68

	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978, 1979	69
	?			84
Eridantes erigonoides Emerton	Johnson	Warrensburg, (Peck)	Exline	68
	?			84
Erigone autumnalis Emerton	Johnson	Warrensburg, (Peck)	Exline	68
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979	69
	?			84
Erigone blaesa Crosby & Bishop	?			84
Grammonota inornata Emerton	Johnson	Warrensburg, (Peck)	Exline	68
	?			84
Grammonota sp	Oregon	Surprise Sinkhole Cave, (Gardner)		34
G sp	Shannon	Bear Cave		34
Islandiana flaveola (Banks)				2
Islandiana longisetosa (Emerton)	?			84
Paracornicularia bicapillata Crosby & Bishop	?			84
Pelecopsis? sp	Johnson	Warrensburg, (Peck)	Exline	68
Origanates rostratus (Emerton)	Johnson	Warrensburg, (Peck)	Exline	68
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979	69
	Wright	Bill Dyer Lead Mine Cave, leaf litter at entrance, (Gardner)		34
Satilatlas marxii Keyserling	Franklin	Washington, west of St. Louis, (J. & W. Ivie)	J. & W. Ivie	62
Scylaceus pallidus Emerton	Johnson	Warrensburg, (Peck)	Exline	68
	?			84
Theridiosoma argentatum Keyserling	Pulaski	(Gardner)	Gardner	34
Walckenaera brevicornis (Emerton)	?	(Millidge)	Millidge	63
Walckenaeria carolina Millidge				84
Walckenaera minuta (Emerton)	?	(Millidge)	Millidge	63
Walckenaeria pallida (Emerton)	?			84
Walckenaera spiralis (Emerton)	?	(Millidge)	Millidge	63
Walckenaera subpallida new sp.	?	(Millidge)	Millidge	63
Walckenaera vigilax Blackwall	Johnson	Warrensburg, (Peck)	Exline	68
Leptonetidae				
Leptoneta sp	Ozark	Goat Cave, (Gardner)		34

Loxoscelidae	Loxosceles reclusa Gertsch & Mulaik	Johnson	Warrensburg, (Peck)	Peck		68
		Boone	Columbia, (Enns)	Enns	WEM	
	(33 counties listed by Cooperative Economic Insect Report 1959-1976)	Boone	Hallsville, (St. Aubin)	Brezner	WEM	
		Boone	Columbia, Aug. 1, 1966; Aug. 14, 1961, (Fagan)	Gertsch & Ennick		39
		Johnson	Warrensburg: Oct. 1971, (Peck)	Gertsch & Ennick		39
		Stoddard	old fruit jar, Aug. 12, 1969, (N. Banks)	Gertsch & Ennick		39
		Vernon	Nevada, in house, June 12, 1962, (J. W. McReynolds)	Gertsch & Ennick		39
		Vernon	Nevada area, Aug. 19, 1959, (D. Lamore)	Gertsch & Ennick		39
		Vernon	Sept. 16, 1961, (D. & J. McReynolds)	Gertsch & Ennick		39
	Loxosceles rufescens (Dufour)	St Louis	St Louis, Aug. 1, 1940, (W. M. Gordon)	Gertsch & Ennick		39
Mysmenidae	Calodipoena incredula Gertsch & Davis	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1979		69
	Mysmena sp?	Camden	Counterfeiters Cave, (Gardner)	Gardner		34
Oecobiidae	Oecobius cellariorum (Duges)	?	human habitations			85
	[poss. syn.: Oecobius texanus]	Boone	Columbia, (J. W. Neal)	Bryant	WEM	
	Oecobius annulipes	St Louis	St Louis, (W. R. Spellerberg)	WR Spellerberg	WEM	
	sp?	Boone	University of MO, Columbia, (Enns)		WEM	
	sp?	Boone	(D. Gilberg)	D Gilberg	WEM	
Pholcidae	Pholcus muralicola Maughan & Fitch	Texas	FS Cave 135, (Gardner)	Gertsch		34
	Pholcus phalangioides (Fuesslin)	Johnson	Warrensburg, (Peck)	Fuesslin		68
		Boone	Columbia, (Ferris)	Gertsch	WEM	
			Kohler City, (Pickard)	Pickard	WEM	
		Douglas	(Spangler)	Spangler	WEM	
	Pholcus sp?	Texas	FS Cave 135, (Gardner)	Gardner		34

Theridiidae	Achaearanea globosa (Hentz)	Boone	Columbia, (Bishop & Crosby)		makes irregular webs in leaf litter, logs, and holes or tree stumps in woods; Eastern U.S. to Veracruz, Mexico.	44;47	
	Achaearanea porteri (Banks)		Springfield region		Eastern U.S., West Indies to Panama		47
		Laclede	Cave, (G. Kastler)	Exline			47
	Achaearanea tepidariorum C. L. Koch	Johnson	Warrensburg, (Peck)	Peck			68
		Barry	Moonshiner Cave, (Gardner)	Gardner			34
		Boone	Little Dome Cave & Rockbridge Cave				34
		Boone	Columbia, (Ferris)	Gertsch		WEM	
		Camden	various caves				34
		Crawford	various caves				34
		Dent	Unnamed Shelter Cave				34
		Franklin	Camper Spring Cave				34
		Jefferson	Heinze Pit Cave				34
		Madison	Marsh Creek Cave No 1				34
		Miller	Buzzards Perch Cave				34
		Oregon	various caves				34
		Phelps	various caves				34
		Texas	various caves				34
		Washington	Green Cave, (Craig)				34
		Worth	Allendale, (House)	Davis		WEM	
		Cole			Eastern U.S. and along the U.S. west coast		47
		Jackson					47
		Saline					47
		St. Louis					47
		Vernon					47
	Achaearanea sp?	Crawford	Indian Cave No 2, (Gardner)	Gardner			34
	A sp?	Miller	McDowell Cave, (Gardner)	Gardner			34
	A sp?	St Louis	Rockwoods Cave, (Gardner)	Gardner			34
	Argyrodes cancellatus (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
		Phelps	10 mi. south of Rolla, (H. E. Frizzell)		Webs of Agelenopsis, Nephila, Argiope, and many other species. Eastern North America		32

Argyrodes elevatus Taczanowski	Phelps	Rolla, (V. Roth, H. E. & D. L. Frizzell)		often found in web of *Nephila* and also in the webs of *Argiope argentata* in CA; southern U.S. (rare in the west), south to Peru and Argentina, Galapagos Islands.		32
Argyrodes fictilium (Hentz)	Madison	14 mi. east of Farmington, (H. E. & D. L. Frizzell)		often make small theridiid webs of their own, but females are sometimes collected in webs of other spiders; from southern Canada to Panama; widely scattered, but rare		32
	Phelps	near Rolla, (H. E. & D. L. Frizzell)			WEM	
Argyrodes trigonum Hentz	Johnson	Warrensburg, (Peck)	Exline			68
	Boone	Rocheport, (Enns)	Exline		WEM	
	Crawford	Indian Cave No 2, (Gardner)	Gardner			34
	Texas	Unnamed Cave No 15 Annex				34
	Franklin	Meramec Springs, (H. E. Frizzell)		usually commensal in the webs of larger spiders, especially orb-weavers, but it has been collected from webs of Agelenopsis and Latrodectus; Ontario, eastern U.S., from ME to FL, central WI, AR to eastern TX		32
	Phelps	Rolla, (H. E. Frizzell)			WEM	
Argyrodes pluto Banks	Phelps	5 mi. south of Rolla; Rolla, (H. E. & D. L. Frizzell)		usually only single individuals are collected. Found in webs of *Latrodectus* (VA & MD), *Metepeira labyrinthea* (Hentz) (MD) & *Argiope aurantia* Lucas (MO). From MD, VA, MO, southwest to Chihuaha, and Jamaica.		32
Asagena americana Emerton	Cole	Brazite, (Moore)	Davis		WEM	
	Perry	Perryville, (Trube)	Davis		WEM	
	see note	(Van Ingen)				2
Ceratinopis laticeps Emerton	see note	(Van Ingen)				2

Conepeira forata (Keyserling)	Cole	Jefferson City, June 30 & July 24, 1945, male, female, (W. W. Dowdy)		Most species of *Conepeira* are either from vertical webs or on a tangle of threads underneath leaves		1
Conepeira nivosa, new species	St. Louis	Kirkwood, female paratype (MCZ)		from water oaks		1
Conepeira ozarkensis, new species	Cole	female paratype from Jefferson City, July 24, 1945, (W. W. Dowdy)				1
	St. Louis	male allotype and female paratype from Diecker, July 4, 1938 (P. Rau, MCZ)				1
		Rankin, June 25, 1939, immature female paratypes (P. Rau, MCZ)				1
		Wentzville, July 9, 1939, immature male paratype (P. Rau, MCZ)				1
Crustalina altera Gertsch & Archer	Johnson	Warrensburg, (Peck)	Davis			68
	St. Louis	St. Louis, (Dowdy, 1950)		found under logs, stones, and in leaf litter. Eastern U.S.		45
prob Dipoena sp	Camden	River Cave, (Gardner)	Gardner			34
Enoplagnatha marmorata (Hentz)	St. Charles			Southern Canada, U.S.		46
Enoplognatha sp	Boone	Columbia, (Neal)	Frizzell		WEM	
Euryopsis funebris Hentz	Johnson	Warrensburg, (Peck)	Peck			68
Euryopis gertschi Levi	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Peck 1978, Levi 1979			69
Euryopis quinquemaculatus Banks	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Levi 1979, Peck 1979			69
Floviona clathrata C. L. Koch	see note	(Van Ingen)				2
Latrodectus mactans Fabricius	Johnson	Warrensburg, (Peck)	Peck			68
	Ste Genevieve	Ste Genevieve, (Enns et. al.)	Enns		WEM	
	Boone	Columbia, (Stubbs)			WEM	
	Greene	Springfield, (Peach)	Davis		WEM	
	Carter	Fremont, (Enns)	Enns		WEM	
	Pettis	Sedalia, (Enns)			WEM	
L. mactans C. L. Koch	see note	(Van Ingen)				2

Paidisca marxi (Crosby)	Carter	Big Spring State Park, (C. M. Goodnight)		Atlantic and Gulf Coast states to central Maine		46
Pholcomma hirsuta Emerton		(Levi, 1957a)				59
	Johnson	Knob Noster State Park, pitfall trap, brushy prairie, (Peck & Peaslee)	Levi 1979, Peck 1979			69
prob. Steatoda albomaculata (DeGreer)	Crawford	Indian Cave No 2, (Gardner)	Gardner			34
Steatoda americana Emerton	Johnson	Warrensburg, (Peck)	Exline			68
	Crawford	(Banks, 1895)		U.S. and southern Canada, except CA and OR, south to Hidalgo		45
	St. Louis	(Banks, 1895)				45
Steatoda borealis (Hentz)	Johnson	Warrensburg, (Peck)	Exline			68
	Randolph	Moberly, (House)	Enns		WEM	
	Mercer	Princeton, (House)	Enns		WEM	
	St Louis	Kirkwood, (Neal)	Neal		WEM	
	see note	(Van Ingen)		found on buildings. East of Rockies, south to TX and NC, north to AK, possibly rare in the southern U.S. now.	2;45	
Steatoda aff fulva Keyserling	Johnson	Warrensburg, (Peck)	Exline			68
Steatoda triangulosa (Walckenaer)	Johnson	Warrensburg, (Peck)	Peck			68
		(Banks, 1895)		Central and southern Europe, southern Russia, Mediterranean St. Helena, U.S., South America		45
Steatoda sp?	Camden	River Cave, (Gardner)	Gardner			34
Steatoda sp?	Crawford	Tube Cave, (Gardner)	Gardner			34
Stemmops ornatus (Bryant)	Johnson	Warrensburg, June 29, 1962, female, (Peck)	Levi	NJ, OH, MO, GA to MS		49
Theonoe stidula Crosby		(Levi, 1955a)				59
Theridion albidum Banks	Johnson	Warrensburg, (Peck)	Exline			68
	Boone			Weeds. Ontario and eastern U.S.		46
Theridion differens Emerton	Johnson	Warrensburg, (Peck)	Exline			68
	Boone			Low vegetation, grass, bushes, and small trees. Southern Canada and U.S.		46

	Theridion flavo Levi	Johnson	Warrensburg, (Peck)	Levi			48
	Theridion lyricum Walckenaer	Johnson	Warrensburg, (Peck)	Exline			68
	Theridion murarium Emerton		(Levi, 1957d)				59
	Theridion neshamini Levi	Callaway	Tucker Prairie, (Weaver)	Coddington			93
	Theridion pennsylvanicum Emerton	Johnson	Warrensburg, (Peck)	Exline			68
		Boone	Columbia, (C. R. Crosby)		Woods, under surfaces of leaves. Eastern states, Ontario		46
	Theridion saylori Fox		Ozark Lake (Lake of the Ozarks?), type locality				90
	[syn.: Teutana triangulosa Walckenaer]	see note	(Van Ingen)				2
	Theridium tepidariorum C. L. Koch	see note	(Van Ingen)				2
	Theridula opulenta (Walckenaer)		(Levi, 1954c)				59
	Thymoites marxi (Crosby)		(Levi, 1957d)				59
Theridiosomatidae	Theridiosoma gemmosom (Koch)	Johnson	(Peck)	Exline			68
		Boone	(Am. Mus. Nat. Hist. Collection)		wet, humid, dark forests		17
Uloborus	Hyptiotes cavatus (Hentz)		2 MO records: Rolla region; northwestern MO (St. Joseph region?)		Mature males and females found in summer and fall; in deciduous trees and underbrush, and pinewoods; common species widespread in the eastern U.S. from northern New England to southern FL and westward to eastern TX and MO		65
	Uloborus americanus Emerton	Johnson	Warrensburg, (Peck)	Peck			68
	U. americanus Walckenaer	Phelps	Rolla, (H. E. & D. L. Frizzell)	Davis		WEM	
	Uloborus geniculatus	Boone	Columbia, at residence near greenhouse, (R. Green)	Thewke		WEM	
	Uloborus glomosus	St Louis	St Louis, MO Botanical Gardens, (Spellerberg)	Spellerberg		WEM	
		Oregon	Two Entrance Cave, (Gardner)	Gardner			34
			3 MO records: Jefferson City region; Rolla region; Dexter (Stoddard Co.) region		Widespread in eastern U.S., north to southern Canada, south into Mexico, Central America, and West Indies		65
	Uloborus octenarius Muma	Boone	University of MO, Columbia, (Zepp)	Zepp		WEM	
	Uloborus sp	Boone	Columbia, (Enns)	Exline		WEM	

Plumopos (?) glomosus [syn.: P. americanus]	Boone	Columbia, (Burgess)	WEM

Commonness Changes in Loess Hill Prairie Plants After a Spring Burn

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Abstract: This study uses surveys of loess hill prairie plants on private property in Atchison Co., Missouri, to compare and evaluate plant commonness before and after a one-time spring burn. Several of the plants found during this study have in recent years been listed by the Missouri Department of Conservation as endangered, threatened, rare or watchlist species in Missouri. Quadrat surveys showed that little bluestem, *Andropgon scoparius*, was by far the most common species over the 6-year period of the study (1991-1996). Other common grasses were plains muly grass, *Muhlenbergia cuspida*, hairy grama, *Bouteloua hirsuta*, and side-oats grama, *Bouteloua curtipendula*. The tall grass big bluestem, *Andropogon gerardi*, was very rare prior to the 1992 burn but it became the second most common plant in the study area during all surveys (1993, 1994 and 1996) after the burn.

Introduction

The loess hills landform stretches from southeast South Dakota along the western border of Iowa and into northwest Missouri. Loess soil originated from rock debris that was pulverized by glacial action during the Illinoian and Wisconsin Periods of the Pleistocene Epoch. The soil was transported by wind from meltwater flood-plains to the west and deposited along the east side of the present-day Missouri River. Mutel (1989) used loess landform maps by Ruhe (1969) to approximate the minimum depth of soil on true loess hills at a minimum of sixty-four feet. However, the loess soil is well over 100 feet deep on much of the loess hills landform. Since the end of the Wisconsin Glacial Period (approximately 14,000 years ago) the loess hills have been subject to erosion with very little building (Salisbury and Knox 1969). Because loess soil has not been smoothly worn by water, the particles are angular and lock together tightly when dry. When saturated the soil is prone to slumping and collapse which has helped to form the finely dissected system of interconnecting ridges and backbones that is characteristic of the loess hills landform.

The significant biological feature of the loess hills is the mixed-grass prairie habitat that occurs there. Novacek et al. (1985) identified 703 species of vascular plants in the loess prairie of which many are western xeric species that reach their eastern extension in the loess hills landform. Although the best examples of loess hill prairies in Missouri presently occur in the extreme northwestern part of the state in Atchison County, Bush (1895) identified the southern-most "bald-headed mound" along the Missouri River several miles south of St. Joseph in Buchanan County and approximately one hundred miles south of the Iowa border.

Heineman (1982) used aerial photographs of loess hills in Iowa to show a 66% woody encroachment of shrubs and trees into the mixed-grass prairie between

1940 and 1981. Heineman suggests that this woody encroachment is likely to be related to management, particularly to the suppression of fires. It has also been suggested that the woody encroachment is due to long term climatic changes but precipitation data from 168 stations in the central United States (Qi Hu et al. 1997) shows a decrease in precipitation from the late 1800's to 1960 followed by a general increase in precipitation to the present time.

One example of a well-developed loess prairie in Missouri is located on private property along the southern border of the Star School Prairie Conservation Area in Atchison County. This site was the loess hill prairie used for quantitative sampling of plants before and after a spring burn. The primary objective of this study is to compare loess hill prairie plant commonness values one year before a spring burn and at given intervals over a four-year period after the spring burn.

Methods

The climate of the study area is subhumid with an average yearly precipitation of 38 inches. The soil is a Timula-Hamburg silt loam (USDA Soil Conservation Service, 1987). The hilltop used in this study is approximately 250 feet (76 meters) above the Missouri River floodplain.

The sampling method used was similar to the one used by Knoop (1984) in his study of tallgrass prairies in Illinoiis. Twenty-five square meter plots were evenly-spaced in an area of 25 x 25 meters near the top of a loess hill on the southwest face. The slope angle of the hill was approximately 35 degrees as measured with an inclinometer.

During plant suveys each species in the plot was recorded along with the estimated percentage of coverage. All plants were identified using Flora of Missouri (Steyemark 1963). The percent coverage was considered to be the vertical projection of the outer edge of the live plant cover over the plot. Since more than one plant can occupy the same area at different levels it is possible to have more than 100% coverage of all plants in a single plot. The following parameters were calculated for each species collected within the plots.

$$\text{Ave. Cover} = \frac{\text{sum of cover values for a species}}{\text{\# of quadrats where the species occurred}}:$$

$$\text{Frequency} = \frac{\text{\# of quadrats where the species occured X 100}}{\text{total \# of quadrats sampled}}$$

$$\text{Index of Commonness} = \text{Frequency X Ave. Cover}$$

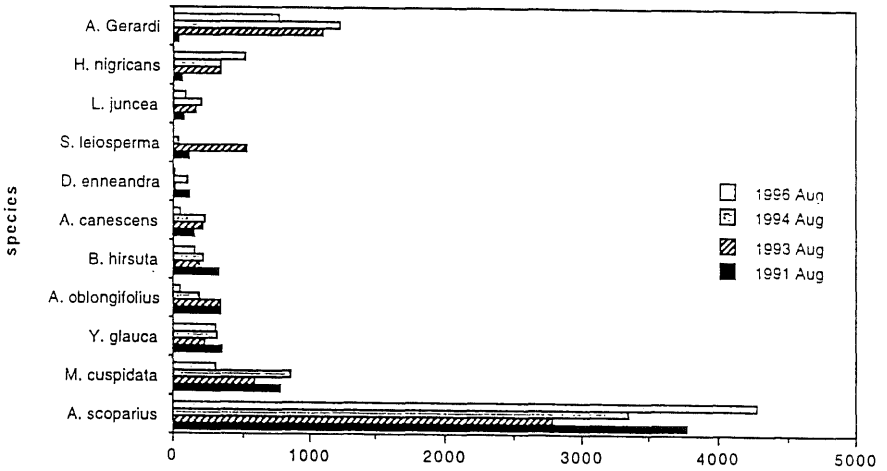
Plant surveys were completed in mid-August during each of the following years:

1991 (preburn), 1993, 1994 and 1996. The study area experienced a complete burn in mid-April of 1992. No plant surveys were conducted in 1992 and 1995.

Results and Discussion

Previous studies (Rosburg and Glenn-Lewin 1996; Novacek et al. 1985; and Iffrig 1980) have shown little bluestem, *Andropogon scopasrius* Michx., to be the dominant plant species on the hilltops of the loess hills landform. This was also found to be the case in our study before and after the 1992 spring burn (See Fig. 1). Iffrig (1980) also found sideoats grama, *Bouteloua curtipendula (*Michx.) Torr., buffalo grass, *Buchloe dactyloides* (Nutt.) Englm., blue grama, *Bouteloua gracills* (HBK) Lag., and muly grass, *Muhlenbergia cuspidata* (Torr.) Muhl. in the Missouri portion of the loess hills landform. Novacek et al. (1985) mentioned hairy grama, *Bouteloua hirsuta* Lag., as a grass found in the Iowa loess hill prairie. Of these grasses, our August 1991 commonness results (Fig. 1) show little bluestem ranked first, muly grass second, hairy grama fifth and sideoats grama sixth. Blue grama and buffalo grass were not found in our study. The third and fourth ranked plants based on commonness values for the August 1991 survey were soapweed yucca, *Yucca glauca* var. *glauca* Nutt., and oblong-leaf aster, *Aster oblongifoilus* Nutt., which according to Novacek et al. (1985) are two forbs typical in the mixed-grass prairies seventy or more miles to the west of the Missouri River. The seventh, eighth, ninth and tenth ranked plants according to commonness values in 1991 were *Amorpha canescens* Pursh, lead plant, *Ambrosia coronopifolia* T. & G., western ragweed, *Dalea enneandra* Nutt., nine-anther dalea, and *Stophostyles lieosperma* (T. & G.) Piper, wild bean. The only tall grass found in our 1991 preburn survey was big bluestem, *Andropogon Gerard* Vitman, which ranked fourteenth according to connoness values.

Figure 1 Commonness Comparisons for August of 1991, 93, 94 and 96



Although none of the plant species found in the study area were on the federal endangered species list, ten species (Table 1) were listed as either endangered, threatened, rare or on the watchlist in the Checklist of Rare and Endangered Species of Missouri in 1984 (Missouri Department of Conservation, 1984). Based on more recent evaluation by the Missouri Department of Conservation, the statuses of several of these species were changed in the Rare and Endangered Species Checklist of Missouri in 1997 (Missouri Department of Conservation, 1997).

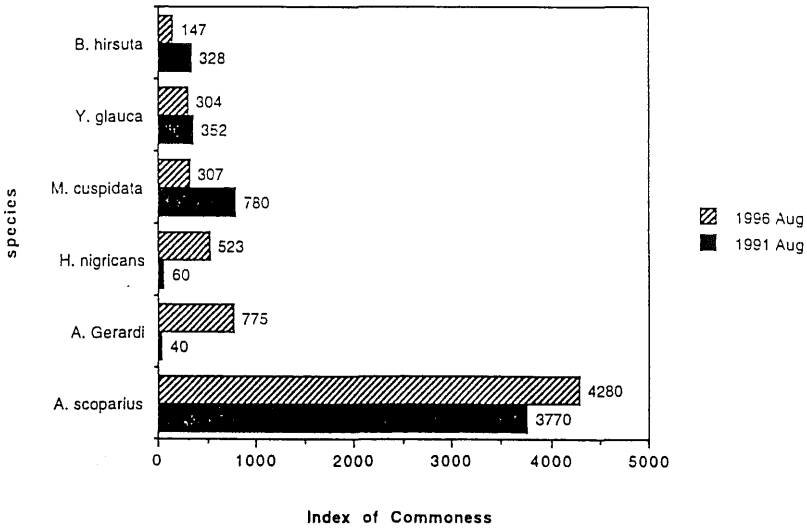
Table 1. Status of Listed Missouri Plants Found in the Study Area According to the Missouri Department of Conservation Natural Heritage Databases of 1984 and 1997.

species	1984	1997
Yucca glauca var. glauca Nutt. soapweed yucca	endangered	watchlist
Lygodesmia juncea (Pursh) D. Don skeletonweed	endangered	watchlist
Castillejia sessiflorum Pursh downy paintedcup	endangered	watchlist
Gaura coccinea Pursh scarlet gaura	watchlist	undetermined
Anemone cylindrica Gray thimbleweed	rare	watchlist
Dalea ennandra Nutt. nine-anther dalea	endangered	watchlist
Oxytropis Lambertii Nutt. locoweed	endangered	watchlist
Astragalus lotiflorus Hook low milkvetch	endangered	watchlist
Penstemon grandiflorus Nutt. large-flower penstemon	endangered	endangered
Bouteloua hirsuta Lag. hairy grama	watchlist	rare

The top five species (Fig. 1) decreased in commonness from 1991 (before the burn) to 1993 (one year after the burn) based on August surveys. However, only hairy grama, soapweed yucca and oblong-leaf aster showed much lower commonness values four years after the burn in 1996. The most dramatic changes in commonness values after the 1992 burn were significant increases in big bluestem, *Andropogon Gerardi* Vitman, and Houstonia, *Houstonia nigricans* (Lam.) Fern. Based on August surveys, big bluestem moved from the fourteenth most common in 1991 to second in 1993, 1994 and 1996 (Fig. 1). Houstonia also showed dramatic increases in commonness values for all surveys after the 1992 burn moving from twelfth in 1991 to third in 1996. (Also see Fig. 2 for preburn and postburn commonness value comparisons of the top six species in 1996.)

Iffrig's (1980) survey of loess hill prairie sites in Atchison and Holt counties in Missouri suggests three main zones on southwest facing slopes: dry (top), dry-mesic (midway), and mesic (bottom). Our study was exclusively in the dry and dry-mesic zones and this is probably the reason why we had very little big bluestem in our initial 1991 survey. However, the dramatic increases in commonness of the tallgrass big bluestem after the burn in 1993, 1994 and 1996 suggests that burning may en-

Figure 2. Commonness Comparisons of Top Six Speices in August 1996.

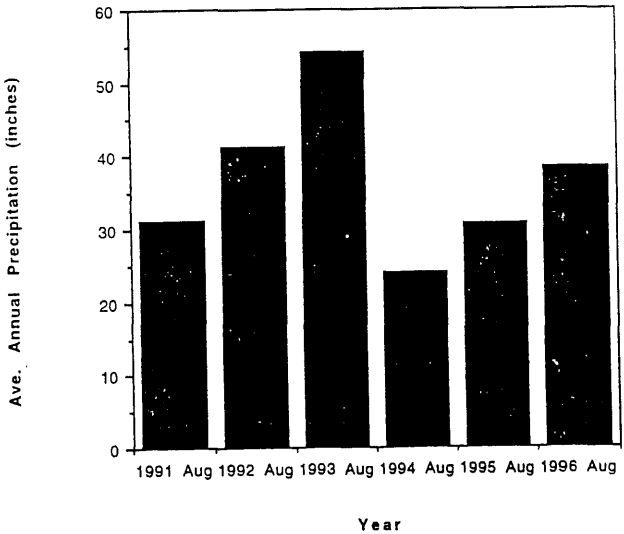


hance the spread of big bluestem into the dry-mesic zone. Other studies have shown increases in shoot growth and tiller spread in tall grasses with spring burning (Owensby and Anderson 1967; Hulbert 1969; Adams and Anderson 1978; Old 1967; Hill and Pratt 1975; Town and Owensby 1984; Peet et al. 1975; Svejar and Browning 1988). It should be pointed out, however, that there was also a dramatic increase in mean annual preciptation in 1992 and 1993 based on data from the National Weather Service's Cooperative Weather Station in Fairfax, Missouri (See Fig. 3). This increased precipitation could have been an additional factor causing the spread of big bluestem after the burn.

The increase in tallgrass during the four year period after the spring burn in our study does not seem to have had a significant effect on the rare forbs in the study area. Hairy grama, a grass that is currently considered rare in Missouri by the Mis souri Department of Conservation, did experience a significant decrease in commonness as big bluestem increased (Figs. 1 and 2). It does seem probable, however, that continued increases in tallgrass in the loess hill prairie could shade out and eliminate some of the low growing forbs such as downy painted cup and low milk vetch.

A fall or winter burn on the loess hill prairie might be beneficial to many of the rare state listed forbs because the burn would be done after the forbs have completed their reproductive cycles. In addition, some studies on tallgrass prairies (Towne and Owensby 1984; Guthrey 1986) have suggested that little bluestem, the dominant grass in the loess hill prairie, is increased over tallgrasses with fall and winter burns. A potential problem with fall and winter burns on the steep loess hills would be increased erosion. All factors should be considered in any loess hill prairie management plan.

Figure 3. Average Annual Precipitation, Fairfax, MO. (Atchison Co.) Weather Station, National Weather Service, 1991-1996.



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Filling in the Gaps: Stand History and Succession of a Mixed Hardwood Old-Growth Forest

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Abstract: Most studies of old-growth forests emphasize structural features (large trees, snags, logs, and vertical stratification) without examining the underlying processes that generate these characteristics. We were interested in how changes in the historical disturbance regime have influenced the structure and composition of Schnabel Woods, a mixed hardwood old-growth forest in Missouri. We reconstructed the stand history of Schnabel Woods from 1817 Public Land Survey records and by examining tree age structures. Future successional trends were modeled from transition probabilities between trees that recently died in the canopy and their potential successors in the understory. The predominant trends over the past 180 years have been an increase in *Quercus rubra* (northern red oak) and *Acer saccharum* (sugar maple) and a decrease in *Quercus macrocarpa* (bur oak). The overstory is currently dominated by even-aged cohorts of 75- to 90-year-old red oaks, but they are currently experiencing heavy dieback. After one complete turnover of the canopy we predict that sugar maple will comprise about two-thirds of the overstory and oaks will dwindle to <3%. Since 1965, new recruitment of sugar maple has declined significantly and its long-term dominance may be less overwhelming than predicted. Although Schnabel Woods has many features associated with old growth, its structure and composition reflect largely transitional states.

Keywords: old growth, treefalls, gaps, succession, *Acer saccharum, Quercus rubra, Quercus macrocarpa*, age structure, transition probabilities.

Introduction

Many natural areas in the Midwest are dedicated to preserving old-growth forests, and strict preservation of remaining old-growth stands is justified because of their extreme rarity. For example, Shifley (1994) estimated that only 0.05% (3160 ha) of Missouri's forests qualified as "old growth." However, the precise area of remaining old growth is difficult to determine, because definitions for "old growth" are not well defined and often vary among resource agencies.

Structurally, old-growth stands are characterized by large, old trees, pronounced vertical stratification, and an abundance of snags and logs (Meyer 1986, Parker 1989, Martin 1992, Richards et al. 1995, Shifley et al. 1995, Oliver and Larson 1996). However, oak (*Quercus)*-hickory (*Carya*) forests occur over such an extensive area that a narrow range of structural characteristics is unlikely to characterize all old-growth stands (White and White 1996). In addition, meaningful definitions for old growth in the Midwest are elusive because forest structure invariably reflects some influence from early industrial logging and/or subsequent fire suppression.

In terms of stand development, *stand age* or *time since last major disturbance* has been used as a criterion for old growth. For example, Meyer (1986) considered stands at least 90 years old to be "old growth" in Missouri. However, stand age can be misleading because different species grow at different rates (Meyer 1986), and rates also depend on site conditions (Robertson 1992). Old growth can also be defined as a *stage in stand development*, thus compensating for differences in growth rates among species or sites. After a stand-initiating disturbance, stands pass through

several structural stages that may eventually culminate in "old growth" (Oliver and Larson 1996). A post-disturbance cohort becomes established (stem initiation), and then thins as trees become larger (stem exclusion). As stands mature, overstory mortality results in larger gaps that foster renewed regeneration of the same or different species (stem reinitiation). A stand becomes "old growth" after the original post-disturbance cohort is completely replaced, through fine-scale gap processes, by trees from beneath. However, the complete disappearance of the initial cohort may be so long that "true old growth"(*sensu* Oliver and Larson 1996) may never be reached in some forest types (e.g., Douglas fir-western hemlock), even if they display many of the structural characteristics associated with old growth. Thus, some researchers have also included the transitional phase as part of old growth (Hayward 1991).

"Old growth" usually refers to the last stage in the structural development, whereas "climax" refers to the endpoint of succession, which emphasizes changes in species composition (Kimmins 1997). These processes are interrelated but emphasize different variables and need not correspond: some old-growth stands are dominated by early successional species (e.g. this study); conversely, a near-climax forest might consist primarily of young trees (e.g., Veblen et al. 1989).

Stand structure is frequently complex, reflecting both the coarse-scale dynamics of an even-aged cohort recovering from catastrophic disturbance and the modifying influence of fine-scale gap dynamics (Henry and Swan 1974, Franklin and Waring 1980, Thomas et al. 1988, Oliver and Larson 1996, Martin 1992). The historical importance of these coarse and fine-scale disturbances in the oak-hickory region is poorly known (Runkle 1985, 1990; Lorimer 1989), but currently the natural disturbance regime in old-growth stands is dominated by small treefall gaps. Gap dynamics are directly responsible for the genesis of many key old-growth structural characteristics (distribution of snags and logs, canopy stratification), and succession occurs primarily as a tree-by-tree replacement process in gaps.

We explored the stand dynamics of Schnabel Woods, a mixed hardwood forest in the loess hills along the Missouri River, by focusing on treefall gaps and age structures. In this paper, we regarded Schnabel Woods as old growth based on Richards et al. (1995), who described mainly structural features. However, our goal was to evaluate old growth in terms of stand development and succession--the processes that generated the current structure and composition. We also discuss management problems of natural areas dedicated as old growth. How do you manage discrete areas for a particular stage in stand development or succession?

Methods

Study Area

Schnabel Woods covers 32 ha on the west-facing bluffs of the Missouri River, 4 km southeast of McBaine in Boone County, Missouri. The soil is a deep Menfro loess, classified as fine-silty, mixed, mesic Typic Hapludalf (S.J. Indorante and R.D. Hammer, unpublished report of the Soil Conservation Service and University of Mis

souri. In 1954 the tract was deeded to the University of Missouri as an arboretum and demonstration area, and in 1978 it was designated a State Natural Area. Since the acquisition by the University of Missouri, no active vegetation management has occurred (Richards et al. 1995).

Field Procedures

We sampled forest composition in 30 circular, 300-m^2 plots. Plots were spaced 40 m apart along 10, 100-m transects, each following a random compass bearing. All trees >10 cm dbh (diameter at breast height, 1.4 m) within a plot were identified and diameters recorded. Stand history and demographic patterns were inferred from static age structures (Veblen 1992). We used the point-centered-quarter method (Cottam and Curtis 1956) to select trees for coring. We established seven random 100-m transects, and at 20-m intervals we selected the nearest oak and maple (*Acer saccharum* or *A. nigrum*) in each quadrant (8 trees total per point). We had no minimum size limit for coring. Trees were cored at a height of 20-40 cm above ground. Cores were dried, mounted, sanded to a high-gloss finish, and counted under a stereomicroscope. Maples were wetted to improve ring visibility. For cores that missed the pith, we subjectively estimated the number of rings to center.

To assess successional trends, we sampled all canopy gaps within a 15.7-ha block, the north half of the Schnabel tract. A gap was defined as a canopy opening at least 20 m^2, with regeneration in the opening no more than 15-20 m tall, approximately two-thirds the height of the main canopy (Runkle 1982). Transition probabilities were calculated based on relative abundances of gap-making species and subcanopy trees regenerating in gaps (Barden 1981; Runkle 1981; Veblen 1985, 1992). Gap-making species were carefully identified by examining branching patterns and bark characteristics. Within each gap we identified the four tallest saplings or small trees (>1.4 m tall, but <15 cm dbh) regenerating within the gap and designated these as "potential successors." If fewer than four trees occurred in the gap, a successor was chosen from subcanopy trees bording the gap. The concept of a "potential successor" recognizes that a tree with an early advantage in height growth is likely to eventually fill a gap (Veblen 1985). The designation of four successors, however, reflects the uncertainty of predicting exactly which trees will eventually reach the main canopy.

Scientific names of taxa follow Little (1953).

Public Land Survey Notes

Historical vegetation composition was gathered from 1817 Public Land Survey records in the vicinity of Schnabel Woods. Public Land Survey records (sometimes called General Land Office or "GLO" notes) have been widely used to reconstruct composition and structural characteristics of vegetation at the time of European settlement (Bourdo 1956, Howell and Kucera 1956, Hutchinson 1988). For composition, we tallied all "bearing trees" recorded by the surveyor along section lines, section corners, and quarter sections. To obtain an adequate sample, we expanded

our tally to several sections (1 section=2.8 km^2) north and south of Schnabel Woods along the bluff line. We only included upland areas; bottomlands along the Missouri River and Perche Creek were not included. A total of 90 trees >10 cm diameter were recorded along 19 section lines (32 km). The methods and locales for the 1817 data were different than those used in our survey of Schnabel Woods, so only very general comparisons were made. Bearing tree selection may be biased towards particular species, but we compared section line narrative descriptions with bearing tree composition and did not detect any obvious bias.

Succession Model

We projected future vegetation using current vegetation and gap transition probabilities to construct a stationary Markov Chain (Usher 1992). A vector of current community composition is multiplied by a matrix of transition probabilities to give a new composition vector which represents the composition after one complete turnover of the canopy. In the projection, we only used five overstory species that were common in past or present surveys, and the rest were grouped into an "other" category. The Markov model rests on the assumption that transition probabilities do not change over time, and once the chain reaches a particular state, it is not dependent on previous states.

Results

Stand History

Based on surveyors notes in 1817, the three most abundant species in the vicinity of Schnabel Woods were white oaks (*Quercus alba* L., and possibly *Querucs muehlenbergii* Engelm., 25% of total), sugar maple (*Acer saccharum* Marsh, 18%), and bur oak (*Querucs macrocarpa* Michx., 12%) (Table 1A). Northern red oak (*Querucs rubra* L.) was not recorded in the area in 1817. Trees identified as white oak ("wo" in surveyor's shorthand) probably included both *Quercus alba* and *Q. muehlenbergii*, because the area was surveyed in winter and these species would have been difficult to distinguish from bark characteristics alone.

The most noticeable changes in the past 180 years have been the decline of bur oak and the rise of northern red oak. Bur oak was the third most frequently mentioned species in 1817, but it was completely absent in 1982-1996 surveys. By contrast, northern red oak was not mentioned in the 1817 surveys, but in 1996 it constituted 20% of the overstory and was the second most abundant species behind sugar maple.

The age structures indicate that most of the present overstory originated in the past 120 years. The age frequency distribution of oaks was trimodal, with episodes of recruitment during the 1870s, 1900s and 1920s (Fig. 1). Most of the largest trees, northern red oaks 50-75 cm dbh, were only 75-95 years old. The oldest trees, chinquapin oaks (*Q. muehlenbergii*) 35-50 cm dbh, were 115-120 years old. The age

structure for maples shows fairly continuous regeneration during the past 100 years (Fig. 1). Establishment peaked between 1930 and 1965, but there has been remarkably little maple regeneration during the past 30 years.

Predicted Successional Trends

The subcanopy tree composition (Table 1B) and treefall gap data (Fig. 2) suggest an overwhelming shift from oaks to sugar maple. Maples constituted 83% of the subcanopy trees in the Forest Service plots in 1992, an increase of 15% compared to the 1982 survey (Table 1B). We found a similar abundance of subcanopy maples in 1996. In contrast, subcanopy oaks were rare in 1996. Chinquapin oak and white oak were regenerating better than nothern red oak, which was absent from the subcanopy tree class in 1992 and 1996.

High overstory mortality has exacerbated the decline of northern red oak. In 1996 it was the dominant gap maker, constituting 26% of 76 gap makers (Fig. 2). All oak species combined accounted for half the gap makers. The dominant gap-filler was sugar maple, which constituted 65% of 304 potential successors (Fig. 2), and based on the Markov projection, it will compose about two-thirds of the canopy after one complete canopy turnover (Table 1A). The formerly dominant oak species will compose <3%. Although hickories and basswood both declined slightly from 1982-1992 in the Forest Service permanent plots, current regeneration in gaps indicates that they will eventually increase in the canopy (Table 1A).

Discussion

Assessment of Old-Growth Characteristics and Stand Development

Schnabel Woods displays all the structural characteristics of an eastern deciduous old-growth forest (Richards et al. 1995, Shifley et al. 1995). Trees have a negative exponential size distribution, with a substantial number of large trees (>30 trees/ha that are >43 cm dbh). Snags are abundant and downed wood volumes are about 40 m^3/ha, more than twice that of second growth stands. However, our results demonstrate two potential flaws in relying solely on structural features in designating old growth.

First, big trees are not necessarily old trees. The largest trees at Schnabel Woods are mainly 75- to 95-year-old red oaks-the same age as those found in most "second growth" stands in the lower Ozarks (Spencer et al. 1992). The Menfro loess soils of Schnabel Woods are much more productive than the cherty, highly weathered ultisols and alfisols of the lower Ozarks, so old-growth structural characteristics were attained more rapidly at Schnabel Woods. Robertson (1994) found a similar bias for mesic sites in the USDA Forest Service's designation of old-growth stands in Colorado. From a management standpoint, the only real concern is that xeric old-growth stands may receive less protection because they are not as impressive, structurally, as mesic sites, even though they may harbor unique plants and animals.

The second problem concerns prioritizing old-growth stands based on the number of large trees without recognizing that a superabundance of large trees may indicate a mature even-aged stand in the late stem reinitiation stage (*sensu* Oliver and Larson 1996). Such stands may present an impressive array of old-growth structural features, but they may also be on the verge of breaking up. Schnabel Woods is clearly in the stem reinitiation stage: the overstory consists of several even-aged, post-disturbance cohorts a few decades apart, with maple and other species now regenerating successfully in treefall gaps. However, as the even-aged overstory breaks up, densities of large trees will inevitably dwindle. Indeed, drought-related oak dieback in the 1980's has already left some parts of Schnabel Woods devoid of large trees. In Colorado, Roovers and Rebertus (1993) described a similar case where the Forest Service designated reserve status for an old-growth stand that later was revealed to be in the stem reinitiation stage. Such forests may continue to provide important wildlife habitat and aesthetic enjoyment to the public, but managers should be wary of "too many big trees" when prioritizing stands.

Ecosystem in Disequilibrium

Profound changes in composition have occurred in the loess hills during the past 180 years. Bur oak was the third most common species in the vicinity of Schnabel Woods in 1817, but it was absent from Schnabel Woods in both the overstory and understory in 1996. In contrast, northern red oak was not recorded along the bluffs by surveyors in 1817, but it was the second most common species in 1996. Howell and Kucera (1956) compiled presettlement survey notes from Boone, Clark, and Dade counties in Missouri and found a similar pattern: bur oak was the second most common species in the three-county area (17% of 6500 bearing trees), whereas nothern red oak accounted for only 2% of the surveyed trees. In the past, bur oak probably was favored by frequent surface fires on upland sites (Lorimer 1985). Turn-of-the-century logging and slash burning, followed by fire suppression, may have favored the replacement of bur oaks by less fire-tolerant northern red oak. The sudden rise in northern red oak dominance parallels a similar trend for scarlet oak on poorer sites in the Ozarks (Batek 1994) and, in general, for the entire red oak group in the eastern United States (Abrams 1992).

Although northern red oak was the second most common species in Schnabel Woods in 1996, it was also the most abundant gap maker and is currently not regenerating via seedlings or sprouts. The Markov projection suggests it will comprise only 1% of the overstory after one complete turnover. White oaks (*Q. alba* and *Q. muelhenbergii*) were also over-represented as gap makers and had poor regeneration, but they can potentially reach 300 to 400 years old and should not decline as rapidly as red oak. Widespread decline of red oaks was reported in Missouri during the 1970's and 1980's (Jenkins and Pallardy 1996) and throughout the eastern United States (Tainter et al. 1983, Starkey and Oak 1989, and others). Red oaks were predisposed to dieback by their even-aged establishment after turn-of-the-century logging. Droughts in the 1950's and 1980's triggered the heavy mortality in Missouri

(Jenkins and Pallardy 1996). Although oak dieback has been widespread in the region, poor regeneration has been limited mainly to mesic sites (Johnson 1993).

Maple Invasion Revisited

The increased dominance of sugar maple on mesic sites in Missouri during the past few decades has been well documented (Kucera and McDermott 1955, Nigh et al. 1985, Pallardy et al. 1988). Fralish et al. (1991) believed that upland oak-hickory forests will become a rare ecosystem as succession continues. Our results confirm this pattern for Schnabel Woods, where we predict that maple will account for 66% of the overstory after one complete turnover of the canopy. Based on the disturbance rates from other old-growth stands in eastern deciduous forests, a rotation period (time required to disturb the equivalent of the entire study area) of approximately 100 years seems likely (Runkle 1985). However, because dieback of northern red oaks is very extensive in these stands, most of the conversion to a maple-dominated overstory will probably occur within the next few decades. On the other hand, complete turnover within 100 years is unlikely given that white oaks may live several hundred years.

In many forest systems, disturbance by treefalls acts as a "lottery" for living space; the element of chance in colonizing a gap tends to increase overall species diversity (Hubbell and Foster 1986). However, a comparison of the understory composition (Table 1B) with the Markov projection (Table 1A) suggests that maple is so widespread in the understory *before* gaps form that any element of chance is essentially nullified. Our predictions demonstrate that a few other species, such as hickories and basswood, may be able to successfully capture enough gaps to maintain themselves in the canopy, but overall tree diversity will be reduced (see Fig. 2). Other organisms will undoubtedly be affected by these changes. For example, abundance and diversity of small mammals appears to be reduced by maple invasion (David Fox, School of Natural Resources, University of Missouri, unpublished data).

In a second-growth stand near Schnabel Woods, Pallardy et al. (1988) noted a ten-year decline in small sugar maple saplings, for which they had "no satisfactory explanation." In 1996, we documented extensive areas lacking any significant maple regeneration <30 years old, and we suspect that self-shading by maple is completely inhibiting new seedling establishment. If the current pattern continues, reciprocal replacement of maples and more shade intolerant species may partially reverse the current successional trend. As the canopy becomes increasingly filled by maples with no further advance regeneration beneath, new gaps may be filled by faster growing species that start from seed. Likely candidates include those with wind-dispersed seeds (e.g. ashes, *Fraxinus*), a persistent seed bank (e.g. black cherry, *Prunus serotina*), but oaks and hickories may also take advantage of larger gaps. Reciprocal replacement and cyclical micro-succession involving sugar maple, American beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis*) is well documented for mesophytic forests in the eastern United States (Woods 1979), but it has not been documented in oak-hickory-mixed hardwood communities.

Conclusion

Old growth can be defined many ways, but it is imperative to understand *how* stands develop to predict future structural and compositional changes. Schnabel Woods, for example, will probably never have as many big trees at one time as it does now. Many people perceive old-growth as a stable stage in stand development-only needing protection from human influence to remain intact (White and Bratton 1980). However, the legacies of native American burning, turn-of-the-century logging and burning, fire supression, and oak dieback have produced profound structural and compositional disequilibrium in Missouri's old-growth forests. Sprugel (1991) stressed that the concept of "natural" vegetation encompasses a dimension of constant change and disturbance. The short term goal of preservation of remnant old-growth sites eventually should be integrated into landscape-scale planning to maintain a variety of stages of stand development and succession.

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Table 1. Past, present, and projected future composition of Schnabel Woods Natural Area, Boone County, Missouri.

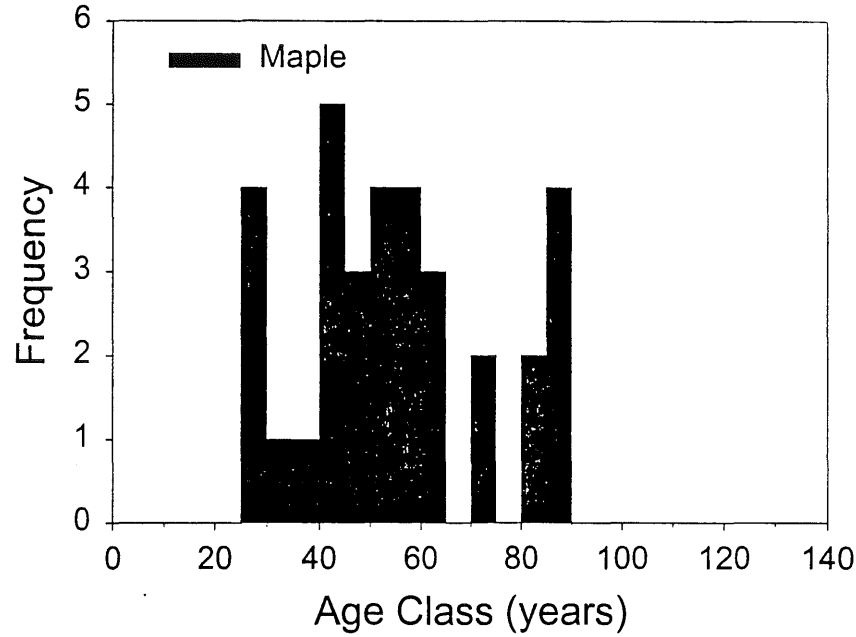
A. Overstory trees ≥ 20 cm dbh

Species or Taxon	PLS 1817[1] n = 83	USFS 1982[2] n = 242	USFS 1992 n = 229	This study 1996 n = 187	Projected after one turnover[3]
Acer spp.[4]	18.1	38.8	42.4	25.0	65.6
Carya spp.	9.6	4.5	3.9	3.2	10.8
White oak group	37.3[5]	16.5	17.0	19.3	1.4
Quercus alba	-	3.7	3.9	8.0	-
Q macrocarpa	12.0	0.0	0.0	0.0	0.0
Q muehlenbergii	-	12.8	13.1	8.6	-
Q. rubrum	0.0	15.7	14.8	19.8	1.4
Tilia americana	2.4	9.5	7.4	3.2	3.9
Other	32.6	15.0	14.5	29.5	16.9

B. Subcanopy trees 10 - 19.99 cm dbh

Species or Taxon	USFS 1982 n = 226	USFS 1992 n = 211	This study 1996 n = 156
Acer spp.	71.7	82.5	60.3
Carya spp.	2.2	1.4	6.4
White oak group	3.5	2.4	3.8
Quercus alba	0.0	0.0	2.6
Q macrocarpa	0.0	0.0	0.0
Q muehlenbergii	3.5	2.4	1.3
Q. rubrum	0.4	0.0	0.0
Tilia americana	3.5	0.9	0.6
Others	18.7	12.8	25

[1] % of recorded bearing trees on 32 km of surveyed section lines along bluffs near Schnabel Woods
[2] based on two 0.8-ha plots on southeast and northwest aspects (adapted from Richards et al. (1995)
[3] Markov projection after one complete canopy turnover (ca. 100-200 years) of the 1996 overstory
[4] *Acer saccharum* and *A. nigrum*
[5] 25.3% of bearing trees were recorded as white oaks; we believe this included both *Q.alba* and *Q. muehlenbergii* because the survey was conducted in winter.



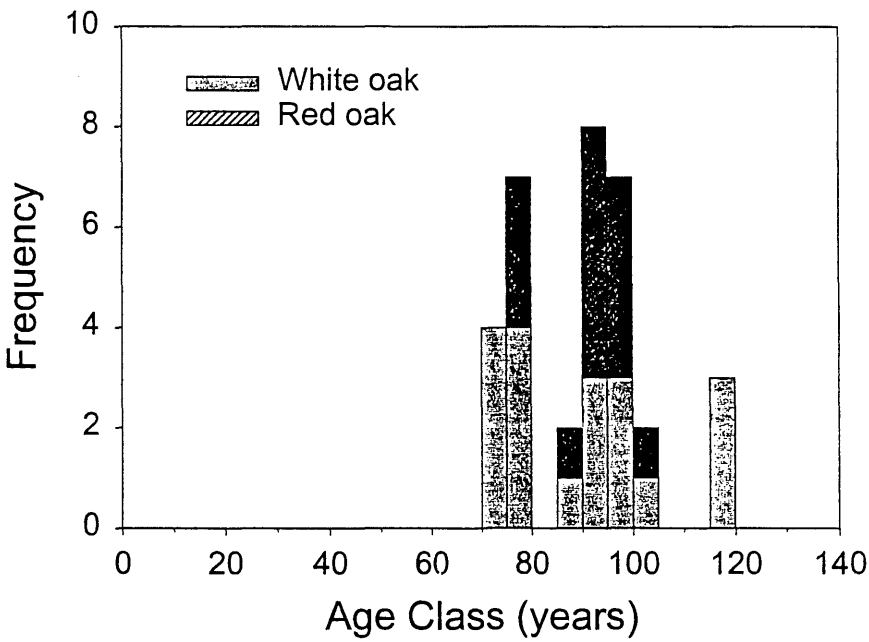


Figure 1. Age frequency distributions for sugar maple (top) and oaks (bottom) in Schnabel Woods, Boone County, Missouri. Ages are for coring height, 30-40 cm above ground. White oaks include both *Quercus muehlenbergii* and *Q. alba*..

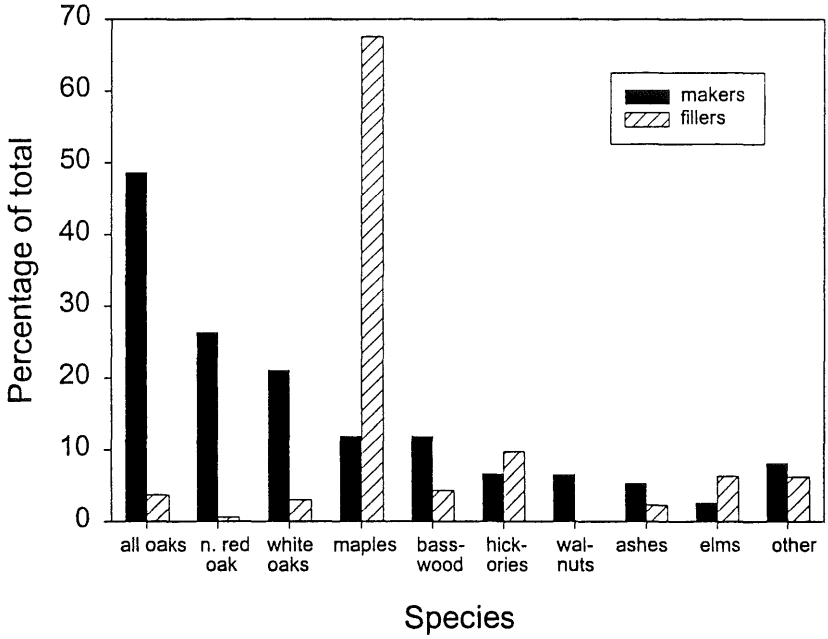


Figure 2. Comparison of gap-making and gap-filling species in Schnabel Woods. Percentages are based on 76 gap makers and 304 gap fillers. Gap fillers or "potential successors" were the four tallest saplings or small trees (<15 cm dbh) regenerating in each gap.

Effect of the 1993 and 1995 Floods on Vegetation of the Marais Temps Clair Conservation Area St. Charles County, Missouri

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Abstract: The 1993 and 1995 floods 25 km upstream from the confluence of the Mississippi and Missouri Rivers were among the most massive ever recorded. We examined the effect of these floods upon the vegetation of the 372 ha Marais Temps Clair Conservation Area in St. Charles County, Missouri. We utilized the point quarter technique to assay the frequency of saplings (dbh = 2.5 to 10 cm) and trees (dbh > 10.0 cm) of the resident species in a triangular study area at the periphery of the flood locally. This area consisted of an upper unit separated by a cleared easement from a lower unit. Overall, species richness was 14. The most frequent species on the upper unit were *Acer saccharinum, Ulmus rubra, Celtis occidentalis* and *Morus rubra* for trees and *A. saccharinum, Cornus florida* and *Celtis occidentalis* for saplings. For the lower unit, *A. saccharinum, Populus deltoides* and *Salix nigra* were the most frequent trees and *A. saccharinum* and *Cornus florida* the most frequent saplings. *Acer saccharinum*, the most abundant species, suffered mortality of 90.2% in the lower level versus losses of 11.2% on the upper area. *Cornus florida* individuals were more adversely affected on the lower level than the upper one. Trees exhibited less mortality than did conspecific saplings. Overall, the relative abundance of *Salix nigra* was increased at the lower zone because other pre-flood species were killed by high water. Qualitative estimates of the effects of flooding on woody and herbaceous vegetation at nearby sites were made. The pre-flood co-dominance of a cultivar of switch grass, *Panicum virgatum*, and the water smartweed, *Polygonum amphibium* on levee slopes were altered radically with the elimination of the former species.

Key words: floods, Missouri River, Mississippi River, woody vegetation

Introduction

The record floods of 1993 caused extensive damage to both rural areas and towns in the flood plain between the Missouri and Mississippi Rivers (Izenberg et al., 1995). The flood of 1995 compounded this damage. This study documents the effect of the floods on native vegetation at the 372 ha Marais Temps Clair Conservation Area (MTC) in St. Charles County, Missouri. This area is 26 km upstream from the confluence of the two major rivers. It and the adjacent privately owned 257 ha constitute the last remaining, large marsh in the area. Both are surrounded by extensive agricultural fields. Through the use of levee-bound impoundments, the Missouri

Department of Conservation owns and manages MTC as a controlled wetland for waterfowl and wading birds. Insular conservation complexes such as MTC are strongly sensitive to catastrophic events such as flooding because of localized, episodic mortality and biased reintroduction of new propagules. This study focuses on quantitative and qualitative estimates of the changes in vegetation associated with the flooding at MTC.

Methods

We conducted a quantitative study of non-climbing, woody vegetation at an isolated wooded area located at the northern border of the Marais Temps Clair marsh complex (Fig. 1). Between 23 September and 11 October, 1995, we used the point quarter technique (Cox, 1976) to sample the abundance of woody vegetation. Those stems with a diameter at breast height (= dbh) ranging between 2.5 and 10.0 cm were classified as saplings, stems with a larger dbh were tallied as trees. The study area consisted of two subunits separated by a cleared easement which was 15-20 m in width. The lower unit is relatively flat and contiguous with the normal high water levels of the marsh. The upper area slopes upward to a local highway. The maximal elevational difference between the upper boundary of the upper unit and the lower boundary of the lower unit is 4 m (Fig. 1). Transects were established at 15 m intervals along north-south bearings across most of the study area (Fig. 1). Where the area narrowed, we ran one transect parallel to the road and a second parallel to the easement. We sampled only within the upland forest or the bottomland forest. All other areas (e.g. Easement) lacked woody vegetation. The northern ends of the north-south transects and the western ends of the two west-east transects served as zero points from which sampling sites were selected. A series of randomly selected numbers served to determine the distance between successive sampling sites along any one transect. Within each quadrant we identified the species of sapling and tree nearest to the randomly selected point, measured their dbh and recorded their conditon (living or dead). The majority of sampling points yielded tree and sapling specimens in each quadrant. However, some quadrants bordering the easement or parking lot lacked trees or saplings due to the open space and thus resulted in differing individual totals for trees ands saplings (Table 2). The number of living and dead stems counted in this post-flooding survey was presumed to represent living stems of the pre-flood period. The condition of the dead stems clearly indicated that the overwhelming majority had died during the floods. The number of living stems recorded was used to determine the frequency of various species in the post-flood period. Nomenclature was based on Yatskievych & Turner (1990).

Results

Visual inspection of the entire study area revealed the presence of 14 species (Table 1). Eleven were recorded during the quantitative survey. The non-sampled

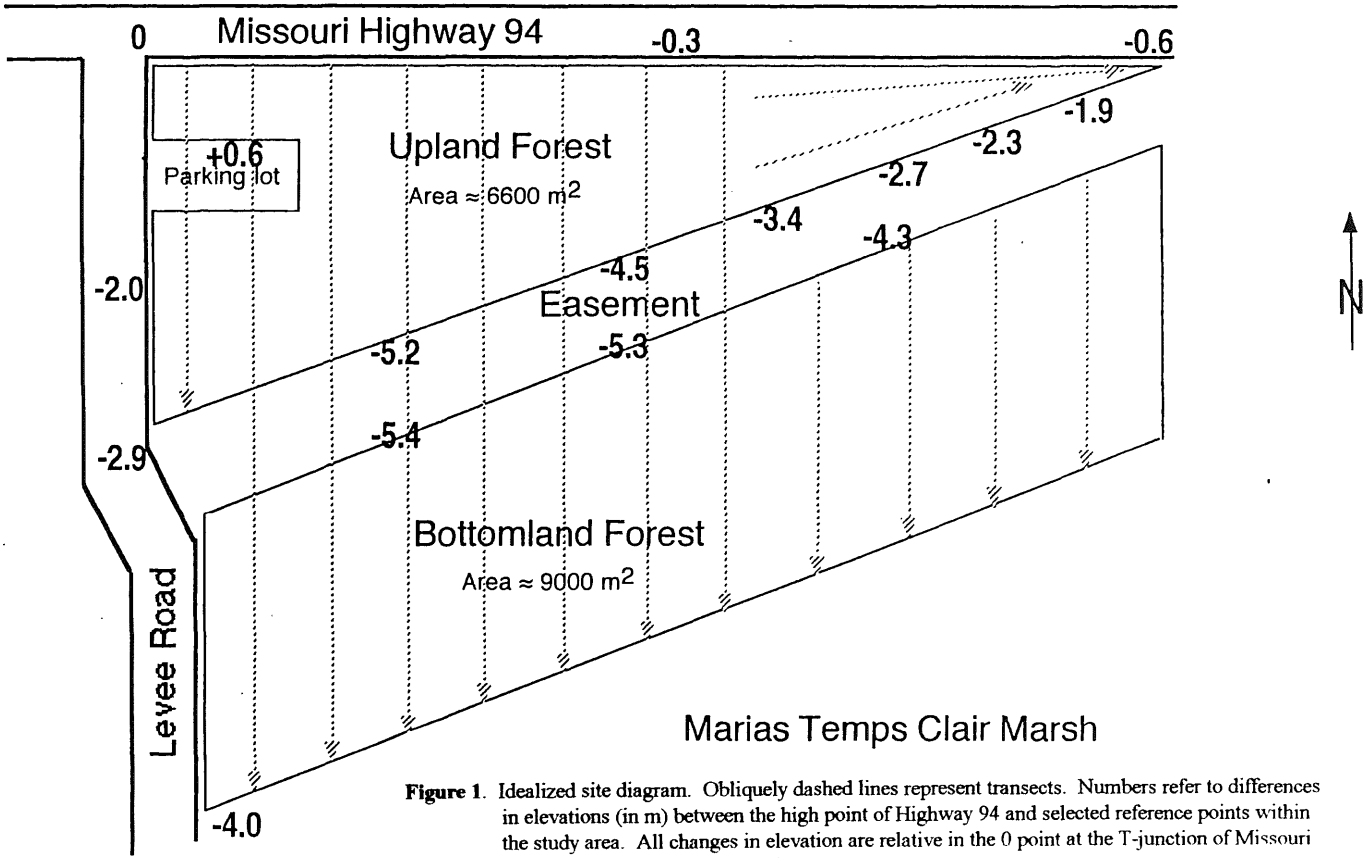

Figure 1. Idealized site diagram. Obliquely dashed lines represent transects. Numbers refer to differences in elevations (in m) between the high point of Highway 94 and selected reference points within the study area. All changes in elevation are relative in the 0 point at the T-junction of Missouri Highway 94 and the Levee Road.

species, *Diospyros virginiana, Juglans nigra* and *Prunus serotina*, were rare members of the upper zone.

All eleven species which were recorded during sampling occurred in the upper zone during pre-flood conditions but only seven of them were recorded in the lower unit (Table 2). Four species (*Acer saccharinum, Morus rubra, Populus deltoides* and *Cornus florida*) were observed relatively frequently in both zones during the pre-flood period. Six species (*Ulmus rubra, Celtis occidentalis, Sassafras albidum, Carya illinoensis, Prunus americana* and *Robinia pseudo-acacia*) were essentially limited to the upper zone as was *Salix nigra* to the lower one.

In the upper zone *Acer saccharinum* exhibited the highest frequency both as saplings and as trees (Table 2). *Ulmus rubra, Celtis occidentalis,* and *Morus rubra* were also abundant with frequencies >0.06 in both sapling and tree categories. The frequency of sapling *Cornus florida* was also high. The remaining five species were of infrequent occurence in one or both size categories.

Within the lower zone *Acer saccharinum* was again the most frequently encountered species, both as sapling and tree. Three species, *Morus rubra, Populus deltoides* and *Salix nigra* had frequencies > 0.02 for both size categories. Only saplings of *Cornus florida* and trees of *Ulmus rubra* and *Celtis occidentalis* were present.

Mortality varied within both size classes and zones (Table 2). Within the upper zone, six species were represented by 20 or more individuals in one or both size classes. *Celtis occidentalis* was the only species to exhibit no mortality. This species is also largely restricted to this zone. Low mortality was also observed for trees of *Populus deltoides*, no saplings were present. Intermediate levels of mortality were exhibited among both size classes of *Morus rubra* and *Ulmus rubra*. A high proportion of saplings of *Acer saccharinum* died in contrast to the low levels of death among trees. Almost a quarter of the saplings of *Cornus florida* died.

Losses were very high within the lower zone for the two size-classes of abundant species such as *Acer saccharinum* and *Populus deltoides* (Table 2). Thirty two percent of the trees of *Salix nigra*, a species essentially restricted to this zone, were killed. All individuals of *Cornus florida* were killed.

Qualitative Observations

Prior to 1993, sides of levees were co-dominated by a smartweed, *Polygonum amphibium* and a cultivar of *Panicum virgatum*. By 18 April, 1994 plant coverage on levees was no more than 50 percent and was comprised solely of 5-10 cm tall sprouts of *P. amphibium*. Thereafter, this species dominated the levee sides and the switch grass was eliminated. One levee-side population of the rose mallow, *Hibiscus lasiocarpos*, did not survive nor did a long established population of American lotus, *Nelumbo lutea*, in normally shallow water. Notable within a second forest enclave was the elimination of poison ivy *(Toxicodendron radicans)*, catbrier, *Smilax* sp., wild goose plum, *Prunus munsoniana*, and rough-leaved dogwood, *Cornus drummondii*. Mulberries, *Morus rubra*, were entirely eliminated along a 0.5 km stretch of a ditch.

Table 1. Listing of the non-climbing, woody species observed in the quantitatively sampled study area at Marais Temps Clair Conservation Area, St. Charles County, Missouri, U.S.A.

Species	*Common Name*
Acer saccharinum L.	Maple, Silver
Carya illinoensis (Wangenh.) K. Koch	Pecan
Celtis occidentalis L.	Hackberry
Cornus florida L.	Dogwood, Flowering
Diospyros virginiana L.	Persimmon
Juglans nigra L.	Walnut, Black
Morus rubra L.	Mulberry, Red
Populus deltoides Bartram ex Marshall	Cottonwood, Eastern
Prunus americana Marshall	Plum
Prunus serotina Ehrh.	Cherry, Black
Robinia pseudo-acacia L.	Locust, Black
Salix nigra Marshall	Willow, Black
Sassafras albidum (Nutt.) Nees	Sassafras
Ulmus rubra Muhlenb.	Elm, Slippery

Table 2. Comparison of preflood and post-flood frequencies of trees and saplings at the Marais Temps Clair study site. N = number of trunks; f = frequency; - = empty.

A. UPPER ZONE

	TREES					SAPLINGS				
	Pre-flood			Post-flood		Pre-flood			Post-Flood	
SPECIES	N	f	% Mortality	N	f	N	f	% Mortality	N	f
Acer saccharinum	181	0.539	4.4	173	0.554	133	0.390	20.3	106	0.367
Ulmus rubra	74	0.220	12.2	65	0.208	34	0.100	2.9	33	0.114
Celtis occidentalis	23	0.068	0.0	23	0.074	65	0.191	0.0	65	0.225
Morus rubra	23	0.068	13.0	20	0.064	20	0.059	20.0	16	0.055
Populus deltoides	20	0.060	10.0	18	0.058	0	0.0	-	0	0.0
Sassafras albidum	5	0.015	20.0	4	0.013	2	0.006	100.0	0	0.0
Carya illinoensis	4	0.012	25.0	3	0.010	5	0.015	0.0	5	0.017
Cornus florida	4	0.012	0.0	4	0.013	72	0.211	23.6	55	0.190
Prunus americana	1	0.003	0.0	1	0.003	7	0.021	14.3	6	0.021
Salix nigra	1	0.003	0.0	1	0.003	0	0.00	-	0	0.0
Robinia pseudo-acacia	0	0.0	-	0	-	3	0.009	0.0	3	0.010
$\sum$ =	336	1.000		312	1.000	341	1.002		289	0.999

B. LOWER ZONE

	TREES					SAPLINGS				
	Pre-flood			Post-flood		Pre-flood			Post-Flood	
SPECIES	N	f	% Mortality	N	f	N	f	% Mortality	N	f
Acer saccharinum	79	0.617	94.9	5	0.172	85	0.669	86.0	12	1.000
Ulmus rubra	0	0.0	-	0	0.0	1	0.008	100.0	0	0.0
Celtis occidentalis	0	0.0	-	0	0.0	1	0.008	100.0	0	0.0
Morus rubra	5	0.039	40.0	3	0.103	2	0.016	100.0	0	0.0
Populus deltoides	22	0.172	73.9	6	0.207	6	0.047	100.0	0	0.0
Sassafras albidum	0	0.0	-	0	0.0	0	0.0	-	0	0.0
Carya illinoensis	0	0.0	-	0	0.0	0	0.0	-	0	0.0
Cornus florida	0	0.0	-	0	0.0	31	0.244	100.0	0	0.0
Prunus americana	0	0.0	-	0	0.0	0	0.0	-	0	0.0
Salix nigra	22	0.172	31.8	15	0.517	1	0.008	100	0	0.0
Robinia pseudo-acacia	0	0.0	-	0	0.0	0	0.0	-	0	0.0
$\sum$ =	128	1.000	-	29	0.999	127	1.000	-	12	1.000

Discussion

Physical disturbances, such as flooding, fire, volcanic eruptions, wind storms, etc., can contribute to local and regional changes in biodiversity (Connell, 1978; Bazzaz, 1996). Anthropogenic structures can intensify the effect of normal perturbations of such natural events. Menigal et al. (1997) discuss negative effects of flooding on forest productivity when exacerbated by the presence of levees or impoundments. The effect of the 1993 and 1995 floods was exacerbated by such artifacts (Izenberg et al., 1995).

There were four high water crests during the flood of 1993 (Anon., 1994). The Mississippi River at the Grafton, IL flood gauge is 7 km NNW of Marais Temps Clair. As registered by that gauge, water was at or above flood stage for 218 days, 6 March to 10 October, 1993. The maximal crest occurred on 1 August. Water overtopped normal, summertime levels by 7 m and levee tops by 4 m. After the river levels began to recede, water levels remained high at Marais Temps Clair because of their retention within the unbreached levee system. On 18 April, 1994 the water surface throughout much of MTC was 1-2 m below the tops of the levees. In 1995, maximal flood height was within 1 m of that of 1993.

One effect of the floods was to increase the difference in relative species abundance between the upper and lower zones. Many species which had invaded the lower zone during preceding more normal fluctuations of water level were greatly reduced within that zone. For example, of the 79 trees and 85 saplings of *Acer saccharinum* present on the lower zone, only 5 and 12, respectively, survived flooding (Table 2). However, the sapling class of *Acer* was the only one which did survive flooding. Saplings of six other species were eliminated. No species represented by trees was completely eliminated in the lower zone although frequencies changed drastically. *Salix nigra* replaced *Acer saccharinum* as the most abundant species.

Change was not as pronounced within the upper level. No species was completely eliminated and frequencies remained relatively constant (Table 2). Total living tree and sapling stems in the upper zone declined 7.1 percent (336 to 312 stems) and 15.2 percent (341 to 289), respectively. Corresponding values for stems within the lower level differ markedly. Living trees dropped 77.3 percent (128 to 29 stems). Cascading effects of the severe decrease in the lower zone can be expected. Some would be the opening of the canopy to enable more light to reach the lower strata, increase in dead material which would serve as a resource for those trophic levels dependent upon that source for nutrient and energy requirements, etc.

Acknowledgments

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A Hypothesis Concerning Vertically-migrating Zooplankton and their Fecal Pellets

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Abstract: Vertical migration and pelletization of feces provide separate, intrinsic evolutionary advantages to zooplankton. Fecal pellets are a valuable source of nutrition, and sink at rates that place them in the depth range of migrators in the daytime. Consequently, migrators at depth can ingest the pellets that were excreted the previous night in surface waters, perhaps providing an important supplement to daily nutrition.

Key words: Copepods, coprophagy, vertical migration.

Zooplankton migrate vertically in many aquatic ecosystems, often spanning a range of tens of meters. In the most common pattern, zooplankton spend the daylight hours deep in the water column, migrate up around sunset, and feed in the surface waters overnight. Near dawn, as ambient light levels increase, zooplankton move back to their daytime dephs (Hutchinson 1967, p.733). Many hypotheses have been advanced to explain the value of this behavior, including the avoidance of visual predators (Zaret and Suffern 1976; Orcutt and Porter 1983; Nesbitt et al. 1996), avoidance of solar radiation (Hairston 1976), optimization of primary production (Kerfoot 1970; Enright 1977), and optimization of assimilation efficiency (McLaren 1963).

Many zooplankton also excrete feces as pellets, encased in mucilage (Turner and Ferrante 1979). These pellets sink at rates that vary widely, but rates of 50 to 150 m/day are commonly reported (Honjo and Roman 1978; Bienfang 1980; Smayda 1969; Paffenhofer and Knowles 1979; Turner 1977). The suggested value of pelletizing feces include reduction of gut abrasion (Forster 1953; Honjo 1976) and the removal of pre-digested material from the feeding zone, where fresh phytoplankton may be more nutritious (Gauld 1957).

Fecal pellets themselves can be nutritious. First, pellets nourish many benthic communities (Bekelmishev 1957; Vinogradov 1962; Newell 1965; Harding 1974). When the shrimp *Palaemonetes* ingests its pellets, it extracts up to 50% of the organic carbon, phosphorus, and protein, while attaining an assimilation efficiency of 78% (Johannes and Satomi 1966). Paffenhofer and Knowles (1979) have raised copepods from copepodid III to adult exclusively on a diet of pellets with a 57% survival rate. In addition, pellets in natural waters may be colonized by bacteria, which could double the nutritive value of pellets (Newell 1965). Strickler (1982) has demonstrated that sinking particles can be easily caught, and coprophagy has been widely reported for copepods (e.g. Frankenberg and Smith 1967; Paffenhofer and Strickland 1970; Harding 1974; Heinle et al. 1977). Honjo (1980) suggested that red pellets,

with few recognizable contents and found in deeper water, may be coprophaged primary pellets. Some migrators feed very rapidly upon arrival in surface waters (Bekelmishev 1957); perhaps the goal of this behavior is to package algae for ingestion the following day.

I propose that, given a migrating population, an additional benefit accrues to pellet producers. Specifically, I hypothesize that pellets excreted overnight become an important food source for migrators at depth during the following day.

An example using reasonable numbers helps explain the hypoothesis. Assume a population density of 1500 copepods/m^3 from 0 to 6m depth, producing pellets from 1700 to 1800 hours at a rate of 8 pellets/copepod/hour (Gaudy 1974). Further assume that sinking rates are normally distributed from 50 to 150 m/d. These pellets sink overnight; around dawn, the copepods migrate downward through the rain of sinking pellets to their daytime depth. Under these conditions, a copepod at 64m deep at 0500 will remain in the rain of pellets for over 11 hours and will experience a maximum pellet concentation of approximately 4700 pellets/m^3. Furthermore, this initial cohort of pellets will be augmented by pellets produced after1800 hours. The resulting rain of pellets, while less nutritional than fresh phytoplankton, nonetheless may provide a valuable supplement to the copepod's diet.

Some field evidence already supports this hypothesis. Williamson et al. (1996) found a three-fold greater mass ingestion rate by *Diaptomus* and *Daphnia* in the metalimnion compared to surface water; other studies have suggested that the thermocline may be a barrier to sedimentation (Hansson 1996; MacIntyre et al. 1995; Haberyan and Porter, in prep) and thus perhaps concentrate fecal pellets. In the North Sea, pellet concentrations generally drop rapidly below the thermocline where copepod concentrations are maximal (Figures 2-5 in Krause 1981).

Vertical migration and pelletization of feces probably evolved independently, and provide their own intrinsic adaptive significance. Once migration and pelletization had appeared, coprophagy allowed more energy gain and hence a selective advantage. Doubtlessly, fresh phytoplankton provide a higher-quality food source, but daytime coprophagy at depth provides a source of nutrition where little else may be available.

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The Effect of Volcanic Ash Influx on the Diatom Community of Lake Tanganyika, East Africa

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Abstract: I examined diatoms in the vicinity of a 56mm ash layer, deposited around 11,850 years ago, in a core from Lake Tanganyika, East Africa, to assess the impacts of ashfall on a large lake. Immediately after the ashfall, diatom concentrations fell by an order of magnitude, and *Nitzschia* dominated the flora instead of *Stephanodiscus*. The strong decrease in *Aulacoseira* abundance suggests that the ashfall probably occurred in the calm season (now November through April). The diatom community had recovered to pre-ash status within a decade.

Key words: Ash, diatoms, Lake Tanganyika, tephra, paleolimnology

Introduction

The western rift valley of East Africa is a fault-bound graben and includes a series of tectonic highlands and large lakes. The largest of the lakes is Lake Tanganyika (Figure 1), over 1470 m deep and containing at least 3 km of sediments (Rosendahl and Livingstone 1983). Reflective layers in these sediments can be quite extensive, and include volcanic ash (Livingstone 1965).

Injections of ash can have a drastic effect on lakes. In a small lake of the Mount St. Helens area, Wissmar et al. (1982a, b) noted a pH decrease from 7.3 to 6.2, and increases of two orders of magnitude in dissolved Mn, Fe, PO_4, SO_3, and Cl ions after the eruption. Biologically, area lakes experienced reduced light penetration and chlorophyll levels, and increased bacterial biomass. Many of these changes are probably due not only to ash, but also to local deforestation. The effect of ashfall alone on larger lakes is unknown.

Modern Lake Tanganyika is very transparent (up to 22m: Beauchamp 1939) and is permanently stratified. The pH ranges from 8.0 to 9.0 and the salinity is somewhat elevated (0.53 ppt: Talling and Talling 1965). The history of the lake includes much lower water levels (at least -300m) around 16,000 years ago, and an episode of increased wind strength or duration in the middle Holocene (Haberyan and Hecky, 1987).

Materials and Methods

Samples were collected from Core T2, a Kullenberg core collected by D.A. Livingstone and R.L. Kendall in 440m of water near the south end of the lake (near 8°30'S, 30°50'E; this is the same core described by Livingstone 1965, and Haberyan

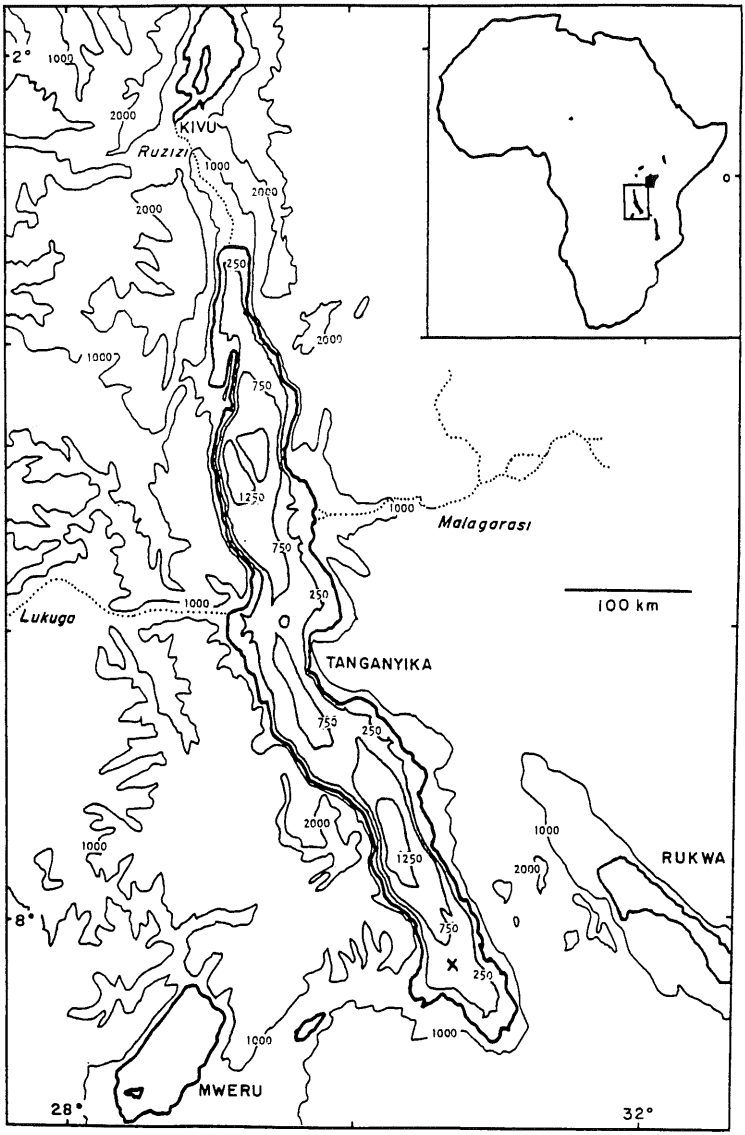

Figure 1. Bathymetric map of Lake Tanganyika, with depth contours in meters. The T2 core site is indicated by 'x' near the southern end.

and Hecky 1987). When sampled, the core was completely dry, and many gaps had developed along bedding planes. Near the middle of the 10.6m core is a 56mm-thick ash layer approximately 11,850 years old (based on a nearby uncorrected radiocarbon date). Six samples were collected in this vicinity, at 10 mm of dried mud below the ash as well as 1, 10, 30, 47, and 74 mm above the ash (Table 1).

Table 1. Diatoms from the vicinity of the ash layer in the T2 core. Relative abundance data are percent of all diatoms.

Sample	Approximate age relative to ash layer	Relative abundance of: *Nitz-schia*	*Stephano-discus*	*Aulaco-seira*	Total diatom abundance (106 valves/gram)
A74	68 years after	13	80	3	35
A 47	43 years after	7	91	2	46
A30	27 years after	13	87	0	150
A10	9 years after	22	74	7	19
A 1	1 year after	67	33	0	3.8
B10	9 years before	33	60	5	30

Samples were weighed and digested with 30% H_2O_2 at 80°C for three hours. After three rinses in distilled water and mixing in a Vortex mixer, subsamples were withdrawn and dried overnight on coverslips. Coverslips were then heated at 200°C for 10 minutes and inverted onto a drop of warm Hyrax on a microscope slide. Slides were counted on a Leitz compound microscope at 400x using methods described in Haberyan and Hecky (1987); at least 300 valves were identified on each slide using Gasse (1986) and van Meel (1954).

Results

Prior to the ash influx (Sample B10: Table 1), the diatoms are typical of the preceding section of the core (Zone A4 in Haberyan and Hecky, 1987), mainly including *Stephanodiscus (S. astraea* and *S. damasii*), lanceolate *Nitzschia* spp., and *Aulacoseira (A. granulata)* (photographs of these taxa are presented in Haberyan and Hecky, 1987). The approximate abundance of valves in sample B10 is 30 x 10^6 valves per dry gram.

Lying atop the ash layer is a 2 mm thick layer that is overwhelmingly composed of lanceolate *Nitzschia* species (67%). This sample, A1, contains approximately 3.8 x 10^6 valves/gram, but ash particles are absent.

The remaining three samples, A10 through A74, strongly resemble the pre-ash sample: dominance by *Stephanodiscus* and at least 19 x 10^6 valves/gram.

Discussion

This ash probably came from Mount Rungwe, approximately 300 km east southeast of the core site. A lava flow on Mount Rungwe has been dated at 11,300 years ago (Crossley 1982), compared to the estimated age of 11,850 for the ash in the core.

This massive influx of ash into Lake Tanganyika had profound, but short-lived, impacts on the diatom community. Diatom concentrations fell by an order of magnitude just after the ash, perhaps a result of decreased light penetration. Although the concentration of *Nitzschia* declined by 75%, it was the most common diatom immediately after the ash.

Theoretically, ash influx should stimulate *Aulacoseira* growth, because ash should increase the ambient concentrations of nutrients, perhaps including silica. However, *Aulacoseira* also requires turbulent water to keep its dense cells in suspension (Lund 1971, Haberyan and Hecky 1987). It seems likely, therefore, the ash entered the lake in the calm season, when the lake's turbulence was insufficient to resuspend and support *Aulacoseira*. It is possible that enough silica was available for *Nitzschia* to outcompete *Stephanodiscus,* but this excess silica did not persist long in the surface waters of the lake. The diatom community seems to have recovered completely within a decade, but the impacts on other organisms is unknown.

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SENIOR DIVISION 1998

Agriculture, Entomology and Herpetology Section

Albrecht, Mark, Gary J. Cwick, and Michael Aide. Department of Geosciences, Southeast Missouri State University. AN ATTEMPT TO MAP FRAGIPANS USING VEGETATIONAL DIFFERENCES AND SATELLITE IMAGERY. Fragipans are silty tectured, subsurface soil horizons that are generally hard when dry and brittle when moist, with a sufficiently high bulk density to restrict the percolation of water and the growth of roots. These soil horizons generally restrict the site index and growth characteristics of forest trees. The objective of this project was to determine the vegetational and soil characteristics of our study area and assess whether tree growth and development is influenced by the presence of fragipans. The study area was located in the Mark Twain National Forest Soils in the study area consisted of two non-fragipan soil series and three soil series with fragipans. Differences in vegetational characteristics were better correlated to soil type than to the presence of fragipans. Landsat TM data were not able to discriminate between fragipan and non-fragipan sites in this case, although it has been successful elsewhere.

Cummings, Mark, and Michael Aide. Department of Geosciences. Southeast Missouri State University. PHOSPHATE INTERACTION WITH CR(VI) ISOTHERMS ON ALUMINUM-INTERLAYERED SMECTITES AND SYNTHETIC ALLOPHANE. Chromium (VI) is the more mobile and toxic species of chromium. Substrates that have a high affinity for Cr(VI) are able to preferentially remove Cr(VI) from the aqueous phase, thereby reducing the potential migration. This investigation describes the infuence of Cr(VI) concentration, pH, ionic strength, and the presence of competitive anions on Cr(VI) adsorption. The substrates used were synthetic allophane, with a 1:1 silica and aluminum ratio, and a smectite, with and without synthetic aluminum interlayers. A batch protocol was used to produce Cr(VI) adsorption isotherms for both substrates. The trends of the isotherms demonstrated that Cr(VI) adsorption, on both substrates, was decreased because of: (i) decreased proton activity, (ii) increased ionic strength, and the presence of phosphorus as a co-solute. The presence of synthetic aluminun interlayers in the smectite greatly increased Cr(VI) adsorption, especially at lower pH levels. The results of this research indicate that when phosphorus is present and/or ionic strength is increased, adsorption of Cr(VI) is decreased. This suggests that the Cr(VI) adsorption has considerable outer sphere character.

Davis, T. and M.A. Wilson. Department of Agriculture, Southeast Missouri State University. PRODUCING ZINNIAS IN A SMALL ECONOMICAL HYDROPONIC SYSTEM. Our studies were conducted in a reserch-dedicated greenhouse at Southeast Missouri (Cape Girardeau), an area with a moderate climate. Styrofoam ice trays, containing four plants each lined with black polyethylene plastic, were used with two nutrient solutions. Nutraculture non-aerated data for stem fresh and dry weights were significantly higher when compared to Hoagland non-aerated plants. Stem fresh and dry weights were higher for Hoagland aerated vs nutraculture aerated. Fresh and dry weights of roots were significantly higher for both aerated and non-aerated nutraculture solutions.

Hope, M.H. and F. Worman. Department of Agriculture, Central Missouri State University. INTENSIVE GRAZING STUDY OF FIVE BERMUDAGRASS CULTIVARS USING THREE TREATMENTS OF ORGANIC FERTILIZER IN WEST CENTRAL MISSOURI. A previous survivability study of five bermudagrass cultivars had demonstrated a significant survivablity of the bermudagrass species in west central Missouri. The cultivars involved were Hardie, Tifton-44, Guymon, Midland, and Quickstand. Three repetitions of each cultivar were established. Each repetition of the five cultivars received a randomly assigned one time application of composted chicken manure. The fertilizer treatments were sixty pounds per cultivar plot, thirty pounds per cultivar plot, and zero pounds per cultivar plot. Using the established research plot, an intensive

grazing study of four rotations using four yearling bull calves was conducted. There was a thirty to thirty-five day rest period between each twenty-four to forty-eight hour grazing session. Two random samples were collected on plant yield and tissue composition for all the cultivars in the three repetitions before each grazing session. Preliminary results using two-way analysis of variance (ANOVA) showed a significant difference in plant yield among the five cultivars in all four rotations ($p<0.05$). A significant difference was also found among the three repetitions for rotations one and three ($p<0.05$). There was no significant difference between the repetitions in rotations two and four. Nutrient composition results were obtained from the tissue samples using a proximate analysis technique. Supported by NRCS.

Lough, Jennifer, and Michael Aide. Department of Agriculture, Southeast Missouri State University. THE APPLICATION OF COAL ASH TO SOIL: A GREENHOUSE EVALUATION. Ash residues from the combustion of coal are increasingly being used as a soil amendment or landfilled. Both alternatives provide environmental risks; however, many ash materials may also supply important nutrients that sustain plant growth. The objective of this study was to determine the suitability of locally generated coal ash as a soil amendment. A laboratory protocol was established to estimate the potential leaching of selected nutrients from the ash and to evaluate the ash in a greenhouse experiment. Neutron activation was used to estimate elemental abundances. Calcium, Mg, K and Na were significantly leached from the ash. The presence of ash in sand dramatically depressed the growth and development of corn (*Zea mays* L.). Boron toxicity was suspected as the major limitation to using coal ash as a soil amendment.

McDowell, Eric, and Michael Aide. Department of Agriculture, Southeast Missouri State University. SOIL GENESIS ON ALLUVIAL FANS IN THE WIND RIVER BASIN IN WYOMING. Three aridisols and two entisols developed on alluvial fans were investigated to determine their carbonate and clay mineralogy distributions. Parent materials for these soils consisted of sandstone and sodic shale. The clay mineralogy of each soil was dominated by smectite, with minor quantities of hydrous mica and kaolinite. The carbonate content was not significantly related to either soil depth or clay content. The presence of argillic horizons in carbonate enriched soils suggests that carbonate deposition in these soils occurred after argillic horizon development. High levels of exchangeable and water soluble Na are likely related to the presence of sodic shale.

Peters, Lisa, and Michael Aide. Department of Agriculture, Southeast Missouri State University. NITRATE MONITORING IN POTATOES. Potato production is an important and relatively recent crop in southeast Missouri. Potatoes are grown on alluvial sands with center-pivot irrigation. The high use of nitrogen fertillizers raises the spector of nitrate contamination of the shallow groundwater. Soil nitrate sampling reveals that large quantities of early applied nitrate are not able to be utilized by the potato crop and are leached below the root zone. Nitrogen fertilization of potatoes may be improved by deferring postemergent N applications until the root system has attained sufficient stature for considerable N uptake.

Rojas, B.L., K. Bacon and F. Worman. Department of Agriculture, Central Missouri State University. THE EFFECTS OF SYNCHRONIZATION PROGRAMS ON CONCEPTION RATES OF ANGUS COWS IN MISSOURI. Conception rate records were compiled on one hundred fifty Angus cows (five to eight years of age) spanning a three year peiod, to determine which management system would produce the highest mean conception rate. Three contemporary groups were studied. These groups were treated as follows: natural service, service by artificial insemination, and a group that was first synchronized and then artificially inseminated. Preliminary data suggests that cows serviced naturally, over a sixty day breeding season, maintained the highest mean conception rate over a three year period, which was 89.6%. This group was followed closely by the group that had been synchronized and then artificially inseminated. The mean conception rate for this group was 87.3% after a sixty day breeding season. Finally, cows that were artificially inseminated maintained a conception rate of 85.3% over a three year period.

Skidmore, Ryan B. and Michael Aide. Department of Agriculture, Southeast Missouri State University. POTASSIUM AND PHOSPHORUS NUTRITION IN RICE. Rice (*Oryza sativa* L.) production requires a consideration of soil fertility, particularly N, P, and K. The objective was to

evaluate the P and K requirements for rice. The research was conducted at the Missouri Rice Research Farm in Dunklin County, Missouri. The field design consisted of 4 rates of K and 2 rates of P in a 4x replicated randomized block design. The rice variety Lamont was planted in 1996 and 1997 and fertilized with potash at 0, 1, 2 and 3 times the soil test recommendations and superphosphate at 0 and 1 times the soil test recommendations. Estimates of population, panicle density, spike development, yield, and elemental concentrations of rice tissues demonstrated that P did not influence any of the yield components. Potassium at twice the recommended rate significantly increased the yield and was economically justified. The K yield advantage was attributed to increases in tillering and spikelet production.

Statler, P., M. Cummings, M. Jarvis, M. Stallins, H. Tibbs, and M. Aide. Department of Geosciences, Southeast Missouri State University. PALEOSOL DEVELOPMENT AND SEISMICITY AS A SOIL FORMING FACTOR. Three paleosols were excavated in a seismically active area adjacent to Commerce, MO. Two paleosols have been classified as being of Pleistocene, while the other paleosol was estimated as Pliocene. These paleosols each present evidence that they have been modified because of faulting, liguification or slumping. The Pleistocene paleosols are buried beneath loess. One palesol has several meters of relatively undisturbed loess, while the other paleosol has a thin, varved loess capping, indicating a possible lacustrian influence. The Pliocene palesol is extensively faulted and has been disturbed by slumping and the emplacement of veins of kaolinitic clay.

Atmospheric Science Section

Leftwich, P.W. National Weather Service, Central Region Headquarters, Scientific Services Division. A MODEL FOR THE LOCAL PROBABILITY OF SEVERE CONVECTIVE STORMS IN THE MIDWEST. In an earlier study, probabilities of severe convective storm occurrence were calculated for local areas near several cities in the Midwest. Probabilities were estimated from past relative frequencies of events within the vicinity (30 nm) of selected cities while these cities were included in Outlooks and Watches issued by the Storm, Predictrion Center (SPC). Via compositing of results from the earlier study, a model was developed for operational estimation of local severe convective storm probabilities throughout the Midwest. As time and space scales addressed by Outlooks and Watches decrease, local probabilities increase. The rate at which local probability increases is affected by the scale of atmospheric forcing that is predominant. Examples of operational applications and associated trends in local probabilities are discussed.

Lupo, Anthony R. Department of Soil and Atmospheric Sciences,University of Missouri-Columbia. CYCLONIC AND ANTICYCLONIC SOUTH AMERICAN COLD SURGES. Few published studies have examined the characteristics of cold air surges in South America compared to those examining, for example, North American cold surges. These studies have associated South American cold surges with strong ridging over the eastern Pacific and South America, troughing over the western Atlantic, and a strong surface anticyclone. However, important cold air surges can occur across Northern Argentina and Southeastern Brazil in the absence of a major surface anticyclone. An example of each type of cold air surge was examined in detail to determine if there was a difference between the fundamental atmospheric dynamics of each and their North American counterparts. Both cases were associated with the downstream development of a surface cyclone. A strong surface anticyclone and the large-scale amplification of the associated upper-air ridge/trough features accompanied the anticyclonic case over South America. These events allowed for the strong equatorward push of cold air over the course of several days. The cyclonic case was associated with a surface cyclone that developed much closer to the coast than in the anticyclonic case. This event was comparatively shallow and of smaller scale than the anticyclonic case and bore a closer resemblance to cold air damming events along the lee of the Appalachian Mountains of North America. Finally, a modeling study suggests that the Andes Mountains and east Brazilian highlands played a key role in funneling the cold air into the South American continent.

McCaskill, J.I. and C.A. Zacher. AERO Research. MEASURING CURRENT VARIATIONS IN THE FAIR WEATHER DIURNAL POINT-DISCHARGE FLUX. *In situ* current measurements of the fair weather point-discharge signal have been made from an ionizing corona point sensor, for a number of clear, wind-free, relatively cloudless days in suburban summer locales. Some of the measurements were recorded by strip chart traces to be shown. Both the diurnal electric evolution and devolution recorded in such a cycle are seen to be gradual, growing from a zero-point (nocturnal) baseline starting at 1200 UTC reaching 25-30 nA near mid-day. Thereafter, these conduction currents, at the point diminish again toward the zero-point, about 0030 UTC. Rapid, highly variable and erratic fluctuations of signal-noise is superimposed on the diurnal curve, and appearing on this instrument somewhat directly proportional to it throughout the day. Signal-noise itself, then, ranges as high as 5-10 nA peak amplitude, again near mid-day. The causes and correlation with other electrical measurements using different means will be commented upon. Overall point discharge current variations can be expected to correspond with potential gradients, e.g. in Vm^{-1} from electric field mill readings over the diurnal cycle.

Biology Section

Brandt, L.S. E. and J.F. Belshe. Department of Biology, Central Missouri State University. DISTRIBUTION AND DISPERSION OF PRAIRIE MOLE CRICKET BURROWS. This study was conducted to determine if the spatial distribution of male prairie mole cricket, *Gryllotalpa major,* burrows at Chapel View Prairie Wildlife Area are organized into leks. Male calling activity was monitored by walking random 10m transects and the burrows of actively calling males were marked. The spatial distribution of burrows was plotted and analyzed on the basis of quadrant counts, nearest neighbor, and expected random frequency distribution in order to determine the level of aggregation and the level of departure from randomness. In all treatments of randomness, the spatial distribution was significantly aggregated ($p<0.05$), suggesting lek behavior. Whether or not these aggregations of burrows represent leks, or just the utillization of available habitat has yet to be determined. Supported by CMSU Willard North Grant, CMSU Biology Alumni Fund, Missouri Department of Conservation, and Sigma Xi.

Carrel, J.E. Division of Biological Sciences, Univesity of Missouri-Columbia. A MODEL SPIDER FOR BIOLOGICAL RESEARCH AND TEACHING. Following two decades of effort, I believe I have found a spider species that can be used for a wide variety of laboratory and field investigations. The spider is *Kukulcania (Filistata) hibernalis*, family Filistatidae, which occurs in the southeastern USA. My criteria for selecting this candidate species, as listed below, will be illustrated and explained in depth during my presentation. 1. Unlike most spiders, *Kukulcania* tolerates the warm, dry conditions that prevail most of the year in classrooms and laboratories. 2. When given a diet of flies, crickets, and mealworms, this spider grows with low mortality from egg to adult. 3. The spider appears to have an annual life cycle, even though females may live for 8-10 years after reaching sexual maturity. 4. Adult *Kukulcania* are large in size; body length is about 2 cm and leg span is 5-6 cm. 5. This spider exhibits complex behaviors, but it is remarkably calm and slow moving. 6. Elegant investigations by molecular pharmacologists have documented that this spider possesses a venom that is toxic only to insects, not mammals, and the fangs of the spider are too small to bite a person, so it is safe around people of all ages. 7. *Kukulcania* produces an ornate, more-or-less permanent web having many bands of "teased" silk that extend radially 15-25 cm from a tubular retreat at its hub. Because so little is known about this species, we have begun a series of projects to learn much more about its genetics, growth, and behavior. I thank the Archbold Biological Station, Lake Placid, Florida for providing facilities for some of my work.

Engle, D.L. and G.J. Schulte. Science Division, Truman State University. CHARACTERIZATION OF TRANSEPITHELIAL MOLECULAR TRANSPORT OF D-GLUCOSE BY INTESTINAL SEGMENTS OF THE BLACK BASSS, *MICROPTERUS SALMOIDES.* This research was undertaken as part of an ongoing program to characterize nutrient absorption mechanisms in the gut of the black (large mouth) bass. Studies conducted included a geography study, temperature study, time study, extracellular space study, kinetic study, competitive inhibition study, metabolic inhibi-

tion study, and a sodium dependency study. Gut segments were incubated in an ambient solution containing a known concentration of ^{14}C labeled D-glucose, usually for 15 min. The pre-incubation ambient solution was assessesd for radioactivity with a Beckman LS 6800 scintillation counter. The post-incubation ambient was assessed for radioactivity and compared to the initial ambient to determine concentration. This was done under a variety of incubation conditions, depending on the particular study. Data from the studies strongly suggest the presence of sodium driven metabolically dependent carrier-mediated absorption mechanism for D-glucose in the gut of the black bass. Studies of this kind will hopefully contribute to a better understanding of optimal environmental conditions for growth and development of one of Missouri's favorite animals.

Hackett, B.J. and J.F. Belshe. Biology Department, Central Missouri State University. TARDIGRADES FROM LICHENS FROM SANDSTONE AND LIMESTONE OUTCROPS. *Parmelia* lichen, a host for tardigrades, was collected from two sandstone and two limestone outcrops on the Springfield Plateau of Missouri during the summer of 1997. This study was conducted to determine whether tardigrade distribution was dependent on substrate type of geographic location. This study suggests that the frequency of individuals and species of tardigrades are greater on sandstone outcrops as opposed to limestone, and that geographic location is not a primary indicator of tardigrade abundance.

Meng, S.W. and R.E. Crumley. Department of Biology, Missouri Western State College. A TEST USING MOTILITY AND ACID PRODUCTION FROM METHYL- α -D-GLUCOPYRANSIDE TO DIFFERENTIATE *Enterococcus casselflavus* and *Enterococcus gallinarum* FROM *Enterococcus faecium* SPECIES GROUP AND *Enterococcus faecalis*. Vancomycin resistant *Enterococcus faecalis* and *E. faecium* are increasingly a major concern in the clinical laboratory, because of the epidemiological ramifications of nosocomial outbreaks that can be devastating due to the opportunistic nature of the organism. *E. casseliflavus* and *E. gallinarum*, though phylogenetically and phenotypically similar to other enterococcus species, are rare causes of outbreaks and more commonly present as normal flora. However, they are difficult to distinguish using conventional biochemical tests. Devriese et al demonstrated that the acidification of Methyl- α -D-glucophranoside by *E. gallinarum* and *E. casseliflavus* but not by pathogenic enterococci, such as *E. faecium* species group can be a differential test. The current test procedure combines a motility test with Methyl- α -D-glucopyranoside containing brom cresol purple in a single tube format. 74 isolates representing 7 species were tested. *E. casseliflavus* and *E. gallinarum* were positive for motility and acid production while *E. faecium* and *E. faecalis* were negative for both tests in this substrate. This combined biochemical procedure is a useful and effective test that can be used in conjuction with routine schemes to aide in the differentiation of pathogenic enterococci.

Plett, J. and J.F. Belshe. Department of Biology, Central Missouri State University. THE EFFECTS OF BURNING ON TARDIGRADES FROM *PARMELIA* SP. LICHENS FROM SANDSTONE OUTCROPS. Six lichens were collected from each of two adjacent sandstone areas. One area had a known recent history of burning. Tardigrades were extracted from each lichen with water over a five day period from round five square centimeter samples, preserved in five percent formalin with phloxine B stain, and identified after being individually mounted in Hoyer's medium on glass slides. More tardigrades were found from the burned than unburned area; however, the tardigrades were distributed more evenly on the lichens from the unburned area. Eight of nine previously reported Missouri species and at least five new species of tardigrades were found.

Raveill, Jay A. Department of Biology, Central Missouri State University. ALLOZYME DOCUMENTATION OF THE HYBRID STATUS OF A RARE PLANT. Allozyme analysis was used to test the hypothesis that *Desmodium humifusum* represents a hybrid between *D. paniculatum* and *D. rotundifolium*. *Desmodium humifusum* exists at only three locations with a total eight genetic individuals. Based on allozyme information, the Rogers genetic similarity of the putative parental species was 0.797 including fixation for different alleles at a single locus, *tpi-1*. All but one individual of *D. humifusum* were heterozygous at this locus, combining alleles unique to both of the putative parental species. *Desmodium humifusum* exhibited an excess of heterozygosity (relative to Hardy-Weinberg expectations) in sharp contrast to the consistent deficiency of heterozygosity in the pos-

sible parental species. *Desmodium humifusum* consists of both F_1 interspecific hybrids as well as later generation hybrids but introgression between the parental species is not apparent.

Conry, D.W., M. Nguyen, D.Cuebas. Department of Chemistry, Southwest Missouri State University. DEVELOPMENT AND OPTIMIZATION OF AN ASSAY OF SCP-2/THIOLASE ACTIVITY IN RAT LIVER. The peroxisome is the site of side-chain shortening of the bile acid precursor 3α, 7α, 12 α-trihydroxy-5 β-cholestanoyl-CoA (THC-CoA) by a β-oxidative mechanism. Sterol carrier protein 2 (SCP-2/Thiolase) has recently been shown to harbor the peroxisomal thiolase activity responsible for cleavage of 24-oxo-THC-CoA to propionyl-CoA and cholyl-CoA. In order to further characterize this enzyme, an assay which is sensitive and specific is needed. We have been developing a method which allows the use of a γ-fraction to provide the enzyme source for an assay of thiolase activity toward 24-oxo-THC-CoA, as measured by a propionyl-CoA production over time. The HPLC method used for this assay is a modification of Demoz *et al.*'s method for measuring short-chain fatty acyl-CoA derivatives in rat liver homogenates. We demonstrate that the assay provides linear, reproducible results for this type of study, and that the method can be extended to allow studies of other enzymatic activities as well.

Chemistry Section

Phillips, C.M., D. Novikov, D. Cuebas. Department of Chemistry, Southwest Missouri State University. THE POSSIBLE INVOLVMENT OF α-METHYLACYL-CoA RACEMASE IN BILE ACID BIOSYNTHESIS. α-Methylacyl-CoA racemase from rat liver peroxisomes is involved in the degradation of α-methyl-branched fatty acids and appears to catalyze the racemization of a wide range of α-methylacyl-CoA derivatives in the α-position. Pristanoyl-CoA (an intermediate in phytanic acid degradation) and trihydroxycoprostanoyl-CoA (an intermediate in bile acid synthesis) are two examples of substrates that the enzyme acts upon. It is not known whether the racemase will act upon α-methylacyl-CoA derivatives in which a β-hydroxyl group occupies the β-position. We investigated whether this enzyme acts upon the substrate 3α, 7α, 12α, 24 ξ -tetrahydroxy-5 β-cholestanoyil-CoA (TeHCA-CoA or 24-OH-THC-CoA) interconverting the α-methyl position. The racemase enzyme interconverted (24R,25S)-TeHCA-CoA to (24R,25R)-TeHCA-CoA and (24S,25R)-TeHCA-CoA to (24S,25S)-TeHCA-CoA. The results suggest that the racemase enzyme is not affected by the presence or absence of a hydroxyl group at the β-position. The significance of these results suggest that the racemase can participate as an auxiliary enzyme in an alternative pathway of bile acid biosynthesis.

Schwarz, R.M. and R.L. Smith. Department of Chemistry, Missouri Western State College. RECENT DEVELOPMENTS IN SPMD TECHNOLOGY. We have used semipermeable membrane devices (SPMDs) as bioaccumulators of environmental contaminants in aqueous media in a number of research studies throughout the world. These devices have proven to mimic biological systems by providing a measure of bio-available pollutants in both fresh and salt water. This is best explained by the fact that the SPMD has transport corridors similar to the membranes in human lungs and fish gills and the potentially toxic uptake of compounds in both systems is based on natural passive transport mechanisms. In addition, SPMDs have shown to be potent air samplers, even sequestering PCBs from the atmosphere. The use of SPMDs for bioconcentration of air-borne pollutants could be a breakthrough for air monitoring. We have participated in research and monitoring studies in such places as Nevada, Australia, Antartica and Missouri. Results of bioaccumulated contaminant residues for PAH's, PCB's, and OC's will be presented.

Computer Science Section

Naugler, David R. Department of Computer Science, Southeast Missouri State University. ANYTHING BUT C (ANYTHING BUT JAVA (ANYTHING BUT SCHEME . ..) ...) ...: PROGRAMMING LANGUAGES AND THE UNDERGRADUATE COMPUTER SCIENCE CURRICULUM.

Discussions about which programming language to use for the introductory classes and which programming languages a computer science graduate must know often generate a lot of heat, even religious fervor, and little illumination. The following questions will be addressed. Does one's first programming language really make a difference? How much importance should be placed on the (current) marketability (local and otherwise) of a language? on the features it possesses and the programming paradigm(s) it supports? on the kinds of systems it is available for? on available tools? on the available environments? on the ease of learning it? on its academic popularity? on what "everybody else" is using? on the interests and background of the faculty? on the kinds of applications it is best suited for? How much programming language variety is required in the education of a well-rounded computer science graduate?

Sanderson, Peter. Department of Computer Science, Southwest Missouri State University. CONSIDERATIONS AND A SURVEY FOR A PRE-CS 1 COURSE. Computer science majors and potential majors bring a diversity of computer skills to the introductory computer science course (CS 1). If the course is simplified to accommodate those with little or no exposure to programming or computer science, the other students will not be sufficiently challenged. If not, those with fewer skills are unlikely to successfully complete the course. Various solutions are possible; we have chosen to propose a course entitled "The World of Computer Science." This is not a "computer literacy" course, it is intended for those students interested in computer science who desire an introduction to the discipline but do not yet have the skills to succeed in CS 1. I have conducted a survey of other universities offering a CSAC/CSAB-accredited computer science program, to determine how or whether they have approached this problem. Results of the survey, which was conducted entirely by searching the departments' Web sites, suggest that many have taken an approach similar to ours.

Vollmar, K.R. Computer Science Department, Southwest Missouri State University. MAXIMUM NUMBER OF GRAPH EDGES WITH RESTRICTIONS ON CYCLE LENGTH. This paper considers the problem of finding the maximal number of edges in a connected graph, with restrictions on the length of every cycle in the graph. The length of each cycle in the graph, relative to some specified constant, must be less than the constant, equal to the constant, or greater than the constant. We present theorems which determine the maximal number of edges in a connected graph for the first three cases of cycle lengths relative to the specified constant.

Wang, Y. Department of Computer Science, Southwest Missouri State University. AN ALGORITHM TO FIND THE AXIS OF A CHROMOSOME. Chromosomes are the primary objects studied in cytogenetics. Recent efforts have been devoted to automating the analysis of banded metaphase chromosomes by computers. A chromosome is a nearly symmetry rod measured along with the chromosome's longitudinal symmetry axis. Therefore, finding this axis is a necessary precursor to making those measurements. There are many different algorithms for finding the symmetry axis. The existing methods, however, are prone to error in a significant number of cases and axis finding is still an unsolved problem.. In this paper, a new algorithm for finding the axis of a chromosome, which makes use of the "local symmetry property" of an object, is described. This algorithm assumes that the boundary of an oblong object is known. The results of the experiments show that the algorithm works well both for straight and bent chromosomes. Since the aslgorithm is based on the geometric properties of an object rather than its biological properties, it is not only used for chromosomes. It can also be used to find the axis of any other oblong object.

Conservation Section

Ashley, David C. Department of Biology, Missouri Western State College. THE HAWKMOTHS (LEPIDOPTERA: SPHINGIDAE) ASSOCIATED WITH THREE PRAIRIES IN NORTHWEST MISSOURI. Studies in 1989, 1995, and 1997, focused on the natural history of an endangered prairie orchid (*Platanthera praeclara*) found at three locations in northwest Missouri. Insect collections were conducted during studies on the pollination biology of the orchid at Helton Prairie Natural History Area (Harrison Co.), Tarko Prairie Natural History Area (Atchison Co.) and Little Tark

Prairie (Holt Co.). Moths were collected from light traps (black-light bucket traps and mercury vapor sheet traps) during several visits to each prairie. Fifteen species of sphingid moths were collected during the course of the study. Three of these species *(Darapsa myron, Laothoe juglandis,* and *Pachysphinx modesta*) were only collected at traps utilizing the mercury vapor lamps. The most common hawkmoth encountered during the study was *Ceratonia hageni.* The hawkmoth diversity and abundance at Helton Prairie seemed greater than at either of the other two prairies which were sampled. Two species *(Sphinx eremitis* and *Sphgecodina abbottii)* were only collected at Helton Prairie during the study. This study was funded in part by the MDC Natural History Small Grants Program and by a Professional Development Grant from the MWSC Division of Liberal Arts and Sciences.

Boyles, P.A., C.D.Chevalier, T.J. Crider, S.P. Dhakal, J.E. Hernandez, T.H. O'Donnell, K.E. Pugh, T.L. Riehle, M.R. Showers, C.M. Uliana. Department of Biology, Missouri Western State College. PRELIMINARY SURVEY OF THE SMALL MAMMAL COMMUNITY AT STARR SCHOOL HILL PRAIRIE CONSERVATION AREA, ATCHISON COUNTY, MISSOURI. The purpose of this study was to inventory the small mammal community at the Starr School Hill Prairie Conservation Area. We sampled the small mammal community during two weekends (26-28 Sepetmber and 10-12 October, 1997). We sampled by trapping, direct observation, and indirect observation (such as sound, burrow type, runways, tracks, scat, etc.). We trapped for a total of 1040 trap-nights, caught 73 specimens, and documented the presence of 5 genera: *Blarina brevicauda* (number traped [n] = 6; relative density [RD] = 0.08); *Didelphis virginianus* (n = 6; RD = 0.08); *Peromyscus sp.* (n = 45; RD = 0.62); *Procyon lotor* (n = 2; RD = 0.03); *Reithrodontomys megalotis* (n = 12; RD = 0.16); *Sylvilagus floridanus* (n = 2; RD = 0.03). Simpson's and Shannon's Diversity Indices were 2.4 and 0.5, respectively. We also noted the presence of *Sciurus niger* (direct obs; several); *Sciurus carolinensis* (direct obs. several); *Odocoileus virginanus* (indirect obs., bed sites, scat, tracks and teeth marks at mineral lick); and *Microtus ochrogaster* (indirect obs., runways). This survey is the beginning of a long-term monitoring effort of the mammal community at this site.

Brunette, J.J., C.D. Chevalier, B.D. Davidson, B.J. Fisher, M.R. Johnson, J.W. Neely, S.P. Norman, A.M. Pranschke, V.R. Sample. Department of Biology, Missouri Western State University. PRELIMINARY SURVEY OF BOTFLY PARASITES OF SMALL MAMMAL SPECIES AT STARR SCHOOL HILL PRAIRIE CONSERVATION AREA, ATCHISON COUNTY, MISSOURI. The purpose of this study was to document occurrence of botfly parasitism in the small mammal community at the Star School Hill Prairie Conservation Area in northwest Missouri. This study was conducted as part of an overall survey of the small mammal community at this site. We sampled the small mammal community during two weekends (26-28 September and 10-12 October, 1997). We sampled by trapping (live and snap traps) for a total of 1040 trap-nights. Of the 6 genera documented (*Blarina, Didilphis, Peromyscus, Procyan, Reithrodontomys,* and *Sylvilagus*) specimens representing two (*Peromyscus* and *Sylvilagus*) contained botfly larvae. *Sylvilagus* was represented by one specimen and was prasitized by one botfly larva, located subcutaneous at the base of the neck above the sternum. *Peromyscus* was represented by 45 specimens, 19 (42%) of which contained botfly larvae. All parasitized *Pereomyscus* specimens had botfly larvae located in the inguinal area, however one individual also contained a larva in the shoulder area. Among *Peromykscus*, mean parasite load was 1.4 (SE = 0.14) botfly larvae per individual. Mean parasite load of male *Peromyscus* (1.7; SE = 0.29) was not significantly different than that of females (1.3; SE = 0.13).

Corman, A.M. and L. S. Ellis. Division of Science, Truman State University. FACTORS AFFECTING NEST SITE LABILITY IN THE SOUTHERN FLYING SQUIRREL, *GLAUCOMUS VOLANS.* Southern flying squirrels, *Glaucomys volans*, are known to shift nest sites frequently within a home range. To view lability in a cost-benefit framework, a systematic analysis of environmental pressures on short-term nest changes is warranted. This study aims to characterize the effect of predation on the timing and position of movements for nocturnal *G. volans*. Five squirrels were radiotracked daily in northeast Missouri to locate nest sites. After two weeks, three great horned owl (*Bubo virginianus*) decoys were placed around each squirrel's nest site, and a recorded mixture of great horned owl and barred owl (*Strix varia)* sounds was played daily at each squirrel's nest site for 30 minutes at dusk. This simulated increased predation continued for another two weeks. Switching, location, and characteristics of the nest sites, as well as home range attributes, were compared

betwen the treatment and control periods. Characterization of the timing of squirrel movements was also attempted using nightly weather and light levels.

Elliott, William R. Natural History Section, Missouri Department of Conservation. THE HISTORY OF CAVE CONSERVATION IN MISSOURI. This paper will detail cave conservation work by cave owners, cavers, state and federal agencies, and others over the last 70 years. Most early efforts were directed towards protecting cave aesthetics, but by the 1970s more consideration was given to endangered bats and cavefish. The earliest cave gates were crude, jail-cell designs. The latest gates are massively strong while still allowing the free flow of bats and air. There is increasing attention to management of whole karst areas and groundwater. The Missouri Department of Conservation has created a cave biologist position to provide many functions, including a more thorough inventory of the state's cave fauna, cooperative work on cave management, and a revision of the cave classification scheme and cave management policy.

Frucht, S.S. Department of Biology, Northwest Missouri State University. USING A CAMPUS TREE WALK TO STIMULATE OBSERVATIONAL AND CRITICAL THINKING SKILLS. Although biology is the study of living organisms, too often instructors have no choice but to use preserved specimens to teach about life. However, the trees in one's local environment can be used as a living laboratory to produce a laboratory exercise that is pedagogically sound, as well as fun and interesting. This exercise was developed for use in Northwest's Genereal Biology laboratory course using the trees on campus. While learning the basics of tree identification, students develop their observational, classification, measuring, communication, and inferring skills. The class begins with a guided tree walk with the instructor using various trees to illustrate easily observed characteristics. Then, each pair of students is assigned an unknown tree to independently observe and measure. Finally, students determine the identity of their tree using their recorded quantitative and qualitative data to answer questions on a dichotomous key. Not only are students introduced to the trees in their immediate environment (while honing their basic science process skills), they gained the ability to apply that knowledge to a specific example, as well as a new and hopefully life long awareness of the trees around them.

Gasper, B. and J. Grant. Biology Department, Missouri Western State College and Centre for Rainforest Studies, Queensland, Australia. THE EFFECT OF RAINFOREST REESTABLISHMENT ON INVERTEBRATE COMMUNITIES IN FOUR RESTORATION PLOTS ON THE ATHERTON TABLELAND. The destruction of the Wet Tropics region of Northern Queensland, Australia has surely led to the demise of hundreds of undescribed species. Tropical reforestation will hopefully encourage the recolonization of other species, including invertebrates, into these areas. The purpose of this study was to compare the invertebrate communities in four sites on the campus of the Centre for Rainforest Studies. Measurements of diversity and sample size and composition were analyzed to determine the similarities and/or differences between the sites. Statistical significance was on the basis of the T-test for Diversity Indices ($p=0.05$) and the Rank Sum Test ($p=0.05$). The hypotheses tested were: 1) the species diversity will be similar in the three reforested plots, 2) there will be a difference in diversity between the reforested plots and the nonreforested plot, and 3) the invertebrate populations will be greater in the reforested plots when compared to the nonreforested plot. Analysis revealed there was a significant difference in diversity among the reforested sites not supporting hypothesis #1. There was a significant difference between the reforested sites and the nonreforested site supporting hypothesis #2. Lastly, the reforested sites yielded larger invertebrate communities than the nonreforested site supporting hypothesis #3.

Goldman, P.C., and L.S. Ellis. Science Division, Truman State University. STUDYING COMMUNITY ECOLOGY OF BIRDS IN THE CHIRICABUA MOUNTAINS OF SOUTHEASTERN ARIZONA. We provided students with the opportunity to participate in research on community ecology in two bird communities in southeastern Arizona. Prior to departure, students read and discussed original and review articles on processes that affect community organization. We talked about how we might characterize species' niches and their distinctiveness within avian communites. We also thought about how niche breadths and overlaps might vary between the focal communities: a riparian forest at 1615 meters elevation and an old growth pine forest at 2590 meters. In the

Chiricahuas, we camped in a primitive national forest campsite near our study sites. Days were spent in small groups at the study sites obtaining data on foraging patterns for about 35 bird species. We also quantified habitat characrteristics. After about ten days, we traveled to the Sonoran desert near Tucson and then to the North Rim of the Grand Canyon. Here students were given questions to address based on data obtained in the Chiricahuas. Students presented their analyses in this grand location. We hope that our students emerge with both a better understanding of science and a more profound love for the biosphere.

Janowski-Bell, M.E., L. Trial, H. Mattingly, and J. Carrel. Department of Biological Sciences, University of Missouri-Columbia. A CONSERVATION PLAN FOR *GLIPHOPSYCHE MISSOURI* (INSECA: TRICHOPTERA: LIMNEPHILIDAE). The Missouri glyphopsyche caddisfly, *Glyopsyche missouri* Ross, is a highly localized caddisfly whose world wide distribution is limited to a single locality, Maramec Spring and its spring branch, in Phelps County in the Ozark Uplands of Missouri. It was a federal candidate (C2 status) for listing under the Endangered Species Act of 1973, and its status in Missouri is endangered. Our objective was to create a recovery plan whose implementation would maximize the likelihood of *G. missouri*'s short and long-term survival in the wild by 1) protecting the Meramec Spring ecosystem and recharge zone; 2) detemining the ecology of *G. missouri,* 3) developing proactive measures to respond to natural and anthropogenic disturbances: 4) implementing a public relations and education program. Meramec Spring and the spring branch are currently owned and operated by the James Foundation, and the Missouri Department of Conservation (MDC) operates a fish hatchery on the site. Potential threats to the population include: strong lighting in the area, use of electric insect killers in the campgrounds, predation by trout, potential impacts of anglers, threats to water quality. However, several recovery acions have been accomplished: fishing is not allowed along much of the spring branch or the Spring proper, on-site naturalists are in place, MDC and James Foundation have a good working relationship, the recharge zone has been determined, the James Foundation has started a public relations campaign regarding water quality.

Nulph, R. and D. Ashley. Instructional Media Center and Department of Biology, Missouri Western State College. MWSC CLASS (NATURAL HISTORY OF SAN SALVADOR) GOES TO THE BAHAMAS. This Video Poster will be shown as a presentation in the Conservation Section's Special symposium: extending the boundaries of the biology Classroom. The video documents a class visit in 1998 to the Bahamian Field Station on San Salvador Island. During the trip to the Bahamas, participants visited coastal coppice assemblages, sea grass beds, patch reefs, lateral branch caves, mangrove lagoons, rocky intertidal habitats, and hypersaline inland lakes. Certified divers were able to complete several shallow water dives and participated in a deeper wall dive which was scheduled through a local dive shop. The class visit provided the basis of a promotional video prepared for the Bahamian Field Station by MWSC Instructional Media staff.

Nulph, R. and D. Ashley. Instructional Media Center and Department of Biology, Missouri Western State College. BIOLOGY OF BELIZE: MWSC TOUR 94. This video poster highlights the activities of a group of Missouri Western State College students and faculty during an extended field trip over Spring Break in 1994. The class visited several aeas in Belize, Central America during their travels. Video and still photography are presented in this short video which will be shown as a poster in the Conservation Section's Special Symposium: Extending the Boundaries of the Biology Classroom. Special coverage in the video poster will include class activities while camping at Monkey Bay Wildlife Sanctuary, caving in Petroglyph Cave, sightseeing at the Belize Zoo, visiting Mayan ruins, visiting the Baboon Sanctuary, and snorkeling at Ambergris Cay. Students conducted several research projects during the trip.

Nulph, R. and D. Ashley. Instructional Media Center and Department of Biology, Missouri Western State College. MWSC MARINE BIOLOGY CLASS VISITS HOFSTRA UNIVERSITY MARINE BIOLOGY LABORATORY. During spring semester of 1997, MWSC offered a Marine Biology course to interested students. Participants in this class met one night weekly throughout the semester to participate in lectures, discussions, demonstrations and to view educational videos on marine habitats. This video poster highlights the activities of the group during their trip to the

Hofstra University Marine Laboratory in Jamaica over Spring break in 1997. During our trip to Jamiaca, we visited sea grass beds, patch reefs, mangrove lagoons, rocky intertidal habitats, and tropical caves. The class visit provided the basis of a promotional video prepared for Hofstra University by MWSC Instructional Media staff. This video will be shown as a Video Poster in the Conservation Section's Special Symposium: Extending the Boundaries of the Biology Classroom.

Powell, R., S.S. Dagett, and G.K. Fitch. Department of Natural Sciences, Avila College. EXTENDED FIELD TRIPS IN THE BIOLOGY CURRICULUM AT AVILA COLLEGE. Extended field trips allow students to focus on selected content and methods in the context of an ecosystem and/or culture different from that with which they are most familiar. This results in a level of concentration and creates perspective not otherwise possible. Based on our own very positive experiences as a student, we have been taking students on extended field trips since 1976, visiting locales throughout the United States, Mexico, and the Dominican Republic. Early trips focused primarily on the experience itself, examining and becoming familiar with the flora and fauna in the context of physical conditions. Though fun and educational, the learning potential went underutilized. Subsequent trips addressed this concern to a considerable degree by being organized around a question that students addressed via collaborative investigations. External funding in recent years has made it possible for participants to develop and implement individual projects. We have established courses designed around trips and have also allowed students to use results of their work on trips to meet requirements of our capstone Research & Seminar courses. The general and professional sophistication of students who have participated in extended trips suggests that experiences based on either or both the collaborative or individual models should be incorporated into undergraduate curricula whenever possible.

Powell, R., G.K. Fitch and S.S. Daggett. Department of Natural Sciences, Avila College. LOW COST USE OF CAMPUS RESOURCES FOR INVESTIGATIVE MODULES IN GENERAL BIOLOGY LABORATORIES. In the context of curricular changes involving an active-learning emphasis in introductory biology courses, the faculty have begun to develop and implement investigative modules for General Biology. This is the first course taken by freshman science majors. The first module to be developed will involve hypothesis testing by teams of students using ecological sampling methods to ascertain differences between two study plots at different successional stages. The development of these study plots on campus has been approved by the administration, the sites have been identified, and the module will be implemented initially in the fall semester 1998. Considerations for plot development included aesthetics, reactions by neighbors, and costs of implementation and maintenance, as well as scientific suitability and location. In the first year, successional stages will differ by only three months, but manipulation of one plot will allow for a one-year differential in subsequent years. Because succession will be allowed to proceed in subsequent years, data from earlier investigations can not be used repeatedly and may actually allow for additional comparisons over time. Students in an interdisciplinary environmental issues course will be developing an environmental impact statement on establishing these plots

Reihle, T.L., T.A. Reihle and C.D. Chevalier. Department of Biology, Missouri Western State College. BAT FORAGING FREQUENCY AROUND TWO DIFFERENT TYPES OF ARTIFICIAL LIGHT SOURCES.. The purpose of this study was to test the hypothesis that different types of artificial light sources have no effect on behavior of foraging bats. We counted visits of foraging bats around two different types of artificial light sources (common mercury-vapor and sodium-vapor street lights) simultaneously during a standardized time period (approximately 2000 hrs - 2200 hrs) nightly. We counted bats in two types of study aeas, an urban site (Cameron, Missouri) and a rural site (Wallace State Park, outside of Cameron). Mean nightly feeding frequency at the urban site was 15.7 (SE = 0.64) around mercury-vapor lights and 2.8 (SE = 0.18) around sodium-vapor lights. Mean nightly feeding frequency at the rural site was 35.8 (SE = 2.19) around mercury-vapor lights and 2.7 (SE = 0.19) around sodium-vapor lights. Mean nightly feeding frequency varied with the weather, but was significantly higher around mercury-vapor lights ($p<0.001$) at both study sites. Our results suggest that types of light sources used in habitat alteration such as street lights, parking lot lights and security lights affect bat foraging behavior. The observed changes in bat foraging

behavior may be due to direct effects of the different light sources upon the bats themselves or be due to the light sources being differentially attractive to the flying insects that the bats hunt. Understanding the effects artifical lighting souces have on prey behavior and/or bats themselves offers the potential for enhancing bat habitat simultaneously to meeting people's needs for lighting.

Robbins, D.J., C. Chevalier, B. Fulton, D. Roberts and R. Bell. Department of Biology, Missouri Western State College. A SEVEN YEAR SUMMARY OF WHITE-TAILED DEER REPRODUCTIVE DATA FROM PRIMITIVE WEAPONS HUNTS AT SQUAW CREEK NATIONAL WILDLIFE REFUGE. One hundred fifty pregnant uteri were collected from white-tailed deer (*Odocoileus virginianus)* during the January primitive weapons hunts at Squaw Creek Refuge from 1988 to 1998. Does were aged and weighed, and embryos were aged utilizing forehead-rump length, weight, and physical characteristics. Sex ratios, productivity, approximate conception and birth date data were calculated.

Rushin, A.J., R. Nulph and J.W. Rushin. Communications and Biology Departments, Missouri Western State College. A STATE OF HARMONY. A 12-minute videotape that highlights the current conservation education opportunities at Missouri Western State College's Biology Study Area (BSA) and the Missouri Department of Conservation's Northwest Missouri Public Service Center that was constructed adjacent to the BSA in 1991. The Service Center includes fully-equipped classrooms and research lab facilities managed by the Biology Department at MWSC. It also includes meeting rooms, an interpretive center, research labs and offices, managed by MDC personnel. This videotape explains the diverse natural habitats and evidences of ecological succession that can be experienced on a self-guided interpretive trail in the BSA. It also explores how MWSC faculty and students have cooperated with MDC personnel to produce innovative programs and other developments.

Rushin, J., T. Ripperger, R. Green, and D. Ashley. Department of Biology, Missouri Western State College and Missouri Department of Conservation. BUILDING CONSERVATION PARTNERSHIPS: THE MISSOURI DEPARTMENT OF CONSERVATION PUBLIC SERVICE CENTER ON THE CAMPUS OF MISSOURI WESTERN STATE COLLEGE. In 1991, a unique conservation partnership was established with the dedicationof the MDC Public Service Center on the campus of Missouri Western State College. The construction of this facilty was a result of a collaborative effort among members of the Missouri Department of Conservation and administration and faculty of MWSC. The placement of this building on the college campus provides easy access for MDC educational programs to the college's 25 acre Nature Study Area and to several ponds on campus. The MDC headquarter facility provides MWSC with additional teaching classsrooms, research laboratories and storage space. Equally as important, the proximity of the MDC Regional Headquarters has facilitated a variety of innovative programs and student employment opportunities for MWSC. The authors will discuss the history of the partnership and present case studies concerning the unique benefits of the collaboration which have been realized by MDC and MWSC.

Weaver, J. and S. Heyman. Division of Biological Sciences, University of Missouri-Columbia. SIZE, ABUNDANCE AND RICHNESS PATTERNS IN A LEAF LITTER COMMUNITY. Community ecologists are interested in how size, abundance, and richness in a community are related. We report here on three patterns in Ozark forest leaf litter arthropods, which range from 0.2 mm to 5 cm, sizes under-represented in the literature. We collected 128 0.05 square m leaf litter samples, extracted the arthropods in Tullgren funnels, sorted them into morphospecies, and then counted and masured the individuals in each morphospecies (32,000 individuals and 547 morphospecies in 22 orders). 1) When the number of species in a size class is plotted against size (in mm), the modal size class is usually 1-5 mm, with species richness decreasing for both larger and smaller size classes. We found a similar result, which confirms that below 1-5 mm, richness decreases as size decreases. 2) When the abundance of a species is plotted against its size, abundance typically goes down as size goes up. When we poltted abundance vs. size, we found no consistent pattern. While abundance did decrease with size, many small animals also had low abundances. 3) Competition between closely related species may be reduced if those species are different sizes. We reasoned that if species length were plotted vs. species rank (by size) for selected groups, that the slope of the line for each group might indicate competition among its members. Our data suggest that the more similar

members of a group are, the greater the size difference in species. Supported by the Missouri Department of Conservation.

Engineering Section

Cox, N.R. Department of Electrical Engineering, University of Missouri-Rolla. PREDICTING THE PERFORMANCE OF TWO-WAY RADIO ANTENNAS ON IRREGULARLY-SHAPED LAND VEHICLES. Two-way radio antennas on trucks, vans and sport-utility vehicles are often mounted with convenience and aesthetics in mind. This raises the question as to how effective some locations can be in providing a useable reception and radiation pattern. To partly answer this question, a powerful simulation program known as the Numerical Elctromagnetics Code (NEC) was used to evaluate popular antenna locations on a generic late-model pickup truck body. The vehicle was modelled as a three-dimensional strucutre of short segmented wires. A simple $\lambda/4$ whip antenna was assumed for the test antenna. Transmission frequencies of 7.2, 14.2, 27 and 144 MHz were used to generate and plot three-dimensional radiation patterns. It was generally found that if the transmission frequency is high enough, the truck body serves as a suitable ground plane. A cab-mounted antenna can provide a fairly omnidirectional pattern, although other locations result in highly-directive patterns. In fringe areas, this can be advantageous. For frequencies below 27 MHz, rear-mount locations can improve antenna loading.

Sauer, H.J., Jr. Department of Mechanical and Aerospace Engineering and Engineering Mechanics, University of Missouri-Rolla. INDOOR AIR QUALITY AND ENERGY EFFICIENCY WITH THE VARIABLE AIR VOLUME SYSTEM. Since the energy crisis of the 1970s, variable air volume (VAV) systems have become the most widely used type of heating, ventilating, and air-conditioning (HVAC) system for commercial buildings. Unfortunately, with this type of system,. the amount of ventilation air usually decreases as the heating/cooling requirements for the building decrease with resultant incidents of sick building syndrome and building related illness. The widely used control strategies all have been shown to have serious deficiencies related to providing good indoor air quality, maintaining building pressure within limits set by the Americans with Disabilities Act, and/or minimizing the energy required for the HVAC system. This study was conducted to determine an improved control scheme which will accomplish all of the objectives of a good HVAC system. A method utilizing economizer damper control based on sensing ventilation air flow rate is shown to be superior to previous techniques. In many cases, the new technique can be applied to existing VAV systems with minimal change. Supported by ASHRAE and CIAR.

Varma, V.K. and M. Najafi. Department of Engineering Technology, Missouri Western State College. NEW DEVELOPMENTS IN MICROTUNNELING TECHNOLOGY. Along with tremendous field efforts devoted in the United States by the microtunneling contractors as well as the entire underground pipeline industry, many research and development (R&D) programs have been set up, executed, planned or are currently underway. These programs are conducted by the joint endeavor of the academic institutes, government, engineering societies, and the manufacturers to gain a better understanding of the science of microtunneling, and to advance this technology to a new level. This paper provides a thorough overview of the background and important results of major research projects, and discusses the latest technical advancements in field applications and related engineering practice. In the context of engineering practice, an update on the development of microtunneling standards by the American Society of Civil Engineers is provided.

Geography Section

Carden-Jessen, M.E. Department of Geography, Geology and Planning, Southwest Missouri State University. PREDICTING SOIL LOSS ON OFF-ROAD VEHICLE TRAILS IN SOUTHWEST

MISSOURI. In the mid-1970s, the United States Forest Service began a program of monitoring trails in the Chadwick Off-road Vehicle Use Area of Southwest Missouri for excessive erosion. Fifty trail cross sections were measured in 1991 and again in 1995 to determine which trails required closing. A more proactive approach to trail management would assess the amount of erosion expected in each situation taking into account the slope, trail aspect, hill slope position and depth to bedrock. Although the Modified Universal Soil Loss Equation is designed for use in forested areas, the unique landuse of this area makes its application impractical.

Coyne, S. Department of Geography, University of Missouri-Columbia. THE MEANING OF MAIN STREET IN FULTON, MISSOURI. The purpose of this paper is to provide an analytical interpretation of Main Street. It is identified as both a real and a symbolic landscape. As a place, Main Street is the economic and social center of the American town. As an image, it is an idealized landscape encompassing a blend of American history and attitude. Technological and social changes in the latter half of the twentieth century greatly altered the geography of towns in general and Main Streets in particular. Using Fulton as a model, it was found that through time Main Street as place evolves while Main Street as image persists. The material culture, stability of business types and spatial expression of downtown Fulton are analyzed to distinguish the real from the symbolic. Research tools include written and cartographic histories, formal interviews, casual conversations and observation.

Daugherty, Daniel J. Department of Geography, University of Missouri-Columbia. EVALUATION OF FLOOD EFFECTS ON WETLANDS USING SATELLITE IMAGERY. By 1992, wetland habitat in Missouri was down 87 percent from 4.8 million acres to just over 600 thousand acres. The National Wetland Inventory (NWI), a US Fish and Wildlife Service project, is a national effort to delineate and map wetlands. The NWI wetland mapping utilized high-resolution color-infrared aerial photography to survey the wetlands. Surveying started in the mid-1980s. Because such a prolonged period has passed since the original survey a need has been expresseed by wetland practitioners for updates to the original NWI maps. This paper will explore the use of Landsat Thematic Mapper imagery for delineating and updating NWI maps. The methodology of this study examines the utility of the Normalized Difference Water Index (NDWI) in the delineation and mapping process. This index will be used, in conjunction with the National Wetland Inventory database, to evaluate the change in wetlands in an area near the conflunce of the Missouri and Grand Rivers in central Missouri. This area was infiltrated by major flooding during the flood of 1993. Evaluation of pre-peak-, and post-flood imagery of the area should show massive wetland reorganization.

Diggs, David M. Department of Geography, Central Missouri State University. GEOGRAPHIC INFORMATION SYSTEMS IN THE INTRODUCTORY GEOGRAPHY CURRICULUM: A PILOT PROJECT. The major intent of this project was to assess the value of using Geographic Information Systems GIS)/computer mapping in general education courses for non-majors. During the spring 1996 term one section of World Geography was used for the pilot project and two sections were used as a control group, whereby traditional teaching methods were employed. A preliminary comparison of the pilot and control goups was done using: an assessment exam given at the beginning and again at the end of the semester, student evaluations, comparison of examination and overall grades, and an analysis of student reactions and comments during the semester. Before and after assessment exams showed little difference between the three classes. Mean % grade for the semester was significantly higher for the pilot group (79.94%) versus the control classes (73.63 and 76.17%). The use of GIS/computer mapping at the introductory level may be of greatest value in helping to energize marginal students. Only 3.6% of students in the pilot group obtrained grades of D or F for the semester, versus 28% in the control classes. Supported by Central Missouri State University, Technology Research Grant Program.

Dodds, Charles. Department of Geography/Geology, Northwest Missouri State University. MEXICAN URBANIZATION: TYPICAL, UNIQUE AND CHALLENGING. The process of urbanization in Mexico is in many respects typical of the changes in population location and characteristics in developing nations. The forces that drive urbanization are well known to geographers and other social scientists. However, Mexico's unique geography has produced some interesting variations on the general themes of urbanization in developing countries. The particular issues include Mexico's

physical geography whose specific charcteristics are not shared with any other geographic realm, but the explainable combination of history, culture and geographic location next to the world's largest economy lead to patterns and processes that are indeed unique to this particular region. This paper will examine the issues and results in a key country in the developing economic and political region based on cooperation between western Hemisphere nations.

Schroeder, W.A. and T.A. Nigh. Department of Geography, University of Missouri-Columbia and Missouri Department of Conservation. THE ECOLOGICAL CLASSIFICATION SYSTEM IN MISSOURI. The Ecological Classification System (ECS) is a new method of understanding the geography of the natural environment. It was begun at the national level in the 1980s by the U.S. Forest Service for land management purposes and has since received support and cooperation of other federal and state agencies. It is hierarchical, from continental size ecological units to local units of a few hundred acres of greater ecological homogeneity. Criteria for establishing a region vary with level in the hierarchy. This paper presents the section and subsection levels for Missouri and introduces the next lower level, the land-type association (LTA), currently being mapped.

Geology and Geophysics Section

Baker, J.A. and N.L. Anderson. Department of Geology and Geophysics, University of Missouri-Rolla. DELINEATION OF POTENTIAL MINING HAZARDS USING THE HIGH-RESOLUTION SHALLOW REFLECTION SEISMIC TECHNIQUE, WESTERN ILLINOIS. A limestone mining company in western Illinois was preparing to expand their mining efforts into a previously unmined area. The mining company removes a total of seventy vertical feet of limestone in a room and pillar fashion. The only depth to bedrock data which existed in the study area consisted of five drill holes collected in the 1950s by the USGS. These data presented the possibility of a potentially dangerous bedrock low. Several boreholes were drilled in the area, but greater control was required. A total of five high-resolution reflection seismic profiles were collected in the study area to gain greater control between drill hole locations. The data were acquired in two phases. The first two profiles were 12-fold data and the last three were 24-fold data. These data show a significant drop in bedrock topography representaive of a paleo stream channel or glacial scour. The results of the survey have caused the mining company to alter their previously intended mine development to insure the integrity of the mine.

Berendsen, P. Kansas Geological Survey, University of Kansas. **M.S. Hubbard and J.R. Underwood,** Department of Geology, Kansas State University. EVAPORITE DISSOLUTION IN THE COUNCIL GROVE GROUP OF EASTERN RILEY COUNTY, KANSAS. Permian rocks of the Council Grove Group make up large portions of the bedrock in eastern Riley County. The Council Grove Group is about 180 foot thick and consists of a series of alternating limestones and shales-mudstones that define a number of repetitive depositional sequences ("cyclothems"). The shales are commonly varicolored. Red shales, indicative of an arid, non-marine environment, and limestones, indicative of a generally shallow, marine setting, attest to relatively rapid sea-level changes. During this time the area shifted northward away from an equatorial position resulting in climate change from wet to more arid. This shift resulted in the deposition of evaporite minerals in most of the formations of the Council Grove Group. Well-documented is the 2.5-3 m. thick gypsum bed that occurs locally at the base of the Easly Creek Shale and is being mined near Blue Rapids about 40 miles to the north. Extensive dissolution of these highly soluble evaporite minerals has occurred over time in the shallow subsurface. Intraformational deformation in the lower part of the Easly Creek Shale and the stratigraphically lower Stearns Shale are exceptionally well displayed in a newly exposed outcrop a few miles southeast of Manhattan along Kansas Highway 177. In the outcrop, high-angle normal and reverse faults (displacement generally < 1 m.), imbricate structures, and brecciation show contrasting styles of deformation. Dissolution of evaporite minerals in the Lower Permian also impacts the modern environment (subsidence problems and groundwater quality) in the midcontinent region.

Cifici, E. and R.D. Hagni. Department of Geology and Geophysics, University of Missouri-Rolla. RARE GOLD AND SILVER OCCURRENCES IN THE MINERAL DEPOSITS OF THE EASTERN PONTIDE TECTONIC BELT IN NORTHEASTERN TURKEY. The Eastern Pontide tectonic belt is a polymetallic province that region contains many miineral deposits with diverse sizes and mineralogies. The region has experienced (from Jurassic-Lower Cretaceous to Tertiary): 1) basic volcanism (Lower Basic complex), 2) an acidic volcanism (host for massive sulfide mineralization), and 3) a second phase of basic volcanism (Upper Basic complex). Four major types of gold mineralization occur in the region: 1) massive sulfide, 2) vein-type, 3) skarn, and 4) porphyry-type mineralization. Stratigraphically, the gold-bearing mineralizations are mostly associated with Cretaceous-age rocks. One microscopic and EPMA study indicates that massive sulfide mineralizations contain gold mostly in the form of electrum in grain sizes up to 10 micrometers, usually attached to chalcopyrite or as free grains in quartz, and to a lesser extent as sylvanite in grain sizes up to 5 micrometers and locked mostly with tennantite-tetrahedrite. Gold occurrences in the vein-type deposits of the Upper cretaceous are generally in two forms: 1) electum and as a solid solution component (up to 0.01% in pyrite, chalcopyrite, and stibnite). Silver also occurs in solid solution in tennantite-tetrahedrite. Gold and silver occurrences in the other mineralizations, including skarn and porphyry-type mineralizations, are currently under investigation. Supported by Nigde University in Turkey.

Dennis, W.H., P.S. Mulvany and D.J. Wronkiewicz. Department of Geology and Geophysics, University of Missouri-Rolla. LEAD, PLATINUM, AND PALLADIUM CHRONOSTRATIGRAPHY OF LAKE SEDIMENTS. A 1.4 meter long sediment core collected from Frisco Lake in Rolla, Missouri shows a 137 year record of development within the Rolla area, a pattern of world wide leaded gasoline consumption, and the mid 1970s introduction of automobile catalytic convertors. The sediment core, which is primarily clay and silt sized quartz, was analyized using ICP to determine the concentrations of 34 chemical elements. Dating of the core was accomplished by correlating sedimentological features with anthropogenic events and trends in the elemental concentrations.

Chemical analyses and subsequent dating show that the core contains a temporal sequence of lead concentrations that correlate with the history of leaded gasoline consumption. Lead concentrations show a dramatic increase between 1930 and the mid 1970s, and an overall decrease from the mid 1970s to the present. The lead pattern in Frisco Lake is similar to that found in other lake sediments from different parts of the world. In addition, measureable platinum and palladium concentrations in the Frisco Lake core increase from 1973 to the present. We infer that the platinum and palladium patterns along with the decrease in lead concentrations are related to the introduction of automobile catalytic convertors and phase out of leaded gasoline that occurred in the mid 1970s. These patterns may be a global trend that can be used as a marker bed for dating sediment cores collected in other regions

Dillon, R.W., J.M. Gregg, N.L. Anderson and J.D. Cawlfield. School of Mines and Metallurgy, University of Missouri-Rolla. PRODUCTION AND USE OF DIGITAL AND ANALOG MAPS TO EVALUATE THE ENVIRONMENTAL IMPACTS OF THE SOUTHERN FIRE CLAY DISTRICT OF MISSOURI. Paleosinks developed in Ordovician carbonates of the Southern Fire Clay District of Missouri ae unstable as indicated by recent collapses within mined clay pits. The enviromental impacts manifested by recent clay mining activities combined with the natural geochemical and hydrological processes have increased the instability of specific areas in this karstic region. Digital and analog maps at scales of 1:100,000 and 1:50,000 were produced of the topographic features and distribution of mined clay pits, subsurface rock formations, recent water levels, and surface fractures. Environmental impacts in this soluble rock terrain are evidenced by (1) modification of ground-water levels of the unconfined Ozark aquifer in the study area (slight offset between ground-water divide south of topographic divide) by the geographical distribution of the mined paleosinks (leaking or dry), which can contribute to ground-water contamination, (2) dissolution of dolomitic bedding planes which resulted in thinning and subsidence of subsurface formations due to the thick overburden of Pennsylvanian material, and solution-widened fractures which increases permeable pathways for ground-water flow. (3) collapse of mined clay pits, and (4) modern-day sinkhole subsidence or collapse.

Dudley, M.A. and R.D. Hagni. Department of Geology and Geophysics, University of Missouri-Rolla. GEOLOGY AND MINERALOGY OF THE IRON MOUNTAIN MINE, ST. FRANCOIS CO., MISSOURI. The Iron Mountain mine represents one of six known major iron deposits in the southeast Missouri Iron Metallogenic Province. The orebody forms an inverted cup, contains skarn-like mineralogy, and is hosted by trachytic volcanic flows of Middle Proterozoic age. The ore occurs as massive veins and matrix between brecciated host rock. Original magnetite was subsequently extensively martized. The orebody shows distinct mineral zonation - the eastern portion consists of magnetite, actinolite, and apatite, and the western portion contains martite, andradite, and apatite. Late crustiform, fracture-filling minerals include quartz, specular hematite, calcite, epidote, chlorite, dolomite, fluorite, and a second genereation of magnetite, actinolite, and andradite. New minerals identified include titanite, anatase, potassium feldspar, tellurobismuthite, nickelliferous pyrite, and Mn-bearing calcite. Lineation of actinolite and apatite, and lack of pervasive wallrock alteration, suggest magmatic origin, i.e., the deposit formed from the intrusion of an iron-oxide rich melt. Alteration and oxidation of the early ore/silcate mineralization probably resulted from interactions with a high temperature magmatic-hydrothermal fluid that probably evolved from the main magnetite body or ore system. Through cooling, the ore system eventually evolved into a hydrothermal-dominant system composed of risidual mineralizing fluids and volatiles unused in the early ore/silcate crystallization.

Ethington, R.L. Department of Geological Sciences, University of Missouri-Columbia. PRECURSOR OF *TRIPODUS LAEVIS* BRADSHAW IN HIGHEST LOWER ORDOVICIAN, CENTRAL NEVADA. Ross and Ethington (1991) selected the section at "The Narrows" of Whiterock Canyon, Monitor Range, as stratotype for the basal Whiterockian stage, and placed the boundary at the lowest occurrence of *Tripodus laevis*, which is abundant in the Antelope Valley Limestone. The conodonts of the underlying Ninemile are widely distributed Early Ordovician species in North America. Lack of a precursor of *T. laevis* raised the possibility that it migrated to Nevada, making its correlation suspect. *T. variabilis* (Sergeeva) occurs in the Latorp Stage southeast of St. Petersburg, Russia, together with the most diagnostic species of the Ninemile fauna. This species has been found in the Ninemile in the Antelope Range, 10 miles east of Whiterock Canyon. Thus, a phyletic lineage involving *T. variabilis* and *T. laevis* exists in central Nevada, and supports the reliability of the boundary recognized by Ross and Ethington.

Friesner, J.E. and R.C. Laudon. Department of Geology and Geophysics, University of Missouri-Rolla. DETERMINATION OF THE INFLUENCE OF SURFACE WATERS ON A KARST AQUIFER USING CALCIUM CONCENTRATIONS. Water supply wells for the city of West Plains, Missouri have become contaminated with fecal coliform bacteria during and after periods of heavy rainfall (1-2 inches within a 6 hour period). Because fecal coliform can only survive in surface waters, it is believed that the aquifer, where water is extracted, is under the influence of surface waters. By using calcium ion concentrations, the water quality has been monitored and the data plotted against rainfall data. By analyzing the two curves, the rate of recharge and the recovery time for the aquifer can be determined. Using a Hach Digital Titration kit, 50 ml samples have been analyzed for calcium ion concentrations each day for each of the seven water suply wells in West Plains, Missouri. With forthcoming data, conclusions regarding the correlation between rainfall and changes in calcium ion concentrations can be drawn. It is expected that the calcium ion concentrations of the groundwater will decrease significantly (10 ppm or more) with the increase of rainfall, indicating that the aquifer is being rapidly recharged. Also by calculating the time needed for the calcium ion concentrations to return to baseline, the recovery time for the aquifer can be determined.

George, S.E., T. Aley and A. Lange. QST Environmental, Ozark Underground Laboratory, Karst Geophysics. KARST SYSTEM CHARACTERIZATION. A characterization study was conducted at an industrial facility located in mantled karst terrain. The study components consisted of: (1) a natural potential (NP) and electromagnetic (EM) surface geophysical survey; (2) borehole geophysical logging, and 3) a comprehensive groundwater tracing study utilizing three dyes (Eosine, fluorescein, rhodamine WT). The study was integrated; selectively drilling positive NP anomalies to encounter high permeability flow zones and subsequent downhole geophysical logging utilized to determine specific groundwater production intervals. Monitoring well screens were set in the high

groundwater production intervals. The information obtained was utilized in the placement of dye introduction points and dye sampling stations.

These studies resulted in the development of a comprehensive conceptual model of the site that allowed the assessment of potential environmental impacts. The underlyiing aquifer could be classified as a fully integrated, dispersion flow dominated system with a perennially flooded epikarst. Rapid or distance conduit flow was not encountered. This type of system has generally slow groundwater flow rates, tends to retain constituents onsite, and is amenable to monitoring with groundwater monitoring wells.

Adams, Glendon, Neil Anderson, Jesse Baker, Mike Shoemaker. Department of Geology and Geophysics, University of Missouri-Rolla. THE APPLICATION OF GROUND PENETRATING RADAR TO DELINEATE SUB-PAVEMENT VOIDS ALONG U.S. INTERSTATE 44 SPRINGFIELD, MISSOURI. In May and October of 1997, two ground penetrating radar (GPR) surveys were conducted for the Missouri Department of Transportation (MoDOT), along a 300 meter section of U.S. Interstate 44 approximately 1.5 kilometers west of the Missouri Highway 266 interchange. This section of interstate overlies an active sinkhole and has experienced gradual subsidence as a result of the progressive "washing out" of fine-grained sub-pavement material. The objective of the first survey was to locate voids beneath the pavement with GPR. The survey was a success, the voids were drilled and a lime-mud slury (grout) was injected. The objectives of the second survey were to determine the effectiveness of the remediation method employed and to detect the presences of new voids. Results from the second survey indicate that the grouting program was successful in containing the subsidence features. A GSSI SIR-8 GPR unit combined with a 500 MHZ monostatic antenna was used to acquire the data. The software package Radan II version 3 was used to process the data.

Hagni, R.D. Department of Geology and Geophysics, University of Missouri-Rolla. CHARACTERISTICS OF CARBONATITE-RELATED FLUORSPAR DEPOSITS. Carbonatite-related fluorspar deposits are currently mined at only three localities in the world (maximum productionin tons concentrate/year in parentheses): 1) Okorusu, Nambia (60,000), 2) Amba Dongar, India (20,000), and Mato Peto, Brazil (110,000). The fluorite ores at all three deposits are closely related to carbonatite intrusions, they share some remarkable similarities (they are geological sisters), but they also exhibit some important differences. All of the fluorite ores mined at Amba Dongar are enclosed within carbonatite, about 20% of the ores at Mato Preto are hosted by carbonatite, and none of the commercial fluorite deposits at Okorusu are enclosed by carbonatite. Most of the ores at Mato Preto occur as replacements of syenite. The fluorite ores at Okorusu are hosted by soda fenite, fenitized marble, and marble. Potassic fenitization occurs above sodic fenitization at Amba Dongar, potassic follows sodic fenitization at Okorusu, and only minor fenitization has been detected at Mato Preto. In contrast to the coarse-grained character of most of the fluorite at Okorusu and Amba Dongar, much of the fluorite at Mato Preto is fine-grained and affected by deep lateritic weathering. Supergene colloform fluorite is present only at Mato Preto. Limited fluid inclusion studies show that the fluorite at Okorusu and Amba Dongar was deposited from low temperature fluids, about 150-100°C, whereas Mato Preto fluorite is thought to have been deposited from much hotter fluids, about 400-450°C

Hoffmeister, A.P. and F.E. Oboh-Ikuenobe. Department of Geology and Geophysics, University of Missouri-Rolla. EVIDENCE FOR OFFSHORE TRANSPORT OF ORGANIC MATERIAL AT DSDP SITE 94, GULF OF MEXICO. Deep Sea Drilling Project Site 94 is located offshore in the Gulf of Mexico on the Campeche scarp in a water depth of 1793 m., 600 km. from New Orleans. Six samples from tghe late Oligocene and early Miocene sections of the core have been examined for palynomorphs (dinoflagellate cysts, spores and pollen). A diverse and abundant dinocyst assemblage is present, along with a surprisingly large number of terrestrially derived pollen and spores. Many of the dinocysts are shallow shelf species such as *Hystrichokolpoma rigaudiae* and *Dapsilidinium pseudocolligerum*. Some of the pollen species include *Carya veripites*, magnolia-type pollen and several bisaccate pollen taxa. Of specific interest is the presence of the dinocyst *Tuberculodinium vankcampoae* and *Nypa* pollen which live in coastal areas today. *Nypa* pollen comprises a significant portion (up to70%) of the sporomorph assemblage in the lower three samples whereas the deep water dinocyst *Nematosphaeropsis labyrinthea* is present in the upper three samples.

The palynomorph association shows evidence of significant offshore transportation of organic material from coastal and shallow shelf areas into the Sigsbee abyssal plain.

Holbrook, J.M. Department of Geosciences, Southeast Missouri State University. A PREVIOUSLY MISSED POSSIBLE CONNECTION BETWEEN THE TETHYAN AND BOREAL SEAS OF THE U.S. WESTERN INTERIOR DURING ALBIAN TIME. The study strives to test the hypothesis that the southern (Tethyan) and northern (Boreal) arms of the Western Interior sea connected across modern southeastern Colorado between the Albian Kiowa-Skull Creek and the Cenomanian Greenhorn transgressive/regressive cycles. The hypothesis is supported by mixing of Tethyan endemic (*Neogastroplites)* with cosmopolitan (*Metengonocras*) ammonites in the Boreal Mowry shale during this time interval. As well, the Mowry section correlates southward into a regional (<35,000 km^2), diachronous (99.4 and 98.2 Ma) sequence boundary that separates estuarine from fluvial valley-fill strata of the Muddy/Dakota throughout southeastern Colorado and northeastern New Mexico. The unconformity represents a major northward excursion and retreat of the southern/Tethyan arm of the Western Interior sea toward the northern/Boreal arm during Mowry deposition. These data support the supposition that the northern and southern arms of the Western Interior sea joined during Mowary deposition. It also suggests the possibility that the Mowry transgressive/regressive cycle rivaled the traditional five Western Interior cyclothems of Kauffman both in duration and regional extent. Fully marine facies that would connect the maximum flooding of the two marine arms are possibly represented by this newly mapped unconformity.

Jarvis, M.J. and B.J. Buck. Department of Geosciences, Southeast Missouri State University and **J.C. Witcher**. Southwest Technology Development Institute. QUATERNARY PALEOSPRING DEPOSITS AT SAN DIEGO MOUNTAIN, SOUTHERN NEW MEXICO. Hydrothermal deposits associated with tectonic activity along the Rio Grande rift are common in New Mexico. Paleospring deposits at San Diego mountain are associated with the West Tonuco Fault and were described to determine depositional environment and relative timing. Five facies were described: bedded opaline sinter, opaline cemented alluviaum, thin-bedded opaline sinter, travertine sloping mount/fan, and travertine cascade. Two models were developed to explain the relationship between the facies: 1) Degassing of CO_2 with carbonate precipitation, followed by cooling and silica precipitation downslope. 2) Changing source temperatures and water chemistry over time resulting in travertine deposits overlying various opaline sinter facies.

Kocher, J.A. and R.D. Hagni. Department of Geology and Geophysics, University of Missouri-Rolla. A MINERALOGICAL AND GEOCHEMICAL STUDY OF THE PRECAMBRIAN W-Sn-Ag ORES FROM THE SILVER MINE DISTRICT, SOUTHEAST MISSOURI. The Silver Mine District of Southeast Missouri is a classic example of Sn-W-Ag-F greisen mineralization and alteration. The deposits of this district were initially mined for silver, and subsequently provided the only source for tungsten in the United States during World Wars I and II. Previous petrographic and ore microscopic studies have found 26 ore and gangue minerals deposited from xenothermal-type ore fluids. Fluid inclusion study has determined ore fluid temperatures that range 380°-121°C and salinity values of 5-20% NaCl eq. The current study is centered on a determination of major, minor, and trace element contents in huebnerite from several deposits in the Silver Mine district. Elements under study include Fe, Mn, Zn, Cu, Co, Ni, Pb, and Cd. The results should provide important information regarding the variations in character of the ore depositing fluids, including the variations in Mn:Fe ratios, pH, f_{O2} and f_{CO2}. Similar studies of tungsten deposits in Portugal provided significant data regarding the fluids that deposited those ores. Cathodoluminescence microscopic study of gangue and alteration minerals also is being conducted to gain a better understanding of the character of those minerals that are closely asociated with Silver Mine ores. These studies have been undertaken to obtain a better understanding of the genesis of this subvolcanic "greisen association" ore deposit.

Kim, C.W. and D.J. Wronkiewicz. Department of Geology and Geophysics, University of Missouri-Rolla ALTERATION PHASES OF SPENT NUCLEAR FUEL. Under oxidizing conditions in the presence of ground water, such as at the proposed nuclear waste repository at Yucca Mountain, Nevada, rapid alteration rates are expected for spent nuclear fuel, based upon experimental studies of UO_2 and spent nuclear fuel. The alteration products are primarily U^{6+} phases. The incorporation of fission products (e.g., Sr, Cs, Mo, Se, Tc, I) and actinide elements (e.g., Pa, Np, Am)

contained in spent fuel into the structure of U^{6+} phases will impact upon the release rate of the radionuclides into the environment. The incorporation of Mo into uranyl sheets is a well known example, and it has been shown that the presence of Mo isotope fission products has led to the formation of Mo-bearing alteration phases during the corrosion of spent nuclear fuel ($(Cs_{2-x}Ba_{x/2})(UO_2)_5(MoO_2)O_4(OH)_6 nH_2O$) We will synthesize U^{6+} phases and characterize synthesis products to examine radionuclide incorporation mechanisms and to determine the extent of radionuclide incorporation into U^{6+} structures. Supported by DOE.

Manuel, O.K. and D.E. Ragland. Departments of Chemistry and Geology & Geophysics, University of Missouri-Rolla. HETEROGENEOUS ACCRETION OF THE SUN AND TERRESTRIAL PLANETS. It has long been suspected that the terrestrial planets accreted heterogeneously, beginning with core formation in a central, iron-rich region of the nebula. It is also commonly assumed that the Sun and meteorites, including IAB iron meteorites, formed at about the same time (4.6E9 yrs ago). In view of the tiny fraction of the solar system's cross-section that encompasses the Sun and the four inner planets, we consider the possiblity of heterogeneous accretion of the Sun. We will summarize observations which indicate that the Sun and the inner planets formed heterogeneously, beginning with accretion in a central Fe-rich region. This seems to offer an attractive alternative to the standard solar model's assumption that the Sun began as a fully convective, homogeneous protostar.

Marple, R.T. Department of Geosciences, Southeast Missouri State University. THE "ZONE OF RIVER ANOMALIES" IN THE SOUTH CAROLINA COASTAL PLAIN: SURFACE EXPRESSION OF A BURIED FAULT ZONE? Although the fault(s) responsible for the 1886 Charleston, SC, earthquake have not yet been identified (primarily because of the lack of surface rupture), evaluation of Lansat imagery, aerial photography, and topographic maps have revealed an ≈ 10-15-km-wide, north-northeast-trending zone composed of subtle topographic highs and morphologic changes in rivers that may be associated with tectonic activity. River anomalies observed within this zone include river bends that are convex toward the north-northeast, incised channels, changes in river patterns, and convex-upward longitudinal profiles. Analyses of geologic and geophysical data further indicate that these surface features may be the result of ongoing tectonic uplift along a north-northeast-trending fault zone possibly associated with recent seismicity near Summerville.

Reese, J.F. Department of Geology and Geography, Northwest Missouri State University, and **G.R. Lowell**, Department of Geosciences, Southeast Missouri State University. THE HAWN PARK GNEISS OF SOUTHEASTERN MISSOURI: A MEGA-XENOLITH OF PRE-ST. FRANCOIS TERRANE AGE? Butler Hill Granite (1.48 Ga) hosts a mega-xenolith (40,000 m^2) with penetrative foliation at Hawn State Park, Missouri (37°50'N/90°14'W). The xenolith ranges from granodiorite to gabbro in composition and exhibits mesoscopic schistose, gneissic, and migmatitic fabrics. Microscopic evidence of dynamic recrystallization in samples from the xenolith includes rounded porphyroclasts of quartz and feldspar, deformed twin lamellae, and kinking. U-Pb zircon dating of Hawn Park gneiss yielded an age of 1500 ± 30 Ma (Bickford and Mose, 1975) but is suspect due to potential mingling of zircons representing neosome, palesome, and veinlets of host granite. However, recent Nd data in the St. Francois terrane (SFT) suggest that granites were sourced from juuvenile (≈ 1500 Ma, Nd TDM age) Mesoproterozoic crust possibly derived from accreted terranes on the southeastern margin of Llaurentia. We suggest that the Hawn Park Gneiss is a large migmatized fragment of this older crust transported surfaceward by rising anatectic melts that formed the host granite. In our view, the mega-xenolith is the oldest exposed rock in the SFT. This interpretation is at odds with that of Bickford and Cullers who consider the Hawn Park Gneiss to be a coeval/cogenetic mafic cummulate related to fractionation of 1.48 Ga granitoids of the SFT.

Repke, B.H. and R.C. Laudon. Department of Geology and Geophysics, University of Missouri-Rolla. 3-D SEISMIC METHODOLOGY AND INTERPRETATION OF THE BOONSVILLE GAS FIELD, FORT WORTH BASIN, TEXAS. Over the past 10 years, 3-D seismic has revolutionized petroleum exploration and development. In the past, this technology was incredibly expensive and required the use of large, industry computers. Three-D seismic has now evolved to the point where it is beginning to be available in the university environment. The shear complexity of 3-D seismic presents many problems for any university. As opposed to the petroleum industry, universities lack

training in Three-D seismic and are short on the industry experience needed to quickly master this new technology. The Boonsville Gas Field data set and the GeoGraphix SeisVision software package provide a unique opportunity for geologists to practice with and learn 3-D seismic methods of interpretation. The study area is composed of a 5.5 square mile survey that contains a series of stacked Pennsylvanian fluvial/deltaic stratigraphic traps that are easy to work with using 3-D seismic. The purpose of this project is to examine various methods of interpretation and to master the procedures needed to work with 3-D seismic. This study represents the first attempt at the Univeristy of Missouri-Rolla to integrate modern 3-D seismic technology into the university environment

Roark, M.S., N.L. Anderson and J. Strohmeyer. Department of Geology/Geophysics, University of Missouri-Rolla. APPICATION OF THE GROUND PENETRATING RADAR TECHNIQUE IN THE DETECTION AND DELINEATION OF BURIED HOMICIDE VICTIMS AND EVIDENCE. During the spring, summer, and fall of 1997, grouund penetrating radar (GPR) profiles were acquired across a controlled/simulated homicide site near Rolla, Missouri. In this study, two deer carcasses were buried in separate trenches at depths of 0.53 meters and 0.58 meters, respectively. The objective of the surveys was to demonstrate the utility of the GPR method in a forensic investigation. A GSSI SIR-8 monostatic GPR system was utilized in the data acquisition. GSSI's RADAN I and RADAN for Windows was used to process the radar data. The burial trenches were excavated in compact, clay-rich alluvium. The carcasses were covered with less compacted alluvium. Several interesting interpretations/observations have been made regarding the GPR signatures of the simulated homicide site. More specifically, the radar signatures of the trenches are mostly a function of the fundamental differences between the trench fill and in-situ soils. On the radar profiles, the undisturbed soil is characterized by laterally continuous reflection events. Over time, the signatures of the trenches have changed subtly, due to compaction of the infill sediments and the decomposition of the deer carcasses. In addition to the carcasses, a piece of metal the size of a handgun was buried. The corresponding anomaly on the profile is a high amplitude, hyperbolic diffraction. The ground penetrating surveys were successful. Over the seven month period, there was a notable change in the signature of the burial trench. The surveys have established the ground penetrating radar technique as a useful tool in crime scene investigation for locating buried victims or evidence.

Shaw, A.E., D. Hoffman, N. Anderson, and M. Shoemaker. Department of Geology and Geophysics, University of Missouri-Rolla, and Missouri Department of Natural Resources Division of Geology and Land Survey. A SHALLOW REFLECTION SEISMIC STUDY OF COMPLEX NEAR SURFACE FAULTING AT BENTON HILLS SOUTHEAST MISSOURI. During the summer of 1997, the Department of Geology and Geophysics at the University of Missouri-Rolla and the MoDNR Division of Geology and Land Survey conducted a second phase of a NEHRP-funded, shallow seismic-based study of the Commerce Geophysical Lineament in southeast Missouri, and, more specifically, the southern escarpment of the Benton Hills. The commerce geophysical Lineament is comprised of Quaternary and Holocene faults. These faults were mapped in shallow, excavated trenches by MoDNR/USGS researchers during their 1995 NEHRP-funded geologic investigation of the southern escarpment of the Benton Hills at English Hill. It was our objective using these methods to determine whether the recent faults in the Benton Hills study area are part of a late quaternary fault system located beyond the New Madrid area of active micro-seismicity. This seismic study has proved successful, in that we have been able to demonstrate that the faults are laterally continuous, near vertical, and deep-seated (sub-bedrock) structures. The ongoing reflection-seismic studies of Quaternary faulting in the Benton Hills area is important because we have further established that significant tectonic activity has occurred in southeast Missouri of the New Madrid area of active microseismicity, impling that the earthquake risk in southeast Missouri is greater than generally thought.

Shivdasan, P.A., S.G. Viladkar and R.D. Hagni. Department of Geology and Geophysics, University of Missouri-Rolla. GEOLOGY OF THE CABONATITE-RELATED FLUORSPAR DEPOSITS AT AMBA DONGAR, INDIA. The carbonatite-related fluorspar deposits at Amba Dongar, India represent one of only three localities in the world where such deposits are currently mined. The fluorite deposits are associated with the carbonatite-alkalic magma (nephelinite and phoolite) Amba Dongar complex (about 63 Ma), a subvolcanic diatreme with a ring dike of carbonatite (sovite).

The fluorite ores are not only closely related to carbonatite intrusions, but they are actually hosted by the carbonatite. The nearby sandstones of the Cretaceous Bagh Formation are intensely altered to potassic fenites. The recognition of soda fenites in xenoliths within the carbonatite and deep drilling indicates that near-surface potassic fenites grade to sodic fenites at depth. Most of the fluorite at Amba Dongar is coarsely crystalline and light yellow to colorless, but green, blue, and purple varieties also are present. Minerals that occur with the fluorite include calcite, ankerite, apatite, quartz, barite, pyrite, chalcopyrite, galena, and dickite. Fluid inclusion studies show that the fluorite was deposited from low temperature fluids, about 160-95°C. Research has been initiated to: 1) investigate the trace element contents of Amba Dongar minerals, 2) study the cathodoluminescence microscopic character of the ores, carbonatite, and fenites, and 3) conduct ore microscopic and microprobe examinations of the associated opaque minerals.

Shoemaker, Mike, N. Anderson, J. Baker, A.E. Shaw, D. Webb, and Allen Haltheway. Department of Geology and Geophysics, University of Missouri-Rolla, and **Timothy Newton**, Missouri Department of Transportation. REFLECTION SEISMIC AND GROUND-PENETRATING RADAR STUDY OF PREVIOUSLY MINED (LEAD/ZINC) GROUND IN JOPLIN, MISSOURI. A geophysical survey was conducted for the Missouri Department of Transportation (MoDOT) across previously mined (lead/zinc) ground along a proposed interstate route (Alternate "E") near Joplin, Missouri. In total, 16,000 m of shallow reflection seismic data, 13,000 m of ground-penetrating radar data, and 9 seismic check shots were acquired. The survey was conducted with two specific objectives in mind. MoDOT wanted to determine: 1) if the reflection seismic profiling technique could be used to map Mississippian bedrock and locate abandoned mine access and ventilation shafts; and 2) if the ground-penetrating radar (GPR) technique could be used to locate abandoned mine shafts in areas that were overlain by a thin (<3 m) veneer of surficial "chat" (milled rock). The geophysical survey was successful. Mississippian bedrock, abandoned mine shafts, and paleosinkholes were imaged on the reflection seismic data. Mine access shafts were also imaged on the GPR profiles, even where such shafts were overlain by a thin veneer of surficial chat. These geophysical interpretations were transferred onto existing mine location maps as an aid to MoDOT engineers involved in route planning, hazards assessment, and site remediation.

Stallings, M.D., D.W. Nees, G.R. Lowell. Department of Geoscience, Southeast Missouri State University. PETROLOGY AND GEOCHEMISTRY OF THE GRANITEVILLE GRANITE, SE MISSOURI. The Graniteville granite is a tin granite present within the St. Francois Igneous Terrane (SFT) of southeast Missouri, near the town of Graniteville. U/Pb dates place the body at 1.38 Ga. The Graniteville granite forms a 10km x 15km rectangular body which is buried beneath the Belleview Basin and is exposed in a number of local quarries. The unit is "brick red" or grey in color and exhibits megacrystic, rapakivi, porphytitic, aplitic and pegmatitic textural variants. Quartz, microcline, albite, biotite, and muscovite are the primary minerals while common accessory minerals include fluorite, allanite, uraninite, cassiterite, and Mo-Cu-Fe sulfides. Sporadic pods and veins of pegmatite contain Li-Fe mica, cassiterite, topaz, beryl, garnet, and sulfides. The Graniteville exposure is very high in SiO_2 (75-79%) and F (1370-3350 ppm). It is a "high heat-producing" granite (HHP) which means it is characterized by high levels of Th and U. Y, Li, Ga, Rb/Sr, F/Cl are prominent while Zr, Sr, and Ba are not. The petrographic and chemical traits identify the Graniteville granite as A-type with a strong resemblance to Finnish topaz granites.

Sun, P. and D.M. Mattox. University of Missouri-Rolla. CORRELATION OF ELECTRICAL PROPERTIES AND MICROSTRUCTURE DURING THICK FILM CONDUCTOR FIRING. The electrical resistance of thick film conductor coatings has been measured during their firing. The measured resistance has been correlated with the developing microstructure using optical and scanning electronic microscopy. Only two previous investigations have been reported and they reached contradictory conclusions about the interplay of the silver and glass phases. We have found a complex, unreported electrical effect related to the developing microstructures which is very important to the resultant properties of the silver films.

Tibbs, N.H., B.J. Buck, J.M. Holbrook, and G.R. Lowell. Department of Geosciences, Southeast Missouri State University. DESIGNING GEOSCIENCE CURRICULA TO MEET MULTIPLE NEEDS. Our undergraduate majors are pursuing either a B.S. in Geoscience or a B.S. Ed. (Second-

ary) in Earth Science. We also have a masters-level grauate program in Geoscience. Some other degree programs at our university require few to many Geoscience courses, and the Geoscience minor is pursued by students in certain majors. We offer several geoscience courses in our University Studies (general education) program. Curriculum efficiency is driven by credit-hour productivity targets; it is difficult for us to achieve because the number of students in any given program or service area that we offer is small. Moreover, allied science and mathematics requirements for these students vary widely. Programmatic effectiveness is determined by outcome measures such as geologist registration, teacher certification, graduate school matriculation, and employment. Finally, recent university and department strategic plans emphasize experiential learning. We have recently completed a series of curriculum reviews, and we will present information on curricula that we have designed to satisfy programmatic objectives and measures and to increase curricular efficiency. We hope this will encourage immediate and longer-term discussion of geoscience curricula in the Geology/Geophysics Section of the MAS

Physics Section

Cadwell, Katie, and Sanchez Velasco, Eduardo. Physics Department. Science Division, Truman State University. THE TURN-OFF TRANSIENT IN TRANSISTORS AND PHOTO-TRANSISTORS: AN UNDERGRADUATE EXPERIMENT ON SEMICONDUCTOR DEVICES. We present a simple and inexpensive experiment, accessible to undergraduate and advanced high-school physics students, to study the turn-off transient of transistors and photo-transistors. The results of the experiment can adequately be explained using the simple charge control model of the transistor, which allows one to deduce from the data a value for the life-time of the minority carriers in base. The experiment is performed with only a few electronic components, a laser diode, and an oscilloscope.

Science Education Section

Babrakzai, Noor. Department of Biology, Central Missouri State University. THE POTENTIAL OF *ALLIUM CEPA* (ONION) AS A MODEL ORGANISM FOR THE BIOASSAY OF MUTAGENS IN UNDERGRADUATE RESEARCH WITH THE HELP OF TECHNOLOGY. The recent explosion of new knowledge in Biological Sciences has necesitated the need for research experience for the undergraduates. Undergraduates have only 2-3 hrs/lab period and resources are usually limited. This observation alone necessitates designing inexpensive, realistic, and workable research experiments with a grain of originality, suitable for their tight class schedules. *Allium cepa* is an ideal organism to investigate experimental mutagenesis in an undergraduate setting. The observed chromosomal mutations are quantified and electronically recorded on a (i) video tape and (ii) are digitized by interfacing the microcomputer with a microscope. Students write their research papers in scientific form including discussion, illustrations, and interpretation of results in the light of published literature. They use on-line research databases for literature search e.g., MedLine, Cancer Lit, etc. To date 80 students enrolled in my Cytogenetics course (Biol. 4511) have successfully used this model to test mutagens experimentally, over the past ten years, and some of them have presented their work to the Missouri Academy of Science. Two students have chosen to do more research for graduate theses in my lab. Examples of some tested mutagens on the Allium research model are: Colchicine, Treflan, chloral hydrate, bromodeoxyuridine, extracts of parseley root, celery root, horse radish root, periwinkle leaves, and May apple rhizomes.

Banks, Larry and Becky Baker. College of Natural and Applied Sciences, Southwest Missouri State University. GOALS 2000 -- PRESERVICE SCIENCE TEACHER EDUCATION. Faculty from the colleges of science and education at SMSU are working with K-12 school groups and professional groups across the state to develop new ways to prepare teachers to teach science. This effort has been divided into three parts: The first is a combined certification program for elementary and middle school. The second is a filtered-cohort approach to 9-12 certification in unified science.

The third part is an assessment component indicating changes in new classroom teachers' use of teaching approaches that are based on the ways in which students learn.

Elledge, A.L., N.H. Tibbs and R.T. Marple. Department of Geosciences, Southeast Missouri State University. ACHIEVING THE EDUCATIONAL MISSION OF THE CENTER FOR EARTHQUAKE STUDIES (CES). The purpose of the CES is promoting earthquake awareness, education, and mitigation through various outreach activities. These activities have been coordinated with the Missouri State Emergency Management Agency, the source of matching funding for the CES. The principal outreach is through presentations to public and private groups and mailings of information in response to direct requests. Other outreach activities of the CES have included 1) developing and presenting public educational displays in businesses and at major events such as the SEMO District fair, 2) developing special programs for public awareness campaigns such as Earthquake Awareness Week, 3) providing information, interviews, and public service programming for news media, and 4) researching and developing new materials for earthquake education and information uses. Regional interest in earthquake awareness and education, especially from schools, has grown rapidly over the last three years. The number of persons attending presentations has more than doubled each of the past two years, with a total of 3,454 persons being directly served. Another 673 requests for written information were answered. The CES provides a model for achieving informal science education about a subject of critical concern for a large number of citizens at a very reasonable cost.

Hiley, S.L. Department of Chemistry, Missouri Western State College. INCORPORATION OF ACTIVE LEARNING TECHNIQUES IN INTRODUCTORY CHEMISTRY AT MISSOURI WESTERN STATE COLLEGE. The Department of Chemistry at Missouri Western State College has been exploring the use of active learning methods in order to improve retention and the overall course experience of students. MWSC's intermediate class size warrants careful trial and assessment before a time consuming curriculum-conversion is pursued. The use of discovery based laboratory exercises, inquiry based discussion sections, and student mentors were used in Introductory Chemistry. Students in laboratory were given the role of scientist by working in small groups to investigate particular focus questions, rather than individually performing prescribed procedures that act only as a demonstration of lecture topics. In discussion, the students were given small group assignments dealing with application of lecture topics or oral discussion of a controversial topic. Preliminary assessments of the Fall 97 and Spring 98 courses (at midterm) showed moderate improvement of retention, overall grade distribution, and student evaluations.

Hulett, M. and B. Schmidt. Department of Computer Science, Southwest Missouri State University. COMPUTERS FOR LEARNING. Technology has invaded society and many people don't understand the extent to which it impacts their lives. Southwest Missouri State University has embraced the challenges of preparing students for a life surrounded in technology by developing a course entitled *Computers For Learning*. The course is designed to meet the aims and goals of the University's general education program; it prepares students to participate effectively in and contribute to an information technology-oriented society. Students gain confidence and knowledge in the use of computers, as well as an understanding of the impact of technology and the responsible use of computers. To support these goals, the University has spent $820,000 to modernize and standardize the computing environment campus-wide, and has allocated $110,000 annually for support staff and ongoing expenses. Utilizing a Windows NT based platform and Microsoft Office 97, students are expected to leave classes and laboratories with a common skill set, based on this software, that will enhance their future learning abilities. Additionally, faculty are encouraged, but not mandated, to support and utilize the same resources in subsequent courses that students take in all disciplines.

Jay, J.S. and A.E. Jay. Department of Science Education, University of Missouri-Columbia. USE OF EARTHWORM TISSUES FOR ENZYME STUDIES IN A CELL BIOLOGY COURSE. College Cell Biology laboratory exercises were used to determine the merit of using earthworm organs and tissues to study enzyme activity and distribution. Tissue homegenates and frozen-tissue sections of body wall, intestine, and gizzard were prepared by strudents and assayed for activity or stained for microphotographic determination of distribution of selcted enzymes. Results provided opportunity for both quantitative and qualitative comparisons to be made between organs and tissues which can be easily understood. These studies successfully introduced students to concepts of

enzyme activity and distribution, and the laboratory techniques employed for such enzyme studies.

Mills, S.H. Department of Biology, Central Missouri State University. COMPUTERIZED DATA ACQUISITION: CIRCADIAN RHYTHMS TO EVOKED POTENTIALS. Since students remember what they do, design and conduct of experiments are central to laboratory activities. Microcomputers allow for more efficient use of laboratory time for data collection. Computer data acquisition systems (CDAS) have been used for monitoring circadian rhythms, metabolic rates, tension changes and circulatory characteristics. Neurophysiology exercises are difficult to implement due to "electronic noise" recorded in standard teaching laboratories. "On-line" processing of data (i.e., data stream averaging) reduces the problem of recording evoked potentials in "noisy" laboratories. Receptor potentials were recorded from the crayfish eye in response to light from a strobe. Action potentials were recorded from a cockroach leg in response to mechanical stimuli to the sensory hairs. The CDAS included a Macintosh 6100 microcomputer running Scope software controlling the MacLab system, a 386 PC running DataQuest controlling a Data Sciences frequency based digital converter, and a 486 PC microcomputer running DataCan controlling an Sable analog to digital converter. Network connection of recording stations to a file server simplified retrieval, evaluation, and compilation of data, and permitted data analysis. Student evaluations indicate that CDAS simplified data manipulation, made reports easier to prepare, and increased teacher/student interactions.

Raveill, Jay A. Department of Biology, Central Missouri State University. ALLOZYMES IN UNDERGRADUATE TEACHING AND RESEARCH. Allozymes, allelic variants of enzymes, were used as genetic markers in an undergraduate laboratory to examine the mating systems of several plants and insects. Advantages of allozymes over other biochemical and morphological markers included low cost, high reproducibility, simple sample preparation, and the ability to determine genotypes in a single laboratory period. The "cellulose acetate" type gels were more suitable for classroom use than starch gels since cellulose acetate gels have running times of only 15-20 minutes. Results were that some plant species were highly selfing while others were completely outcrossing. All insect species examined were estimated to have been completely outcrossed. Further applications to other laboratory exercises and undergraduate projects were envisioned including genetic drift, determining genetic variation within and among populations and determining parentage in mate competition experiments.

Roy, P., M. Payne, A. Kinslow and A. Johnston. Department of Education, Drury College. A COOPERATIVE MODEL FOR A SECONDARY SCIENCE METHODS COURSE. How to teach methods courses for future high school teachers is a challenge faced by many teacher preparation programs throughout the nations, especially those with small enrollments. Drury College's secondary science methods course was enhanced by the development of a collaborative partnership between college faculty and the science teachers at a local middle school. A number of Missouri Show-Me Standards as well as the National Science Education standards were successfully implemented in collaboration with the middle school science teachers. Drury College students were actively involved in facilitating hands-on activities and providiing individualized tutoring. The Drury pre-service science teachers highly rated the experience of methods course being taught in a center-city middle school with an ethnically diverse student population. This experience raises a possibility of restructuring other secondary methods courses after this model.

Schmidt, Cheryl A. Department of Biology, Central Missouri State University. MICROSATELLITES: HYPERVARIABLE MARKERS FOR UNDERGRADUATE LABS. Many undergraduate students perceive a chasm between the field biologist and the laboratory. Recent developments in molecular biology have provided "bridges" between these areas, resulting in unprecedented ability to elucidate the effects of ecological parameters on the genetic structure of populations and species. The use of molecular techniques such as PCR (Polymerase Chain Reaction) combined with recently developed methods to locate hypervariable DNA such as microsatellites (tandem repeats of simple motifs), has yielded sets of genetic markers which allow us to address issues ranging from population genetics to behavioral ecology. Microsatellite primer pairs developed for the native white-footed mouse (*Peromyscus leucopus*) provided 11 to 29 alleles per locus,

with a mean of 7.3 alleles per locus per population. Undergraduates have successfuly used these primers to amplify orthologous loci from closely related taxa. Potential application of these primers to amplify hypervariable markers for parentage determination and elucidation of genetic mating systems was addressed. The techniques and principles described could be applied to a diversity of extended independent undergraduate research questions (e.g., determination of genetic relatedness and pedigrees), as well as to different taxa for which microsatellite primers are available.

Tibbs, H.C., M.F. Cummings, N.H. Tibbs, and E.L. Kern. Department of Geosciences, Southeast Missouri State University. LABORATORY MANUAL DEVELOPMENT FOR AN INTRODUCTORY EARTH SCIENCE SERVICE COURSE. We developed a laboratory manual for the multi-section University Studies (general education) geoscience course "Earth Science: Environmental Hazards." Our objectives were: 1) emphasize geoscience principles and topics of importance and interest to students as citizens, 2) promote environmental consciousness - "Think globally, act locally," 3) increase active learning in the laboratory, and 4) reduce productioin costs and eliminate copyright considerations so that the manual can be provided free to students. Methods employed to accomplish these objectives included: 1) a modular approach in the development of the manual, 2) identifying and developing geologic topics relevant to environmental issues and hazards, 3) reinforcing fundamental skills, and 4) requiring a capstone problem solving project with a juried poster presentatioin. Evaluation of student assignments, surveys of pre- and post- attitudes, skills and knowledge, periodic laboratory examinations, and team observations of in-lab student behavior and participation were used to refine the laboratories for the final draft of the manual.

Zweerink, G.L. Department of Chemistry, Missouri Western State College. THE DEVELOPMENT AND EFFECTIVENESS OF A MULTIMEDIA PHASE EQUILIBRIUM PRESENTATION FOR FRESHMAN CHEMISTRY. The presentation will focus on illustrating the three phase pressure - temperature diagram for a liquid. Video of the critical point, triple point, liquid-vapor equilibrium, liquid-solid equilibrium, solid-vapor equilibrium will be included in the presentation. MicroSoft Power Point for PC will be the presentation tool. The presentation will be tested in the spring semester of 1997-98 in freshman chemistry. The effectiveness will be evaluated and results will be presented.

COLLEGIATE DIVISION 1998

Biological Science Section

Bhansali, J.B., and R.H. Luecke. Department of Chemical Engineering, University of Missouri-Columbia. METHYL MERCURY METABILISM IN GUINEA PIGS AND HAMSTERS. Previous studies show that pharmacokinetic modeling is a useful tool for drug and xenobiotic testing. This study was performed to develop pharamacological and kinetic models for methyl mercury metabolism in *Cavia porcellis* and *Mesocricetus auratus*. Methyl-mercury was administered through various methods. Concentrations of mercury and methyl mercury were measured in multiple tissues over a period of weeks. The resulting data were fit using a regression on multiple differential equations to derive pertinent rate constants. The resulting models are excellent fits to the experimental data, evincing the future potential of pharmacokinetic modeling. Supported by HHMI@MU.

Brownlee, J.W., J.M. Stone, and J.C. Walker. Divison of Biological Sciences, University of Missouri-Columbia. MOLECULAR CHARACTERIZATION OF AN *ARABIDOPSIS THALIANA* GENE ENCODING A KINASE INTERACTION DOMAIN. Understanding the molecular mechanisms of plant signal transduction pathways and identifying their components is a fundamental question in biology. The most common form of signal transduction in eukaryotic organisms is protein phosphorylation. Protein domains that can specifically recognize the phosphorylated forms of proteins are integral components of these signal transduction pathways. The Kinase Interaction Domain (KID) is one such protein domain and associates with the phosphorylated region of certain proteins, allowing the signal cascade to be propagated. Researchers have identified many genes that contain regions homologous to the KI Domain. One of the genes identified as having a KI domain is an expressed sequence tag from *Arabidopsis thaliana* (*AKHP*). We are characterizing *AKHP* through many basic molecular biology techniques. From northern blot analysis it was determined that a full length *AKHP* mRNAtranscript would be approximately 1.4 kb in length. The northern also showed that *AKHP2* is expressed in multiple tissue types, roots, leaves and flowers. From a high stringency southern it was determined that there is only a single copy of *AKHP* in the *Aradidopsis* genome. At present both cDNA and genomic libraries are being screened to isolate a full length cDNA version as well as a genomic version containing the promoter region. In the future we hope to perform interaction cloning and/or far western with plant extracts to determine with what *AKHP*s KI domain interacts. We also hope that sequencing data will yield some clues as to the function of the gene. Additionally, to determine where *AKHP* is expressed we will fuse its promoter with a reporter gene and look at its expression in the plant.

Calloway, J.C., H.K. Reddy, R. Schmaltz, D.J. Voelker, B.R. Wamhoff and M. Sturek. Dalton Cardiovascular Research Center and Departments of Internal Medicine, Surgery, and Physiology, University of Missouri-Columbia. SARCOPLASMIC RETICULUM Ca^{2+} BUFFERING IN SMOOTH MUSCLE FROM HUMAN AND PORCINE INTERNAL MAMMARY ARTERY. Increased levels of myoplasmic Ca (Ca_m) lead to antherosclerosis. The purpose of this investigation was to compare sarcoplasmic reticulum (SR) calcium (Ca) unloading in human internal mammary arteries and porcine internal mammary arteries (IMA). This laboratory has published data consistent with a model whereby the close proximity of the SR to the sarcolemma, coupled with preferential Ca release near the sarcolemma, can deplete the SR Ca store without increasing basal (Ca_m), a process referred to as "SR Ca unloading." Ca_m was measured by digital imaging in IMA and porcine coronary smooth muscle cells loaded with the fluorescent dye, fura-2. Cells were exposed to 80 mM potassium (K) prior to the release of Ca from the SR with caffeine to provide the control Ca_m response to caffeine (5mM). Cells were again depolarized by 80 mM K and allowed to recover for 2 min or 11 min before a second exposure to caffeine. A significant decrease in the second caffeine response compared to the control response ($p<0.05$) denoted "SR Ca unloading". Human and

porcine IMA were similar in that significant SR Ca unloading occurred at 2 min. In contrast, SR Ca unloading in the IMA (2 min) was not similar to SR Ca unloading in the porcine coronary artery which occurred mostly at 11 min. In conclusion, we propose that the SR Ca buffering properties of human and porcine IMA may underly the lower incidence of atherosclerosis in IMA and, thus, may explain the preferred use of the IMA in coronary artery bypass grafts. Supported by HHMI, Am. Diabetes Assoc., NIH HL02872.

Chappell, Andrew S. and Mark Hannink. Biochemistry Department, University of Missouri-Columbia. IDENTIFICATION OF A SECOND NLS IN THE V-REL ONCOPROTEIN. The Rel/NF-κ B family of eukaryotic transcription factors regulates immune and inflammatory responses by binding to specific enhancer sequences termed κ B sites. This family of transcription factors includes the c-Rel protein. The nuclear import of c-Rel is regulated by the Inhibitor of kappa B alpha protein (Iκ Bα) which masks the NLS of c-Rel and thereby retains c-Rel in the cytoplasm. The transcription factor v-Rel, the oncogenic mutant form of c-Rel, is comprised of 503 amino acids with a size of 59 kilodaltons and contains 17 single amino acid differences relative to c-Rel. The v-Rel oncoprotein is a transcription factor capable of nuclear focalization and activation of gene expression. The ability of v-Rel to constitutively activate gene expression is required for v-Rel-mediated oncogenesis. The NLS of v-Rel is cmprised of the same amino acids that comprise the NLS in c-Rel. However, in contrast to c-Rel, when the NLS of v-Rel is removed, the v-Rel-Δ NLS protein remains nuclear, suggesting that a second non-classical NLS in v-Rel might exist. Furthermore, the v-Rel-Δ NLS protein is able to transform avian cells. One hypothesis for the ability of v-Rel to transform cells is that this second v-Rel NLS allows for the nuclear localization of v-Rel, despite the fact that Iκ Bα masks the primary NLS of v-Rel. We report here that 57 amino acids from v-Rel that are located C-terminal of the classical NLS in v-Rel are able to functionally substitue for the NLS in nucleoplasmin. We are currently trying to further define the minimal non-classical NLS in v-Rel.

Day, J., B. Ray and C. Samidzi. Department of Biochemistry, University of Missouri-Columbia. STRUCTURAL STUDIES OF SAA: CLONING AND EXPRESSION OF THE SAA GENE. Serum amyloid A (SAA), one of several acute phase reactants (APRs), is a high density mammalian lipoprotein located in the plasma whose production is greatly intensified during periods of inflammation. Generally, APRs aid in a rapid return to homeostasis for tissue that has been affected by infectious or injurious stimuli. The overall goal of the project is to undersand the role that SAA plays during acute phase reaction by studying its three-dimensional structure. The first step toward this goal of investigation is to clone and express the SAA gene in order to obtain large amounts of the pure protein for crystallization. This is a summary of the first stage of the project. By using the known nucleotide sequence of rabbit SAA cDNA, a DNA primer was constructed and a polymereas chain reaction was performed. Next, *Eco*RV was employed to cut a plasmid. After ligation, the plasmid (pBC SK) with the insert was transformed into competent cells. The insert was removed by cutting it from the plasmid after inoculation with *Nco*I and *Bst*BI and was purified from the plasmid on an agarose gel. Finally, the insert was ligated into an expression vector (pRSET C). Results of the cloning of the cDNA sequence and its insertion into a plasmid vector have yielded a portion of the desired product but not in sufficient quantities for its expression. Supported by Howard Hughes Medical Institute.

DeiSanti, A.D., A. Sawani, L. Katwa, P.R. Myers, M. Sullivan, and J.L. Parker. Dalton Cardiovascular Research Center, University of Missouri-Columbia. EXPERIMENTAL ENDOTOXEMIA ALTERS ^{125}I-ENDOTHELIN BINDING AND ^{125}I-ANGIOTENSIN-II BINDING IN MYOCARDIAL HOMOGENATES. Vascular and cardiac responses to many vasoconstrictors and inotropic agonists (catecholamines, angiotensin) are decreased during endotoxemia and shock. In contrast, endothelin (ET)-mediated vasoconstriction increaases in certain tissues, and ET-receptor blockade has been reported to improve mortality and cardiopulmonary fuction during experimental endotoxemia. We used guinea pigs to investigate effects of *in vivo* endotoxin (LPS; bacterial lipopolysaccride, 4 mg/kg i.p.) on ET and angiotensin receptor binding. Receptor binding was studied in crude myocardial homogenates using ^{125}I-ET and ^{125}I-angiotensin II ligands (and respective cold peptides). ET-receptor binding increased from 24.72+/-3.3 to 33.99+/-5.9 fmol/mg

protein ($p<0.05$) in control compared to LPS myocardial homogenates, respectively. In contrast to ET, angiotensin-receptor binding decreased from 1.23+/-0.11 to 0.8+/-0.04 pmol/mg protein ($p<0.05$) in control compared to LPS myocardial homogenates. These results suggest that up regulation of ET receptors may contribute to vasoconstriction and inotropic responses during endotoxemia; further studies are required to delineate vascular and/or cardiac myocyte specificity and potential role of reciprocal effects of ET and angiotensin-mediated responses.

Eschenbrenner, T., D. Stuckey, and Rao Ayyagari. Department of Biology, Lindenwood University. ENDOGENOUS INFECTION OF RHABDIAS IN BUFO MARINUS. Our original aim was to obtain fertilized eggs from *Bufo marinus* toads to attempt cloning by physical division. Three pairs of toads were purchased from a biological supply company and housed in three individual 10-gal. tanks. The toads were fed crickets and a day/night cycle was maintained by artificial light. Six weeks into the experiment two of the frogs suddenly died, and even after four months of maintenance no eggs had been deposited. An autopsy exam of the cyst from the dead toads led us to the conclusion that death occurred by parasitic infection of the lungs. We also concluded that the toads were not able to produce eggs because of the stress due to infection by parasites. The parasites from the lungs of the dead toads were morphologically identified as belonging to the Rhabdia phylum. Furthermore, we also concluded that the frogs were endogenously infected after testing the crickets and water for parasitic worms.

Esparza, T.J., J.D. Wall. Department of Biochemistry, University of Missouri-Columbia. ISOLATION AND CHARACTERIZATION OF SIGMA-54 DEPENDENT ACTIVATORS FROM *DESULFOVIBRIO DESULFUICANS*. Alternative metabolic pathways are often regulated by dedicated transcription factors that allow gene transcription only when bound by an activator protein. The sigma factor, sigma-54, makes functional contact with bacterial RNA polymerase only in asociation with a sigma-54 dependent activator that is produced when signaled by external stimuli. Conserved gene sequence similarity allows isolation of this region from many different bactreria with the Polymerase Chain Reaction (PCR) technique. Using the PCR technique, we have isolated three unique amplicon products from the sulfate reducing bacterium (SRB) *Desulfovibrio desulfuricans* G20. Greater knowledge of SRB metabolism will aid understanding their role in biocorrosion and increase their utilization in bioremediation.

Esses, J.A. Department of Physics, University of Missouri-Columbia. VISUALIZATION OF PLANT CELL WALLS BY ATOMIC FORCE MICROSCOPY. Atomic force microscopy has been used to visualize the fine structure of plant cell wall material from *Arabidopsis thaliana* root sections. Resin coated and extracted samples were imaged in air at ambient temperature and humidity, using scanning mode atomic force microscopy. The three dimensional images obtained highlight plant cell wall structure. Scanning microscopy is a powerful new biophysical tool for imaging of biological samples. The images obained are of a resolution associated with electron microscopy, however without the damaging preparations associated with electron microscopy.

Finder, D.R. and C.D. Hardin. Department of Physiology, University of Missouri-Columbia. TRANSPORT OF EXOGENOUS FUMARATE AND 3-PHOSPHOGLYCERATE (3PG) BY A DICARBOXYLATE TRANSPORTER. The keto (linear) form of exogenous fructose 1,6-bisphosphate, a highly charged glycolytic intermediate, may utilize a dicarboxylate transporter to cross the cell membrane, support glycolysis, and produce ATP anerobically. Could a dicarboxylate transporter be exploited by other structurally similar intermediates, such as fumarate and 3PG, to provide ATP during hypoxia? To assess ATP production during hypoxia we measured force maintenance by hog carotid arteries during hypoxia in the presence or absence of 20 mM fumarate or 3PG. Fumarate decreased peak isometric force development by 9.5% ($p=0.008$) but modestly improved maintenance of force ($p<0.05$) throughout the first 80 min. of hypoxia. ^{13}C-NMR on tissue extracts and superfusates revealed 1,2,3,4-^{13}C-fumarate metabolism to 1,2,3,4-^{13}C-malate under oxygenated and hypoxic conditions suggesting uptake and metabolism of fumarate. 3PG also improved maintenance of force ($p<0.05$) during 30-80 min. period of hypoxia. In conclusion, exogenous fumarate and 3PG readily enter vascular smooth muscle, presumably by a dicarboxylate transporter, and support energetically important pathways. Supported by AHA Established Investigator Grant (CDH) and HMMI internship (DRF)

Gaines, A.C. Division of Biological Sciences, University of Missouri-Columbia. ALTERED GENE EXPRESSION IN RESPONSE TO NEURAL INJURY IN *Aplysia californica*.. Differential gene regulation underlies the nerve response to injury and axonal regeneration. To study changes in gene expression in response to central nervous system injury, a technique called AFLP was combined with cloning and sequencing of cDNA's. Nerves emanating from the cerebral ganglia of *Aplysia californica* were crushed with #5 forceps. messenger RNA was isolated and reverse transcribed to create double stranded cDNA which was then cut with restriction endonocleases and ligated to double stranded adapters of known sequence. Selective PCR amplification of a subset of those cDNA fragments was performed using radioactively labeled primers which complemented the adapter sequence. Differentially expressed fragments from control and lesioned groups were identified on polyacrylamide gels, cloned and sequenced. Further studies are needed to determine the functional roles of these same products in nerve regeneration. Supported by HHMI.

Gasper, B., S. Schwery, and T. Eckdahl. Department of Biology, Missouri Western State College. ANALYSIS OF GENETIC VARIATION IN SCULPINS FROM OZARK WATERSHEDS. The genus *Cottus* includes numerous species, all of which are morphologically similar. This leads to difficulty in species determination. The two sculpins (*Cottus hypselurus* and *Cottus bairdi*) used in this study have overlapping distributions. *C. bairdi* has previously been limited to specific areas in Missouri while *C. hypselurus* has been observed in a wide range of watersheds. The scope of this study was the determination of the population composition of five Ozark watersheds: the Meramec River, Pearson Creek, Clear Creek, the Little Black River, and the Niangua River. The analysis used a molecular genetics technique called the Polymerase Chain Reaction (PCR) and Randomly Amplified Polymorphic DNA (RAPD) primers. The technique yielded rsults which allowed comparisons within and between populations. Phylogenetic trees were constructed as a means of demonstrating relationships. The data show several populations to be genetically distinct while others were not. Further phylogeographic analysis of the populations will likely clarify sculpin species distribution.

Hoehne, D.P., J.C. Simmons, and R.H. Freeman. Department of Biology, Culver-Stockton College. THE EFFECTS OF L-NAME ON ARTERIAL PRESSOR RESPONSES TO PHENYLEPHRINE AND ANGIOTENSION II IN RATS. Previous studies have shown an attenuated pressor response to angiotension II in rats pre-treated with the nitric oxide synthase inhibitor, NG-nitro L-arginine methyl ester (L-NAME). We hypothesized the attenuated pressor response to angiotension II is not a unique interaction between L-NAME and angiotension II. To test this hypothesis rats were administered L-NAME (185 umol/kg body wt, iv) and the alpha adergenic agonist, phenylephrine (10 and 100 ug/kg body wt, iv). Arterial pressure was elevated in rats administered L-NAME compared with control (114 ± 7.8 vs 146.6 ± 10.8 mmHg, $p<0.05$). The pressor response to phenylephrine (10 ug/kg body wt, iv) was attenuated in rats pre-treated with L-NAME compared with control (5.4 ± 9.1 vs 2.5 ± 7.6 mmHg, $p<0.05$), while the pressor response to phenylephrine (100ug/kg body wt, iv) was not significantly different from control (47.0 ± 10.7 vs 32.8 ± 13.4 mmHg, $p>0.05$). The pressor response to angiotension II (10 mg/kg body wt, iv) in rats pre-treated with L-NAME was attenuated compared with the control (67.2 ± 11.5 vs. 36.4 ± 5.7 mmHg, $p<0.05$). These results suggest the pressor response to phenylephrine (10 ug/kg body wt, iv) and angiotension II are attenuated in rats pre-treated with L-NAME.

Johnson, M.R., and W.F. Andresen. Department of Biology, Missouri Western State College. THE EFFECT OF THYMIDINE AND RIBOFLAVIN ON GROWTH AND MORPHOLOGICAL CHANGES SEEN IN AGING CULTURES OF *Tetrahymena pyriformis*. In earlier research, replicate cultures of *Tetrahymena pyriformis* were initiated in medium consisting of 1% proteose peptone #1 (Difco) and 1% glucose (1% PPG-1). The growth and morphological changes observed in these cells were compared to those observed in 1% proteose peptone #3 (Difco) and 1% glucose (1% PPG-3). In 1% PPG-1, rapid proliferation of cells was observed in cultures after the onset of the maximum stationary growth phase. This proliferation was not seen in the cells cultured in 1% PPG-3. The cells in the older 1% PPG-3 cultures (10-14 days after inoculation), became very small and nearly spherical. These small cells were not noted in the cultures in 1% PPG-1. These two media (1% PPG-1 and 1% PPG-3) differ primarily in the amount of thymidine and riboflavin. In this study, these two vitamins were added to 1% PPG-1 to see if either affected the cellular morphology or

growth pattern as the cultures aged. Neither thymidine (1-[2-Deoxy-B-D-ribofuranosyl]-5-methyl-uracil) or riboflavin, added individually to 1% PPG-1, had a significant effect on the morphology or growth pattern observed in aging cultures.

Ko, S.W. Department of Biochemistry, University of Missouri-Columbia. DOES THE MUTATION IN α -KETOGLUTARATE DEHYDROGENASE AFFECT THE EXPRESSION OF DOWNSTREAM GENES? *Bradyrhizobium japonicum* forms a symbiotic relationship with soybeans and participates in a process called nitrogen fixation. The citric acid cycle provides energy needed for the bacteriod to fix atmospheric nitrogen. We are studying the effects that an intererupted citric acid cycle will have on nitrogen fixation. Insertional mutagenesis was performed on *suc*A, one of the three genes encoding the subunits for α -ketoglutarate dehydrogenase (α -KHD), the other two are *suc*B and *lpd*. Without α -KHD the cell can not complete the citric acid cycle. The phenotype of this mutation was delayed nodulation and nitrogen starvation. Further studies of the mutant's genotype are needed in order to understand the full affect of the mutation. Our goal is to determine if the expression of genes found downstream of *suc*A are affected by the mutation. We used information obtained from restriction mapping to isolate the regions downstrem from *suc*A. We sequenced these pieces and searched for homologies to known genes. From our sequencing we found the *suc*B gene directly downstream from *suc*A. Northern blots reveal that neither *suc*B nor *suc*A are expressed in the mutant bacteria as opposed to the wild type. This suggests that the two are co-transcribed and that the interruption of *suc*A also caused a block in *suc*B production. Further downstream we found the *lpd* gene. Northern blots show no expression of this gene in the mutant. Now we are focusing on the region between *suc*A and *lpd,* to see if there is a gene and if it is expressed. Preliminary sequencing shows a strong homology to *nod* G genes which may help explain the delayed nodulation phenotype observed from this mutant. Supported by Howard Hughes Medical Institute.

Kreunen, S.S. and J.J. Osborn. Division of Science, Truman State University. POLLEN AND ANTHER DEVELOPMENT IN THE AMERICAN LOTUS (*NELUMBO LUTEA*; NELUMBONACEAE). *Nelumbo lutea* is one of two species that comprise the Nelumbonaceae, a small family of aquatic flowering plants. This species is commonly known as the American lotus or water chinquapin and occurs throughout the eastern United States, including Missouri. Evolutionary relationships among plants can be assessed through studies of pollen and anther development; however, little has been known about these important events in the reputedly primitive genus *Nelumbo*. The focus of this presentation will be these ontogenetic aspects, which have now been studied utilizing scanning electron microscopy, transmission electron microscopy, and light microscopy. A complete developmental sequence has been documented that includes anthers at the undifferentiated sporogenous tissue, microspore mother cell, tetrad, free spore, and mature pollen grain stages. Features such as the deposition of a microspore mother cell coat; the deposition, persistence and degradation of a callose wall in the tetrad stage; and the formation of the primexine in tetrads have been documented. Additionally, ultrastructural details of the development of the exine and intine layers of the pollen wall, as well as pollen aperture formation will be shown. Associated developmental changes in the anther have also been documented. These include number of cell layers composing the anther wall; tapetum type and pattern of its maturation and degradation, and endothecial thickenings, including type and location. The present study is the first to employ electron microscopy in the study of pollen and anther development in *Nelumbo lutea.*

Littlejohn, A.D., K.J. Miles, T.S. Lucas, and M.L. Spratt. Department of Biology, William Woods University. AN EXAMINATION OF SELECTED SPECIES OF TICKS IN CALLAWAY COUNTY, MO, AND ADJACENT COUNTIES FOR *Francisella tularensis* AS IDENTIFIED BY DNA AMPLIFICATION. *Francisella tularensis* is the bacterium responsible for causing tularemia, a sometimes fatal disease. In the past fifteen years, 532 cases of tularemia have been reported in Missouri, and MO is one of the three leading states in the nation in cases reported. This presents public health concern for contracting the disease from infected animals, both domestic and wild, through tick vectors. The detection of the bacterium causing tularemia can be of significant importance to the community in terms of education, prevention, and control of this important tick-borne disease. Three species of local ticks have been collected and identified from Callaway and surrounding counties. Veterinarians in Callaway county collaborated with us in collections from small

domestic animals. DNA samples from ticks were extracted and purified using a phenol/chloroform procedure developed and modified for arthropod DNA. We used a stringent polymerase chain reaction (PCR) protocol with specific primers flanking a 751 base pair sequence on the 16s ribosomal subunit of *F. tularensis*. Consistently positive results on laboratory-cultured *F. tularensis* have been attained. Preliminary results on extracted tick DNA indicate that some ticks of Callaway County do carry the causative agent for tularemia.

McWilliams, R.T., J.M. Osborn, and I.M. Lindevald. Division of Science, Truman State University. AERODYNAMIC FEATURES OF SACCATE POLLEN: EVOLUTIONARY IMPLICATIONS FOR WIND-POLLINATED PLANTS Pollen grains of many wind-pollinated plants have one to three air-filled sacs; these add considerable surface area, but minimal weight. However, there is no available research on how well the sacs of different species actually assist in flight. Using light and electron microscopy, I have examined saccate pollen of three conifers (*Pinus, Falcatifolium,* and *Dacrydium*) and documented multiple morphological characters. These include overall size, main body size, sac size, surface ornamentation pattern, wall thickness, wall infrastructure, sac infrastructure, overall mass, and wall mass. Some of these characters have been incorporated into a custom computer model, using the programming language C and *Mathematica*, that calculates flight properties for the theoretical grains. The model takes into consideration both the biologically based structural features, as well as a number of salient physical parameters such as height at time of dispersal, wind speed, and wind direction. The model is being tested by stroboscopic photography of actual pollen. This is the first study to correlate structural and aerodynamic features of pollen, providing the opportunity to evaluate the adaptive significance of saccate pollen from both extant and extinct wind-pollinated plants.

Megee, D.M., and K.S. Gates. Department of Chemistry. University of Missouri-Columbia. DNA CLEAVING ABILITY OF DEOXYMETHYL-MYXIN. Deoxymethyl-myxin (1,6-dimethoxyphenazine di-N-oxide) is currently being studied for possible anti-tumor activity as demonstrated in myxin, possibly through a hydroxyl radical method. Previous work with the natural product myxin has yet to resolve an exact chemical mechanism by which this agent damages DNA. The compound was synthesized following a preparation by Prachter. O-Anisidine and o-nitroaniline were reacted with potassium hydroxide to form 1,6-dimethoxyphenazine, which was subsequently oxidized in a solution of mCPBA to form deoxymethyl-myxin. Studies are now in progress to establish deoxymethyl-myxin's DNA-cleaving ability in relation to similar known DNA-cleaving agents. Additional studies with the mono-N-oxide should yield a more comprehensive understanding of the chemical mechanism by which the di-N-oxide and subsequent mono-N-oxide by-product hydroxyl radicals that lead to DNA cleavage.

Milanick, M.A., and M.C. Azu. Department of Physiology, University of Missouri-Columbia. CALCIUM PUMP INHIBITION VIA EOSIN AND ROSE BENGAL. Calcium pump inhibition leads to an increase in intracellular calcium in many cells; an increase in calcium is an importaant second message. Currently, there are no useful calcium pump inhibitors available and the aim of my project was to characterize one inhibitor. First, we began with eosin, a compound that is known to be a reversible inhibitor. We confirmed previous results that eosin binds with hgih affinity and is reversible. Eosin has been a useful tool for distinguishing between the plasma membrane calcium pump and the sodium/calcium pump exchanger. Eosin is the most selective inhibitor of the plasma membrane available, but its binding site is unknown. Next, tetrafluoroesoin (TFE), a compound similar to eosin, was tested. TFE inhibited with high affinity. Surprisingly, we found that albumin reversed the inhibition of TFE, if the reaction was done in the dark, thus showing that TFE is a reversible inhibitor. We plan to test rose bengal, another compound similar to eosin. Preliminary data suggest that rose bengal is irreversible and if this is true, the binding site can be determined. After testing rose begal's irreversibility, we will test eosin's effect on the binding of rose bengal. We want to determine if eosin protects the calcium pump against rose bengal's binding and proven inhibition of the pump. If eosin does in fact prevent rose bengal from inhibiting the calcium pump, then eosin and rose bengal have the same binding site and the pump can be isolated to determine the location of the binding site. By determining the binding site, better drugs can be developed which, in turn, will benefit patients significantly.

Oehrle, N., L. Zweifel, and V. Peterson. Department of Biochemistry, University of Missouri-Columbia. PURIFICATION OF WHEAT GERM ACID PHOSPHATASE (E.C.3.1.3.2) AND CHARACTERIZATION WITH PHOSPHOENOLPYRUVATE AS SUBSTRATE. An acid phosphatase (orthophosphoric monoester phosphohydrolase, acid optimum; E.C.3.1.3.2) from wheat germ was purified 1000 fold to near homogeneity. Purification of the enzyme included ammonium sulfate precipitation, DEAE-cellulose ion exchange chromatography, and Concanavilin-A affinity chromatography. The primary goal of the investigation was to determine the optimum conditions (pH, tempeature, and reaction rate) under which the enzyme operates and to determine the enzyme's specificity for the natural substrate phosphoenolpyruvate (PEP). The result of the investigation showed that a glycosylated protein with acid phosphatase activity was purified to near homogeneity and showed 6-fold less substrate specificity for PEP versus the common synthetic substrate p-Nitrophenylphosphate (p-NPP). The size of the protein was determined using SDS-PAGE, native-PAGE, and activity-PAGE techniques; it was found to have a molecular weight near 65,000 Da. Supported by Department of Biochemistry Teaching Lab, University of Missouri.

Parks, S.E. Division of Biological Sciences, University of Missouri-Columbia. GENETIC VARIABILITY IN FORTY YEAR OLD CULTURES OF *Escherichia coli* AND *Salmonella typhimurium*. Considerable attention has been focused on mutation in aged bacterial cells. Samples from University of Missouri-Columbia's bacterial collection have been examined for specific variabilities that may have occurred during a storage period of more than forty years. Viable cells can be recovered from over 85% of *S. typhimurium* and *E. coli* cultures even after prolonged storage in nutrient gar stabs. It is assumed that a very low metabolism has been maintained in these cultures due to dead cells providing small amounts of nutrients to viable cells. Cultures stemming from one or two parent strains were examined for mutations with a small amount of variance expected. The variability I focused on was in the regulator of two catalases (hydrogen peroxidase) genes which are important in a cell's ability to overcome stress from external stimuli, particular oxidative stress. Using polyacrylamide gel electrophoresis, sizeable differences in amounts of catalase were found to vary greatly among strains. It is yet to be determined if there is variability in the sequence of the *rpo*S gene which regulates catalase.

Riekhof, W.R., A. Goldraij and J.C. Polacco. Department of Biochemistry, University of Missouri-Columbia. IS ARGINASE A MITOCHONDRIAL ENZYME? Arginase catalyzes the hydrolysis of arginine (Arg) to urea and ornithine, a crucial step in the utilization of nitrogen stored as Arg in seed storage proteins. In etiolated soybean seedlings, subcellular fractionation over Percoll density gradients shows that arginease activity is closely associated with cytochrome c oxidase (a mitochondrial matrix enzyme), and shows no significant association with catalase (a peroxisomal enzyme). Since arginease appears to be a mitochondrial enzyme encoded by a nuclear gene, the mature protein should have a truncated N-terminus due to removal of a transit sequence during the importation process. We have sought to confirm the existence of this truncation by comparing the amino acid sequence deduced from an arginase cDNA with that of the mature N-termiinus. We have identified a likely arginease band in the SDS-PAGE of a partially purified preparation, and sequence analysis is in progress.

Rist, M.R., J. Xia, G.Y. Sun, and P.K. Rudeen. Departments of Pathology & Anatomical Sciences, and Biochemistry, University of Missouri-Columbia. EFFECT OF ETHANOL EXPOSURE ON INDUCIBLE NITRIC OXIDE SYNTHASE (iNOS) IN DEVELOPING CHICK BRAIN. Formation of nitric oxide (NO) is one mechanism by which ethanol has been postulated to induce developmental malformations in the brain. A radioenzymatic assay was developed to measure iNOS activity in chick brain embryos. iNOS activity was found to increase during development, significantly increasing by d16 compared to d6 ($p<0.05$) in the cerebral cortex. This assay was utilized to examine the effects of acute and chronic ethanol exposure to embryonic chick brain on iNOS. Embryos were injected with ethanol (0.6g/kg egg weight) on various days of development. When exposed to an acute (single) injection of ethanol, there was no effect on the levels of iNOS compared to vehicle treatment. Chronic exposure of ethanol on days 7, 9, 11 and 13 of development resulted in levels of iNOS in cerebral cortex that were lower, but not significantly ($p>0.05$) than that in chick brains exposed to a vehicle solution. The results indicate that while iNOS may be measured in developing chick brain, there is no significant effect of ethanol exposure on iNOS activity. Sup-

ported by Departments of Pathology & Anatomical Sciences (PKR), and NIAAA Grant 06661 (GYS).

Rodgers, J.M. and D. Eide. Department of Nutritional Sciences, University of Missouri-Columbia. TRANSCRIPTIONAL REGULATION OF A METAL ION TRANSPORTER BY ZINC IN *S. cerevisiae*. Previous studies have revealed that the ZRT1 gene encodes the transporter for the system that has a high affinity for zinc [apparent K_m of 10 nM free Zn(II)], and it is induced in zinc-deficient cells. However, the ZRT2 gene has a lower affinity for substrate {apparent K_m of 100 nM free Zn(II)] and is also highly regulated by zinc status. ZAP1 is another zinc-regulated gene. This gene encodes a transcriptional activator of ZRT1 and ZRT2 as well as its own promoter in response to zinc through a positive autoregulatory mechanism. To investigate how these genes respond to zinc, intracellular zinc levels were measured and related to zinc-responsive promoter activites. Methods used included atomic absorption spectrometry to determine zinc levels inside the cell at medium zinc concentrations ranging from 0-1000 βM zinc chloride and time intervals from 1-12 hours. Also, fusions of the ZRT1, ZRT2, and ZAP1 promoters to a *lacZ* reporter gene were used to evaluate the activity of the promoters by measuring the amount of β-galactosidase activity. Results showed that as the concentration of zinc supplied to the cell increased, intracellular zinc levels for the three strains also increased and then reached maximum at approximately 200 pool/cell (10^{-6}). However, regulation of ZRT1, ZRT2, and ZAP1 gene expression showed temporal differences and different steady state expression levels. These results indicate that these three genes are differentially regulated by ZAP1. Supported by Howard Hughes Medical Institute.

Ryther, R.C.C., A.N. Vomund, S.R. Braddock, and C.L. Phillips. Department of Biochemistry, University of Missouri-Columbia. R618Q SUBSTITUTION IN THE PRO α 2(I) COLLAGEN GENE IN NORMAL INDIVIDUALS AND MARFAN-LIKE CONNECTIVE TISSUE PATIENTS. Marfan's Syndrome (MFS) is an inherited connective tissue disorder with a dominant mode of inheritance affecting 1 in 10,000 individuals. MFS affects three main body systems: ocular, skeletal, and cardiovascular. 90% of MFS patients contain a defect in their fibrillin, a connective tissue protein. We propose a candidate protein mutation to explain some of the remaining 10% type I collagen. Type I collagen is a connective tissue protein composed of two α 1 (I) chains and an α 2 (I) chain covalently crosslinked. In 1990, Phillips et al. reported a non-glycine amino acid substittuion, arginine to glutamine at position 618 (R618Q), in the α 2 (I) collagen gene in an individual with MFS. This same substitution has been found in an additional, unrelated MFS patient. We developed a PCR based restriction endonuclease assay to identify the R618Q substitution. We screened 173 control individuals and 56 connective tissue patients, including MFS patients, to determine if the R618Q substitution represents a normal variant in the population or if it is associated with specific connective tissue problems and/or MFS. Currently, 2 of 37 MFS individuals possess R618Q (5.4%), and none of our 19 other connective tissue patients do. In our control population, we found an individual who also had the R618Q (1 of 345 chromosomes, 0.3%) and whose connective tissue has yet to be evaluated. The R618Q substitution appears to be rare in the normal population and its affect on the structure and function of type I collagen needs further investigation.

Schaetz, G.M., and P.W. Gabrielson. William Jewell College. **G.R. Vandenbark, and E. Friday**, Department of Biochemistry, Louisiana State University Medical Center. IDENTIFICATION OF THE C-KIT-LUCIFERASE TRANSGENE IN MICE BY THE USE OF POLYMERASE CHAIN REACTION (PCR). The human proto-oncogene c-kit has been shown in previous studies to be controlled transcriptionally in a cell specific manner by repression and derepression of transcriptional initiation. In the present study, mice potentially containing the c-kit promoter fused to the luciferase gene were screened using PCR analysis. Initially, seven potential transgenic founder mice containing the c-kit-luciferase transgene were evaluated using 100ng of EcoRI digested genomic DNA. A 540 bp luciferase fragment within the EcoRI/EcoRI fragment was amplified using PCR. All PCR reactions were confirmed using the positive control, glyceralderhyde 3-phosphate dehydrogenase (G3PDH). PCR products were visualized on an eithidium bromide 1% agarose gel along with a 500 bp marker. Amplification of the c-kit-luciferase transgene was observed from three of the seven potential transgenic founder mice. These three transgenic mice were mated and their offspring screened for an inheritable transgene using PCR. All three founder mice transmitted the c-kit-luciferase transgene to their offspring. Now that transgenic mice have been identified, *in vivo*

experiments will be conducted to determine if the first 5500 bp of the human c-kit promoter is sufficient to express the transgene reporter in the same manner as the endogenous gene.

Schoone, D., E. Lawson, G. Bouchard, G. Johnson, and H. Shibuya. Department of Biology, Columbia College and Department of Veterinary Pathobiology, University of Missouri-Columbia. THE PORCINE CDK4 GENE IS NOT THE SINCLAIR SWINE MELANOMA LOCUS. Mutations in the CDK4 and P16 genes are known causes of familial melanoma in man. To test the hypothesis that a mutation in the procine CDK4 gene is responsible for familial melanoma in the Sinclair swine model, we used two PCR/RFLP assays to genotype 52 Sinclair swine in three families. The *Rsa*I PCR/RFLP marker was based on an "A" or "G" polymorphism at nucleotide 47 in intron 3 and the *Nco*I PCR/RFLP marker was based on an "A" or "T" polymorphism in the 3'-untranslated region, 219 bp downstream from the stop codon. The pattern of CDK4 alleles in affected family members was inconsistent with our hypothesis that Sinclair swine melanoma stems from a single mutation in the porcine CDK4 gene. We are, therefore, examiniong the porcine P16 gene as a candidate for the Sinclair swine melanoma locus.

Sipe, J.D. Division of Biological Sciences, University of Missouri-Columbia. CELLULAR RESPONSE TO NERVE INJURY IN *Applysia californica*. Investigation of the response to nerve injury is of vital importance in the understanding of how the nervous system functions. We studied regeneration of axons expressing the neuropeptide Phe-Met-Arg-Phe-amide (FMRFamide) which has a variety of functions in the nervous system of invertebrates and vertebrates. To examine the response to nerve injury, lesions to the cerebral-buccal and cerebral-pleural connectives in *Aplysia californica* were performed and were examined 7-days post-lesion. FMRFamide immunocytohistochemistry was performed on frozen sections of the *Aplysia* central nervous system. The sections were treated with a 1:100 dilution of rabbit anti-FMRFamide primary antibody and then a 1:50 dilution of goat anti-rabbit antibody. FMRFamide immune reactivity was observed in cell bodies and axon processes. Regenerating axons expressing FMRFamide-like immunoreactivity were observed in the connectives and ganglia. Our studies of regeneration in the central nervous system may be applicable to higher vertebrates, including humans. Supported by HHMI.

Speichinger, E.D., H. Tang, and H. Braley-Mullen. Department of Molecular Microbiology and Immunology, University of Missouri-Columbia. IN SITU ANALYSIS OF INTRATHYROIDAL PHENOTYPES IN SPONTANEOUS AUTOIMMUNE THYROIDITIS. The murine model of spontaneous autoimmune thyroiditis (SAT) is being used to study the mechanism involved in the induction and regulation of organ-specific autoimmune inflammatory responses. Male and female mice with the genetic background NOD.H-2h4 develop SAT; administration of 0.5% NaI water increases both the severity of thyroid lesions. Thyroid lesions in SAT are characterized by infiltrating CD4+ and CD8+ T lymphocytes. Tg, the predominant protein produced in the thyroid, is presented to CD4+ T cells by antigen presenting cells (APCs), activating Tg-specific CD4+ T cells. Studies are in progress to determine how CD4+ T cells become activated. Specifically, we are interested in identifying whether B-cells act as APCs to CD4+ cells. Thyroids are assessed by immunocytochemistry for expression of antibody/complement complexes. Our aim is to ascertain if these complexes appear in the thyroid prior to inflammatory lymphocytes and CD4+ T effector cells.

Wagner, J.S., and T.E. Phillips. Division of Biological Sciences, University of Missouri-Columbia. ANTIGEN RETRIEVAL TECHNIQUES FOR IMMUNOFLUORESCENT MICROSCOPY. Indirect immunofluorescent microscopy is used to characterize the spatial distribution of specific antigens within cells and tissues. Unfortunately, antigenic binding sites are frequently lost when tissues are fixed and embedded for microscopic sectioning. We designed a screening protocol in which we tested the ability of three buffer systems to retrieve lost antigenic binding sites. Using a panel of monoclonal antibodies that worked either poorly or not at all in conventional immunochemistry protocols, we were able to develop conditions which allowed strong, specific immunofluorescent labeling on paraffin embedded tissues. In general, a pre-treatment of heating the sections in 10mM glycine (pH 9.7) resulted in the strongest labeling. After success in paraffin was established, the techniques were applied to tissue embedded in several plastics such as JB-4, LR Gold, LR white, and methyl methacrylate. The antibodies failed to label antigens in JB-4, LR gold, LR White, even after pre-treatment. Sections of methyl methacrylate were treated with acetone to partially remove

the plastic and then stained with antibodies. Again, labeling was the strongest, or in some cases occurred, only after pre-treatment with the glycine buffer. The ability of the antigen retrieval protocol to restore immunoreactivity has greatly expanded the range of antibodies which can be used in immunocytochemistry studies.

Whited, J.L. and M. Golomb. Division of Biological Sciences, University of Missouri-Columbia. GENE REPLACEMENT OF *CBL*, A YEAST HOMOLOGUE OF HUMAN *CBF*. Human *CBF* gene encodes a transcription factor that binds DNA sequence CCAAT. In human cells, this transcription factor actrivates growth-related gene(s) and interacts with an oncoprotein and tumor-suppressor protein. To learn more about the functionand targets of the CBF protein, yeast can serve as a model. A functinal copy of *CBL*, the homologous gene in yeast, is essential for survival. Overproductionof CBL protein is also growth-inhibitory or lethal. To test the functional similarity of the yeast and human CBF proteins, the plasmid shuffle technique is being used to introduce into yeast host cells a centromeric vector constructed with yeast upstream and downstream regulatory sequences. Between the upstream and downstream sequences will be inserted a yeast *CBL* gene in the control, and either a nematode or human *CBF* gene in each of the experimental constructs. Each construct will be used to transform yeast. If yeasts survive with an experimental gene insert, then the foreign gene's protein is sufficiently similar in function to the homologous yeast protein. I am currently constructing suitable replacement vectors and host for this experiment. Supported by the HHMI Undergraduate Research Program.

Wicker, J.A. and F.J. Schmidt. Department of Biochemistry, University of Missouri-Columbia. RANDOM MUTAGENESIS AND ITS APPLICATION IN THE GENERATION OF HIGH AFFINITY LIGANDS. The generation of random point mutations and selection of high affinity aptamers mimics the processes of evolution and natural selection. A random mutagenesis system has been coupled to the SELEX protocol in order to isolate sequences with high affinity to a target stem loop associated with RNase P in *Bacillus subtilis*. The mutagenesis system utilizes the 5'-triphosphates of 6-(2-deoxy-β-D-ribofuranosyl)-3,4-dihydro-8H-pyrimido-[4,5,C][1,2]oxazin-7-one (dP) and of 8-oxo-2'deoxyguanosine (8-oxodG). These two base analogues produce both transition and transversion mutations and yield mutational frequencies exceeding 1.9×10^{-1} when used in equimolar concentrations with the normal dNTP's. This system exploits the lack of proofreading activity of the *taq* enzyme in PCR to create and amplify mutations, thereby leading to a fairly randomized library of mutant sequences. The mutant library can then be transcribed and applied to several rounds of SELEX to generate aptamers with a high affinity to the target sequence. Conserved regions of the isolated sequences will provide clues to the possible structure of the aptamer-target sequence complex. Supported by the Howard Hughes Undergraduate Research Intership Program.

Chemistry/Geology Section

Herzog, M. and G. Cwick, Department of Geosciences, Southeast Missouri State University. MAPPING SURFACE FEATURES IN THE WIND RIVER BASIN OF WYOMING USING LANDSAT TM DATA. An area in the eastern portion of the Wind River basin containing a variety of bedrock outcrops, unconsolidated sediments and geologic structures was chosen as a test site to determine if Landsat Thematic Mapper (TM) imagery could delineate and map them. Some of these features are associatd with mineral and hydrocarbon resources found in this part of the basin. Several digital processing techniques such as spatial filtering, band ratioing and principal components analysis were employed on the original visible and near-infrared spectal channels to derive enhanced image products showing specific features of interest. These resultant images also served as input sources for supervised and unsupervised classification procedures which produced maps of the study area. Comparisons were ultimately made between the classified images and available field maps to ascertain feature correspondence. Preliminary results indicate that the TM data were sucessful in discriminating certain rock units and soils, although there were limitations in its ability to denote some types of structures.

Kaps, S.E. and D.J. Wronkiewicz. Department of Geology and Geophysics. MICROSCOPIC EXAMINATIONS OF SIMULATED CERAMIC WASTE FORMS. Proper disposal of radioactive and mining wastes requires key developments in storage technologies to keep waste products isolated from the biosphere. In this study, the microstructural characteristics of several types of waste forms are being investigated to identify features which may affect their durability. Examinations have been conducted using scanning electron, reflected, and transmitted light microscopy to find crystal deformational features which could cause increased rates of corrosion. The samples examined to date have not shown any evidence of crystal deformation. This indicates that either the deformational features do not exist or they are too small to be observed using the previously stated microscopic techniques. This project hopes to gain more insight using optical microscopic properties not previously conducted with the goal of using these synthetic mineral structures for containment of nuclear and mining waste materials. Supported by OURE

Myers, Fred and John Kuo. Department of Chemistry, Central Missouri State Univeristy. DEVELOPMENT OF THE TEACHING SOFTWARE "THERMODYNAMICS OF COMBUSTION OF ORGANIC COMPOUNDS." Combustion of organic compounds involves a number of important thermodynamic functions, such as heat capacity (Cp), change of enthalpy (H), change of Gibbs free energy (ΔG), and change in entropy (ΔS). Commonly, the change in ΔH, ΔG, and ΔS of an organic compound at standard conditions is tabulated. However, the change of these thermofunctions at different temperatures are not readily available. A study of the temperature dependence of these functions becomes difficult due to the amount of computation involved. To aid student learning of the thermodynamic functions in the field of combustion, we have developed the program "Thermodynamics of Combustion of Organic Compounds." The software was written in Visual Basic language for PC. The program automatically balances the chemical equation for the chosen compound. With a built-in database, the program calculates the values of the thermodynamic functions for about 50 common organic compounds at any selected temperature within a preset temperature range. The software also provides a real time graphical display of the dependence of thermodynamic functions on temperature.

Nees, D. Department of Geoscience, Southeast Missouri State University. MELANOCRATIC ENCLAVES IN THE GRANITEVILLE GRANITE: POSSIBLE MINGLING PRODUCTS. The Graniteville Granite is a well known A-type "tin granite" quarried many decades as "Missouri Red" at Graniteville, Missouri. The major facies is red, coarse-grained, two feldspar granite composed of quartz, microcline, and sodic plagioclase with minor biotite, muscovite, fluorite, and magnetite and traces of zircon, allanite and apatite. Quartz was the first phase to crystallize and forms distinctive multigranular 5-10mm "eyes" bounded by an embayed resorption surface. The granite hosts rare dark enclaves of two types: 1) subangular xenoliths of aphanophyric rhyolite country rock containing high temperature phenocrysts set in a formerly glassy matrix and 2) a 0.1-2.0m pillows of melanocratic two-feldspar microgranite. The latter are composed of 1-2mm microphenocrysts of acicular (24:1) Ca-plagioclase and ragged blades of Fe-rich biotite set in fine-grained matrix of blocky Na-plagioclase, acicular (20:1) apatite and anhedral quartz, alkali feldspar, Fe-oxide, and fluorite. The Ca-plagioclase microphenocrysts are intensely altered to clay and enclosed by unaltered rims of Na-plagioclase. The dark microgranite enclaves are non-foliated at all scales and enclose large grains of host-derived microcline, Na-plagioclase, and partially digested quartz "eyes". Outcrop and petrographic traits suggest the melanocratic microgranite enclaves are hybrid rocks that may have formed by injection of plagioclase-bearing mafic melt into the chamber of the Graniteville Granite magma before it rose to its present level

Stevenson, E. Department of Geosciences, Southeast Missouri State University. USING LANDSAT IMAGES TO MAP THE MISSISSIPPI RIVER MEANDER BELTS. LandSat imagery was used to observe lithologic differences in an area just south of New Madrid, Mo. in order to distinguish fossil meander belts and their components. Various band ratios and overlays were attempted with the LandSat images using G.I.S. approaches to distinguish lithologies. Cores and soil maps were used for ground truthing. Clay has a high reflectance pattern in band 5. Band 4 is good at gauging the soil moisture and positive water body identification. The product of bands 3 and 5 darken the clay rich areas, helping to indicate ridge/swale patterns in meander belts. A map of fossil meanders scrolls and a map of lithologies was generated, and will be used as a compoonent of a current study

to reconstruct the fossil course of the Mississippi River.

Walsh, R.M. and R. Glaser. Department of Chemistry, University of Missouri-Columbia. SN2 PREFERENCE ENERGIES IN THE GAS-PHASE IDENTITY REACTIONS OF DINITROGEN WITH DIAZONIUM IONS. The reactivities of diazonium ions vary over an extreme range. While benzenediazonium ions are stable, many heteroaromatic and alipha-tic diazonium ions are highly unstable. These differences are not fully understood. We studied the SN2 identity reactions of the prototypical methyl-, vinyl-, ethynl-, cyano-, and benzene- diazonium ions with ab initio methods (RHF, MP2) in the gas phase. Precoordination complexes and transition states were located and various attack paths were considered. The SN2 preference energies, the difference between the C-N dissociation energy and the SN2 activation energy, seem to correlate with the binding energy of the C-N bond. Also, barriers to front-side attack in these systems appear to relate to the C-N bond dissociation energy. Therefore, we feel that the stability of the benzenediazonium ion is due to a kinetic effect. Supported by the Howard Hughes Institute.

Wunderlich, R.F. Department of Geosciences, Southeast Missouri State University. GEOLOGY OFVANCILL HOLLOW NATURAL AREA AND INDIAN CREEK WILD AREA, TRAIL OF TEARS STATE PARK, CAPE GIRARDEAU COUNTY, MISSOURI. Geologic investigations are being conducted in the northern two thirds of Trail of Tears State Park as an internship project sponsored by the Missouri Division of Parks, Recreation and Historic Preservation. The objectives of this project are to verify previous mapping done at the quadrangle scale of 1:24,000, to add details to previous mapping, and especially to identify any unique geologic features. The topography is rugged with steep slopes and local relief of approximately 250 feet. Intermittent streams in narrow valleys drain the area, and the Mississippi River forms its eastern boundary. Vegetation cover is almost 100% mature hardwood trees. The best outcrops occur in the bluffs and two abandoned quarries along the Mississippi River. The strategy for this investigation has been to extend the geology from this well-defined base line into the interior of the Wild Area and Vancill Hollow. This has proved to be more difficult than was anticipated because of the cherty residuum and Quaternary loess which mantles the hill tops and slopes, leaving few visible outcrops. To date, no unique geologic features other than the spectacular but inaccessible river bluffs have been identified.

Physics/Engineering/Computer Science Section

Coon, Gabriel T. Department of Mathematical Sciences, University of Missouri-Columbia. GENERALIZATIONS OF THE VANDERMONDE DETERMINANT. The objective of the research was to find the determinant of generalizations of the Vandermonde matrix. The determinant of this matrix is known as the Vandermonde determinant. First I found the determinants of a few arbitrary generalizations of the Vandermonde matrix. Then I looked for a pattern in these determinants, and put forth a theorem for the determinant of n x n generalizations. I then proved these theorems. I found the determinant for a matrix equal to the Vandermonde matrix except that the power in the last column was raised to the power k + 1 greater than the power in the n - 1 column, such that k is an integer greater than one, to be the Vandermonde determinant times the sum of all monomials of degree k. I found the detrminant of a matrix equal to the Vandermonde matrix except the power in the second column is raised to a power k + 1 greater than the power in the first column to be the Vandermonde determinant times the sum of all monomials of degree k(n - 1) such that no exponent on each variable is greater than k. Finally I found the determinant of a matrix equal to the Vandermonde matrix except that the power in the f column is raised to power k + 1 greater than the power in the f - 1 column to be the Vandermonde determinant times the sum of all monomials of degree k(n + 1 - f) such that no exponent on each variable is greater than k. This theorem is of course consistent with the first two theorems and is a generalization of the first two theorems, so it is by far the most powerful. This theorem will be useful when finding the determinant of a generalization of the Vandermonde matrix where the powers in the columns greater than the first are raised to an arbitrary values where the powers are in ascending order which is simply a generalization of the final theorem I discovered.

Christy, Joseph, Department of Physics, University of Missouri-Columbia. CONSTRUCTION OF A SAMPLE HOLDER FOR AN UHV MBE SYSTEM. The purpose of constructing an Ultra-High-Vacuum (UHV, pressure $\leq 10^{-11}$ torr) Molecular-Beam-Epitaxy (MBE) system at the University of Missouri is to provide the capacity to prepare samples of the highest crystalline quality for study. In order to assure proper growth with sub-monlayer thickness control and *in situ* characterization, a sample holder was designed to allow 1) five degrees of freedom of movement to secure proper positioning of the sample, and 2) an operating temperature range of -200°C to +1200°C to ensure clean growth. The holder will be constructed out of various materials to facilitate certain necessary characteristics, for example, thermal isolation, thermal conductivity, electrical isolation, etc. The entire UHV system, including the sample holder and the flanges, will be baked-out at +200°C to lower the possibility of out-gassing and contamination during growth. Once the MBE chamber and its constituent elements have been completed, sample preparation can begin and investigation of the structural and magnetic characteristics of thin (and ultrathin) magnetic films and multilayers can ensue.

Good, W.S. Department of Physics and Astronomy, University of Missouri-Columbia. PHYSICAL MATRIX ANALYSIS OF BUCKMINSTER FULLERENE USING AFM AND STM TECHNIQUES. In order to ascertain bonding and polymerization properties of Buckminsterfullerene (bucky balls), it is important to see the physical matrix that it forms in bonding to another molecule. This study is focused on obtaining images at high resolution of bucky balls bonded to a molecule of similar size. The other molecule is of irregular shape which makes it possible to distinguish the round bucky balls. The diameter of bucky balls is on the order of 1 nm, so it is necessary to employ techniques of Atomic Force (AFM) and Scanning Tunneling (STM) microscopy. Images were taken, in air, on a vibration isolation platform. They were then analyzed for alignment and patterns among the bucky balls. The images will be displayed with analysis of the matrix of molecules. Supported by Howard Hughes Medical Institute, the University of Missouri-College of Arts and Science, and NSF RAIRE Grant No. 9620032.

Behavioral and Social Sciences Section

Adamson, B. C. Department of Geography, Northwest Missouri State University. THE SOUTH CHIPS IN: A GEOGRAPHICAL APPRAISAL OF MEN'S MAJOR COLLEGE GOLF. Much research has been conducted in the field of sport geography regarding male involvement in athletics. In particular, college football and basketball have extensive literature. However, at this time, little work has been conducted regarding the geography of men's golf at the collegiate level. The purpose of this study was to collect and analyze NCAA Division I Golf roster data in order to conduct the geographical analysis of golf. This required a study of the origin (hometown/high school) and destination (college) of the elite players. The golf roster data was collected from the National Collegiate Athletic Association (NCAA), participating sports information offices and team World Wide Web sites. It was then geocoded in order to be aggregated to city, state, and regional levels of geography. This geocoded data was in turn mapped to examine the resulting spatial distribution regarding pattern, density and dispersion to determine if variation in levels of involvement intensity exist. The results were then compared with perceptual golf regions as identified in the popular literature in an atempt to quantify vernacular regions.

Beasley, D.M. Department of Geography, Northwest Missouri State University. SNOWBELT VS. SUNBELT: THE GEOGRAPHY OF MAJOR COLLEGE BASEBALL. Few games played in the U.S. can be considered as 'American' as baseball. The 'Summer Game' has long been called America's national pastime. While competition from other sports has chipped away at that lofty place in the culture of this nation, interest in the college game is on the increase. Although much work has been conducted regarding the geography of professinal baseball, little if any has focused on the college game. The purpose of this study was to conduct a geographical analysis of major college (NCAA Division I) baseball. The variables that were assessed to determine regions of varying involvement include: tournament win-loss %, poll rankings, All-Americans, and player origin from 276 Division I teams during the time period, 1992-96. The origin and destination data was compiled by a geographic sampling of team rosters from the eight regions that comprise major college baseball. This

data was collected with the aid of the NCAA, team sports information offices and web sites. The data were geocoded for computer mapping and analysis. Per capita origin, by state of high school, maps indicated snowbelt states were equal to their much publicized southern counterparts. Additional maps also provided insight into the geography of recent major college baseball success.

Ciani, S.J. Department of Geology/Geography, Northwest Missouri State University. WINNING THE RACE: A GEOGRAPHICAL ANALYSIS OF ELITE FEMALE INTERSCHOLASTIC TRACK & FIELD PERFORMERS. The popular literature has indicated that interest and involvement in track & field in the United States is waning. This comes at a time when women's athletic opportunities, in general, have been increasing. Earlier research on the state origins of elite men's and women's interscholastic track and field performers, 1981-1985, indicated a marked regionalization when grouped by events. The event groupings were divided by sprints, distance, jumps and throws. Further investigation on the origins of top performers for the time period 1981-1990 at the state and county level of geography revealed marked spatial variations by individual events, grouped events and aggregate events. What changes, if any, have occurred since 1990? The purpose of this study was to determine the origins of the superior women's high school track & field athletes during the time period, 1991-97. Each year's list of top performers by event, numbers approximately 1,000 athletes. An updated geographic analysis indicates variations in performance by groupings which occur from region to region and within regions and states reflect a multitude of factors including state to state variations in participation opportunities, facilities, culture/tradition, and demographic composition.

Marquez, M.P. Department of Geography, Northwest Missouri State University. THE SOUTH CHIPS IN: A GEOGRAPHICAL APPRAISAL OF WOMEN'S MAJOR COLLEGE GOLF. Sport geographrs have conducted research, albeit limited, regarding women's professinal golf. As of this time, investigations into the geography of women's golf, at the collegiate ranks, are non-existent. The purpose of this study was two-fold: 1) to collect and analyze NCAA Divisiion I Women's Golf roster data; and 2) determiine the success of women's major college golf programs based upon poll rankings, team tournament success and individual honors. This required a study of the origin (hometown/high school) and destination (college) of the elite players. The golf roster data was collected from the National Collegiate Athletic Association (NCAA), participating sports information offices and team Wold Wide Web sites. It was then geocoded in order to be aggregated to city, state, and regional levels of geography. The team success variables were collected from the NCAA. This geocoded data was in turn mapped to examine if variation in levels of the involvement and intensity exist. Origins of golfers did not have a high degree of correlation with success of college programs. The map results were then compared with perceptual golf regions as identified in the popular literature in an attempt to quantify golf's vernacular regions.

McMichael, T.M. Department of Geography, Northwest Missouri State Univrsity. SOCIOECONOMIC FACTORS THAT CONTRIBUTE TO THE DISTRIBUTION OF COLORECTAL CANCER. The rate of incidence and death caused by colorectal cancer has increased in the United States. Missouri ranks in the top 20 states in new cancer cases as well as cancer related deaths. The purpose of this research project was to conduct a geographical analysis of the colorectal cancer cases in Missouri at the county level during the time period from 1991 to 1995. Data was collected from the Missouri Department of Health concerning new colorectal cancer cases and deaths for all counties in Missouri during this time period. Data analysis included the statistical comparison of increased incidence of new cancer cases and deaths with various socioeconomic factors. These factors include race, income, housing, education, occupational structure and population density. The resulting maps revealed a distinct regionalization of colorectal cancer within Missouri. Regions involved in primary and secondary occupations have experienced an increase in the number of new colorectal cancer cases and deaths.

Monroe, J.D. Department of Geography, Northwest Msisouri State University. PRESIDENTIAL ELECTIONS, 1976-1996: A POLITICAL GEOGRAPHY ASSESSMENT. Throughout the history of American Presidential elections, the outcome has generally been determined by the higher populated states with their greater number of electoral votes. The base on which Republican majorities

have been built in recent presidential elections has been a wide swath of states that has been referred to as the "Repbublican L." It takes in the Rocky Mountain region, the Plains states and the entire South. What are the characteristics that provide these consistent voting patterns within this region of the United States? The purpose of this study was two-fold: 1) to determine the spatial patterns of voting results at the state level for the Presidential elections over the last two decades and, 2) to identify the relationship between voting patterns and selected socioeconomic variables including: education, urban/rural status, income, employemnt, occupation, taxation, and percent of registered voters. Results identified distinctive regions associated with selected socioeconomic characteristics that provide a more detailed description of American political geography.

Morrow, Amy. Department of Political Science and Geography, Central Missouri State University. THE ANTIETAM GAME. By using Game Theory and quantitatively examining the production of the Union and Confederate armies throughout all five major conflicts of the Battle of Antietam, it can be numerically determined which army met with the most success. Through extensive research into documentation of losses incurred and assigning of points for designated occurrences, such as the wounding and killing of enemy soldiers, the battle can be numerically assessed. The battle is broken into rounds, as in a game, and each round is calculated separately. Then, all rounds are totaled, which leads to a clear conclusion that the Confederates should be declared the numerical victors of this most controversial contest. This shows that the methods of political science can be employed to quantitatively settle historical issues.

Potter, J.R. Department of Geography, Northwest Missouri State University. HOOPS RECRUITING--THE BATTLE OFF THE COURTS: A GEOGRAPHICAL ANALYSIS OF 1997 MEN'S MAJOR COLLEGE BASKETBALL BLUE CHIPS. Much work was conducted in the field of sport geography regarding recruitment of high school football and basketball players in the 1980s. This work by Rooney focused on high school origin data derived from college team rosters. This study differs, in the fact that, only the top or signed recruits (Blue Chips) makeup the database and all 308 NCAA Division I Men's Teams are included in the database rather than a sampling of rosters. This study mapped the most current data (1996-97) and determined how many of these blue chip players end up making the team at the college where they signed their national letter of intent. This study found one-third of the men's recruits to be from junior colleges. Thus, it was found to be important to further analyze the geography of blue chip recruits from junior colleges, as well as, high school origins. The data was mapped and analyzed using computer mapping and statistical analysis software. The resulting spatial distribution indicate distinct regions of high and low involvement exist.

Rinehart, M.A. Department of Geography, Northwest Missouri State University. THINCLADS: A SPATIAL ANALYSIS OF ELITE U.S. MALE INTERSCHOLASTIC TRACK & FIELD PERFORMERS. Where do the premier high school track & field athletes come from? Earlier research on the state origins of elite men's interscholastic track and field performers, 1981-1985, indicated a marked regionalization when grouped by events. The event groupings were divided by sprints, distance, jumps and throws. The purpose of this study was to determine the origins of the superior men's high school track & field athletes during the time period, 1991-97. Over 7,000 athletes make up the database that was geocoded from *High School Track*, an annual publication that lists the best high school performances from throughout the United States. The data was preprocessed adding zip codes based upon the athlete's high school and/or hometown. The resulting geographic analysis, consisted primarily of maps. These maps indicated a striking regionalization based upon event groupings and changes over time. Factors influencing these spatial patterns include demographical composition, settlement patterns, climate and tradition.

Stephanie, S.E. Department of Political Science, Central Missouri State University. CASE STUDY OF MISSOURI HOUSE BILL 1629 FOLLOWING THE POLICY MAKING PROCESS MODEL. The purpose of this examination of House Bill 1629 is to apply the policy making model to actual legislation and discover the attributes and flaws of the model. The author intends to establish the validity of the model in case study analysis and how the model could be modified to account for phenomena that occur at the state level of government. These phenomena include the misinformation that is received by the "attentive public," the effects of committee reactions, and the effects of the amendment process. The data collection process used is general observation and the analysis of

government documentation.

Smith, T.H. Department of Geography, Northwest Missouri State University. FROM BOSTON TO HONOLULU: A GEOGRAPHICAL ANALYSIS OF U.S. MARATHONS, 1997-1998. It is generally agreed by scholars that the decade of the 1970s witnessed the 'Running Revolution'. Previous work conducted in the field of sport geography regarding the spatial distribution of marathon racing in the United States reinforces the phenomenal growth in the number of marathons during that decade. What, if any, changes have taken place in the last 10-15 years? The purpose of this study was to collect and analyze marathon road race data in order to conduct the geographical analysis of marathon races. The race data were collected from several sources, including the 1997 Marathon calendar from the *Runner's World* web site. The race data were then geocoded in order to be aggregated to city, state, and regional levels of geography. This geocoded data were in turn mapped to examine the resulting spatial distribution regarding pattern, density and dispersion to determine if variation in levels of involvement intensity exist. Also, a temporal analysis was conducted to determine spatial changes since the 1970s study. It was found that the number of marathons has not increased since the 'Running Revolution'. However, the number of participants and the reliance on corporate sponsorship has increassed markedly.

Voge, M.D. and G.L. Goudge. Department of Geography, Northwest Missouri State University. PIGSKINS & BLUE CHIPS: 1997 HIGH SCHOOL FOOTBALL RECRUITS. The term 'Pigskin Cult' was coined by Rooney and Pillsbury in reference to the fusing of football into the southern culture. This melding began in the 1890s and has reached a zenith in recent years. Some of the evidence to support the Pigskin Cult is based on college and professinal football programs and player origins. If quality high school football is associated with this southern region, then the origins of the better players (Blue Chips) should be significantly influenced by this region. Thus, the purpose of this study is to determine the origins and destinations of the best high school football recruits who signed with NCAA Division I schools during the Spring 1997 national letter of intent signing periods. The blue-chip recruits numbering in excess of 2,000 players are mapped by zip code, county, state and conference. The resulting maps indicated a distinct regionalization of areas of high and low production of quality high school players. Also, when broken down by position striking patterns resulted.

Transactions of the Missouri Academy of Science

Vol. 32, 1998

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 promotiong 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 neceessary 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 Paprs 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 *Bulletins*, 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 $25.00 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 Academy Business Office:

   Missouri Academy of Science
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   W.C. Morris 203
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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.
   Names of two or three possible reviewers should be supplied in a cover letter.

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 6 1/2 x 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.