JOURNAL

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ARIZONA - NEVADA ACADEMY OF SCIENCE

FORTY FOURTH ANNUAL MEETING

April 15, 2000

The University of Arizona

Tucson, Arizona

1999-2000 Annual Reports

APRIL 2000
ACKNOWLEDGEMENTS

The Arizona-Nevada Academy of Sciences gratefully thanks the following individuals and groups for their generous support for the 2000 Annual Meeting.

College of Agriculture, University of Arizona
Desert Archaeology, Inc.
Institute for the Study of Planet Earth, University of Arizona
Office of Arid Lands Studies, University of Arizona
University of Arizona Vice President for Research
University of Arizona College of Science
Department of Geosciences, University of Arizona
ABBREVIATED SCHEDULE AND ACTIVITY LOCATIONS

Friday, April 14

6:00 - 7:30  Board Meeting and Registration
             University of Arizona, Harvill Building Room 150
7:30 - 9:00  Evening Speaker

Saturday, April 15

All section meetings on Saturday April 15 will take place on the campus of the
University of Arizona, Harvill Building

7:00 - 8:00  Registration: Atrium, First Floor
8:00 - 10:00 Paper Sessions (See Section Schedules)
10:00 - 10:30 Coffee Break in Atrium, first floor of Harvill Building
10:30 - 11:30 Paper Sessions (See Section Schedules)
11:30 - 1:40  Annual Academy Awards Luncheon and Business Meeting
              Plaza International Hotel - Wildcat Rooms 1 and 2
1:40 - 3:00  Paper Sessions (See Section Schedules)
3:00 - 3:30  Coffee Break in Atrium, first floor of Harvill Building
3:30 - 5:30  Paper Sessions (See Section Schedules)
4:30        Junior Academy Awards

A map of the University of Arizona campus is located at the end of the
Proceedings.
## SUMMARY OF SECTION MEETINGS

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* Indicates a paper to be considered for the Best Student Paper Award
Biology Section

SESSION I 8:00 A.M.

ROOM: 108

Chairperson: Stephen Shuster

8:00 - 8:15 A COMPARISON OF TWO METHODS FOR SAMPLING THE GULF OF CALIFORNIA MUD-SHRIMP, *NEOTRYPAEA UNCINATA* (CRUSTACEA: THALASSINIDEA).


Methods for collecting mud-shrimp are highly variable, and the efficiency of these techniques is poorly known. In October 1999, on a mud flat near Puerto Peñasco, Sonora, Mexico, we compared the "kiwi" method for extracting mud shrimp from their burrows with a core sampling method designed to accomplish the same goal. The coring method involved pressing a 10cm x 150cm PVC pipe into the substrate, creating suction in the pipe, and withdrawing a core of mud and the shrimp within. The kiwi method required 8-10 researchers to march in a circle on the mud flat to gradually liquefy the mud, thereby forcing shrimp to the surface as the circle closed inward. Two transects of 30 cores conducted at high and at low tide yielded similar numbers of adult animals of both sexes. Previous results show that mud shrimp tend to aggregate within burrows when breeding. In this collection, the distribution of mud shrimp in cores did not differ from a Poisson distribution, suggesting that these shrimp were non-reproductive. The kiwi method provided no such information on mud shrimp distributions. Moreover, this method generated significantly fewer intact mud shrimp than cores. Our results indicate that compared to the kiwi method, the coring method is more efficient, less destructive of mud shrimp habitat, and provides more precise information on mud shrimp populations.

8:15 - 8:30 ANALYSIS AND DISCUSSION OF ELEVEN MONTHLY SAMPLES OF THE GULF OF CALIFORNIA MUD SHRIMP *NEOTRYPAEA UNCINATA* (CRUSTACEA: THALASSINIDEA)

Herbert C. Wildey and Stephen M. Shuster (Northern Arizona University, Flagstaff, AZ)

*Neotrypaea uncinata* and other members of the family Callianassidae play important roles in estuarine and mud flat habitats yet many aspects of their biology remain poorly understood. We collected monthly samples totaling over 1400 mud shrimp from January 1999 to November 1999 at Estero Morua near Puerto Penasco, Sonora, Mexico. Shrimp were collected in 10cm x 150cm cores of mud along 30 meter transects. We gathered data on distribution of animals, carapace length, habitat preference, chela dominance, sex ratio, and
female reproductive condition of the population over this span. The presence of larger shrimp in submerged habitats suggests discrete habitat preferences for adult mud shrimp. A high frequency (0.9), relative to other months, of gravid females in the month of November indicates synchronous breeding, consistent with other studies of *Neotrypaea* spp.

**8:30 - 8:45** **THE EFFECTS OF CANNIBALISM ON NATURAL AND CAPTIVE POPULATIONS OF THE ENDANGERED SOCORRO ISOPOD.**

N. Zorich and S. Shuster (Northern Arizona University, Flagstaff, AZ) and B. Lang (New Mexico Game & Fish)

*Thermospheroma thermophilum* is an endangered species, endemic to a single spring in Socorro, NM, USA. Intraspecific cannibalism, in which large males attack smaller females and immatures, is well-documented in this species. In 1992, isopods from the natural population were introduced to 4 concrete propagation pools. We measured the body lengths of isopods collected from their native spring and from the 4 concrete pools in 1996 and 1998. The average body lengths of spring isopods did not change during the sampling period and did not differ significantly from samples collected in 1978-79. However, average body lengths of isopods collected from the concrete pools in 1996 were significantly larger than those in the spring, and average body lengths of isopods collected in 1998 were significantly larger than those of isopods collected from the same pools in 1996. The degree of sexual dimorphism in body length among pools correlated negatively with increasing physical structure (i.e. refugia from cannibals) within pools. Rearing experiments were used to estimate heritability of body size and intensity of cannibalism. Also, we attempted to determine trophic linkages using stable isotopes. We suggest that large body size and increased sexual dimorphism have evolved within captive populations in response to intraspecific cannibalism on females, as well as on small or slow growing juveniles.

**8:45 - 9:00** **THE EFFECTS OF MATING ORDER ON FEMALE FECUNDITY IN A MARINE ISOPOD, *PARACERCEIS SCULPTA* HOLMES (CRUSTACEA: ISOPODA).**

Saundra Embry and Stephen M. Shuster, (Northern Arizona University, Flagstaff, AZ)

Sperm utilization strategies are poorly understood among isopod crustacean females. In the Gulf of California isopod, *Paracerceis sculpta*, females are attracted to breeding sites in sponges that are defended by individual males. Although average harem size equals 1.5 females per male in this species, harems commonly include five or more females. If male fertility decreases with mate numbers, late arriving females could suffer decreased fecundity. To determine if the order in which a female mates with a male influences the number of offspring she produces, we mated three to five females to each of 15 males. If mating order influences female fecundity, we expected female fecundity to decrease with increasing mating order. Using ANCOVA, with female body size as the covariate, we found no relationship between mating order and fecundity in this species. Our results indicate that
males can mate more than once without decreased fertility and that females do not suffer decreased fitness by mating with already mated males. These results justify sperm competition experiments in which males mate more than once. We will report the results of a study in which females mate twice with males bearing distinct allozyme markers. By balancing the order in which matings occur and electrophoresing the progeny, we will determine if first male or last male mating advantage occurs in this species.

9:00 - 9:15  THE EFFECTS OF LINKAGE AND SELECTION ON ALLOZYME VARIATION IN A MARINE ISOPOD, PARACERCEIS SCULPTA HOLMES (CRUSTACEA: ISOPODA).

Kimberly Perry and Stephen M. Shuster (Northern Arizona University, Flagstaff, AZ)

Three discrete male morphotypes coexist in P. sculpta. Phenotypic differences among males are caused by a major gene (Ams=alternative mating strategy), whose inheritance is Mendelian and whose alleles exhibit directional dominance (Ams\^B>Ams\^Y>Ams\^A). Alloalleles of the enzyme, phosphoglucomutase (Pgm) segregate with male phenotype, indicating that Pgm and Ams are closely linked, although alleles at each locus are not in linkage disequilibrium. Pgm alleles can thus serve as genetic markers for alleles at Ams. Alleles at Ams appear to be under strong frequency-dependent sexual selection. Since Ams and Pgm are closely linked, frequency-dependent selection on Ams alleles is expected to generate variation in the frequencies of Pgm alleles through "hitch-hiking." Thus, Pgm allele frequencies are expected to be more variable than those observed among allozyme loci that are not linked to Ams. We tested this hypothesis by first calculating the average frequency of the most common allele for each of four, tri-allelic loci (Pgm, Pgi, Mdh2 and 6pgdh) between 1987-88. We then calculated for each locus in each sample, the deviation in the observed frequency of the most common allele, from its average frequency. Using ANOVA, we found that the magnitude of the observed deviations from the average frequency for each locus differed significantly, with Pgm deviations being greatest. Our results are consistent with the hypothesis that genetic variation at neutral loci is enhanced by linkage to loci under selection.

9:15 - 9:30  THE EFFECTS OF FOOD AVAILABILITY ON ADULT PHENOTYPE IN PARACERCEIS SCULPTA HOLMES (CRUSTACEA: ISOPODA).

E. Omana, K. Johnson, S. Embry, J. Learned, S. Vuturo, and S. Shuster (Northern Arizona University, Flagstaff, AZ)

Three discrete male morphotypes coexist in P. sculpta. Phenotypic differences among males are caused by a major gene (Ams=alternative mating strategy), whose inheritance is Mendelian and whose alleles exhibit directional dominance (Ams\^B>Ams\^Y>Ams\^A). To determine the effect of food availability on the expression of adult phenotype, we reared individuals to maturity from homozygous Ams\^A lineages under high and low treatments of food availability (food provided every 2 days; food provided every 4 days). Among families, we found significant family and sex effects on adult body length (F\^{11,167}=2.39, P<.01;
F[2,167]=22.78, P<.001), molt number (F[11,168]=3.68, P<.001; F[2,168]=5.44, P<.001) and maturation rate (F[11,168]= 7.58, P<.001; F[2,168]=3.81, P<.03). These results indicate that (a) body length, molt number and maturation rate are heritable, and (b) that these characters differ between the sexes. Alpha-males are larger and molt more than females before maturity. In Ams² lineage, feeding treatment significantly affected body length and days to maturity, but had no effect on molt number. Starved individuals were smaller and took longer to mature than well-fed individuals. These results suggest that molt number in this species is constant and that nutrient deficits limit intermolt growth and delay sexual maturation.

9:30-9:45 EVIDENCE OF SIMULTANEOUS HERMAPHRODITISM WITH A PROTANDROUS PHASE IN THE COMMENSAL POLYCHAETE OPHIODROMUS PUGETTENSIS

Steven Vuturo and Stephen Shuster (Northern Arizona University, Flagstaff, AZ)

Hermaphroditism is common in polychaete worms. Here we report the appearance of this reproductive strategy in O. pugettensis, a hesionid known to inhabit and suspected to breed in the ambulacral grooves of sea stars. We examined the reproductive condition of 181 polychaetes inhabiting the ambulacral grooves of 22 host stars (Asterina = Patiria miniata) collected from Venice Beach, California in November and in December 1999. We classified individuals from both collections into one of three reproductive conditions: (1) male possessing motile sperm, (2) simultaneous hermaphrodites with sperm and small eggs, (3) simultaneous hermaphrodites with sperm and large eggs. Six percent of the first collection were hermaphrodites. In the second collection we compared the number of segments in each class using ANOVA. We found significant differences among the three classes (F = [2,101] 22.75, p = .0001) in the number of segments. A Tukey-Kramer HSD post hoc test showed no differences in the number of segments between the two classes of hermaphrodites. However male worms had significantly fewer segments. Less than twelve percent of all worms in the December sample were hermaphrodites. Our observations suggest that O. pugettensis is protandrous, that is worms mature testes at small sizes and as they grow they develop ovaries and become hermaphrodites.

9:45 - 10:00 AN ANALYSIS OF GENETIC DIFFERENCES AMONG NINE POPULATIONS OF THE FRESHWATER ISOPOD THERMOSPHAEROMA SUBEQUALUM COLE AND BANE.

Jennifer Learned and S. Shuster (Northern Arizona University, Flagstaff, AZ)

The eight described species of Thermosphaeroma isopods inhabit warm springs in Mexico, Texas, and New Mexico. Thermosphaeroma subequalum, the easternmost described species of the genus, is found in nine hot springs located on both sides of the Rio Grande River over approximately 90 miles. To determine if the nine populations of T. subequalum are isolated within the hot springs or represent one continuous population, we examined genetic variation at 9 allozyme loci using starch gel electrophoresis. We then analyzed these results for deviation from Hardy-Weinberg equilibrium and
calculated the $F$-statistics and Nei’s genetic distances for all nine populations. Our calculated mean $F_{ST}$ value of 0.1032 reveals moderate genetic differentiation and the Nei’s distance results split the populations into two groups at a distance of 0.0485. These results indicate that significant population structure does exist among the nine *T. subequalum* populations.

10:00 - 10:30 COFFEE BREAK - ATRIUM OF HARVILL BUILDING

10:30 - 10:45 *POPULATION ECOLOGY OF A DESERT PERENNIAL, *HESPEROCALLIS UNDULATA*

Janelle R. DeGroot, Thomas R. Jones (Grand Canyon University, Phoenix, AZ)

_Hesperocallis undulata_ (ajo lily) is a perennial, bulb-forming, herbaceous plant found in sandy soils in the Mojave and Sonoran deserts. Its life history is similar to that of desert ephemerals in which germination, growth, and reproduction occur in response to a very specific set of environmental conditions. As a result, little is known about basic population biology, e.g., phenology, age distribution, and reproductive ecology. We have collected data on lilies for two years in the Mohawk Dunes in southwestern Arizona. During the El Niño winter of 1998 we marked 680 plants on a 2500 m$^2$ plot; another 36 individuals were added in 1999. We assigned individuals to age classes (seedling, juvenile, subadult, adult) based on leaf size, leaf number, and reproductive status. In 1998 we collected data on leaf number, scape height, number of flowers, and number of fruits. In 1999 we described leafing phenology only; no individuals flowered. Age distribution for 1998 and 1999, respectively, was as follows: seedlings (51% and 13%), juveniles (29% and 76%), subadults (14% and 10%), adults (6% and 1%). Of the 1999 plants (n = 136), 100 had reemerged from 1998, and the 36 new individuals included seedlings, juveniles, and subadults. Distribution of individuals among age classes in any year might not reflect actual population demography, however, because we have no data on bulb survivorship. Despite substantial growth in 1998, reproductive success was low (12.2% of flowers produced fruit).

10:45 - 11:00 CRYPTANTHA (BORAGINACEAE) - ARIZONA ANNUALS AND ANGUSTIFOLIAE

Jeffrey Wayne Brasher (Arizona State University, Tempe, AZ)

_Cryptantha_ is a genus of about 150 species of South America and especially western North America. There is a widely recognized need for _Cryptantha_ specialists. Herbaria have many misidentified specimens, the last monograph for North America was published in 1925, and a search of the literature shows many disagreements between authors on the classification of species. Two related studies are underway. First, a dissertation on _Cryptantha_ section _Krynitzkia_ series _Angustifoliae_, a group of about 9 annual species centered in the Sonoran Desert. It will be a complete taxonomic revision supplemented by DNA sequence data and cladistic analysis. Second, a treatment of the 22 annual species of _Cryptantha_ for
the future *Manual of the Vascular Plants of Arizona* that will replace Kearney and Peebles' *Arizona Flora*. The two *Cryptantha* projects together include about 26 species. Thus far I have collected all but 1 or 2 of the Arizona annual species and about half of the species of series *Angustifoliae*. Findings on two species have been particularly interesting. 1) The first collection of *C. dumetorum* in Arizona and east of the Colorado River was made. 2) *Cryptantha albida* was collected in Arizona for the first time since 1986 and only the second time since 1944. It apparently was more common in Arizona prior to 1944.

11:00 -11:15 **FREDERICK MORTIMER IRISH: FOUNDER OF THE ASU HERBARIUM**

Amy Trauth-Nare and Donald J. Pinkava (Arizona State University, Tempe, AZ)

In 1896, Frederick Mortimer Irish of Dubuque, Iowa was hired by the Arizona Territorial Normal School (later Arizona State University) to instruct the sciences. During his 45-year tenure at ASU, Irish served as more than simply a science instructor. He served in the capacity of Registrar, the first football coach, sponsor of the Cactus Walking Club as well as other outdoor organizations, and leader of the Cadet Corps, a military training group.

Among his many noteworthy accomplishments, Irish founded the ASU herbarium with his contribution of more than 715 collections from various parts of Arizona, including San Francisco Peaks, Sierra Anchas, and the Superstition Mountains. The Frederick M. Irish collections date from 1887 until 1920 and represent Arizona flora before the presence of large urban areas. His early botanical exploration and collections of Arizona are here recorded in a Microsoft Access database as an important record for understanding past distributions of plants. The database contains all Irish collections housed at the herbaria of Arizona State University (ASU) and the Desert Botanical Garden (DES).

11:15 - 11:30 **VASCULAR PLANT TYPE SPECIMENS IN THE ARIZONA STATE UNIVERSITY HERBARIUM**

Stefanie M. Ickert-Bond and Donald J. Pinkava (Arizona State University, Tempe, AZ)

The Arizona State University Herbarium (ASU) contains 749 type specimens of vascular plants. These include 28 holotypes, 348 isotypes, 4 isolectotypes, 9 isosyntypes, 3 neotypes, 4 isoneotypes, 222 paratypes, and 103 isoparatypes and 28 type specimens of unconfirmed status. For each basionym typified by an ASU specimen we provide with its original description and publication, collector and collection number, locality information, and date. The type specimen list reflects the history and strength of the ASU herbarium. Regionally the majority of the specimens are from Mexico (366), while 335 are from the U. S., 21 from South America and 26 from the Old World. Taxonomically the majority of type specimens belong to the Asteraceae (174), followed by Cactaceae (76), Polygonaceae (60), Scrophulariaceae (39), Malvaceae (31) and Rosaceae (21). Significant are the 70 type specimens collected by C. G. Pringle, a prominent early plant collector in Mexico from 1885 to 1909. Other busy “type collectors” include N. H. Holmgren with 50 type collections,
J. L. Reveal with 48 type collections, D. J. Pinkava with 47, and G. B. Hinton contributing some 30 type specimens.

11:30 - 1:40 ANNUAL ACADEMY AWARDS LUNCHEON AND BUSINESS MEETING - PLAZA INTERNATIONAL HOTEL

SESSION II: 1:45 P. M.

ROOM: 108

Chairperson: Stephen Shuster

1:45 - 2:00 CRUCIFIXION THORNS: CONVERGENT DESERT ADAPTATION OF THREE UNRELATED GENERA

Carol Crimmins, Stephanie M. Ickert-Bond and Kathleen B. Pigg (Arizona State University, Tempe, AZ)

Three genera are commonly known as crucifixion thorns in the Southwest deserts: Canotia holacantha Torr. (Celastraceae), Castela emoryi (Gray) Moran & Felger (Simaroubaceae) and Koeberlinia spinosa Zucc. (Capparaceae). Although these plants exhibit similarities in overall appearance, they have distinctly different floral features and are assigned to three separate families. In the present study we describe new features of stem anatomy and cuticle micromorphology for the three genera as observed with light and scanning electron microscopy. All three genera have thick cuticle, cyclic stomata and prominent stomatal plugs. While both Castela and Canotia have deeply sunken, tricyclic stomata, those of Koeberlinia are only slightly sunken. External stem surfaces of Canotia and Koeberlinia have granular to amorphous wax platelets, but lack trichomes. Castela has abundant, long tapering trichomes and elongate epidermal extensions resembling volcanoes. Stomatal orientation is characteristic at the family level, while some other features such as stomatal plugs and cuticle thickness are apparently xeromorphic adaptations.

2:00 - 2:15 NEW COLLECTIONS OF LESQUERELLA AND PHYSARIA (BRASSICACEAE) AS SOURCES OF HYDROXY FATTY ACIDS

Andrew Salywon (Arizona State University, Tempe, AZ) and Dave Dierig (USDA-ARS, Phoenix, AZ)

All the species of Lesquerella and the closely related genus Physaria (Brassicaceae) possess seed-oil rich in one of three types of hydroxy fatty acids (HFA) as the main component of its oil profile. These HFA’s (lesquerolic, densipolic, auricolic) could be used as replacements for imported castor oil in the production of plastics, lubricants, protective coatings, surfactants, cosmetics, and pharmaceuticals. Because of considerable genetic
variation for chemical composition of the seed oil and other important agronomic characteristics both within and among species, new germplasm is required to assist the commercialization efforts, therefore we have made new collections from the US and Mexico. Hybridization and polyploidy shows promise for increasing favorable traits so cytology is being carried out on new accessions. Several new chromosome counts have been attained along with the first record of an inversion in *Physaria*.

2:15 - 2:30  DIATOMS OF TOWN LAKE

Jennifer Hunter, Mark Compton, Doug Crowl, and Milton Sommerfeld (Arizona State University, Tempe, AZ)

Tempe Town Lake is the newest and largest of the urban lakes in the Phoenix metropolitan area. Town Lake extends over two miles of the Salt River bed and contains one billion gallons of water. Initially the lake was filled with Colorado River water through the Central Arizona Project canal water system. Town Lake may also receive water from other sources during its operation, including flood waters from the Salt River and Indian Bend Wash, and ground waters from several recovery wells. Changes in source water may influence the water chemistry and biota of Town Lake. Phytoplankton abundance and species diversity, for example, may be altered by changes in nutrient availability, temperature, and light penetration. The purpose of this research is to enumerate and identify diatoms present in Town Lake and to determine if the diatom population changes over time as the lake ages. Monitoring the diatom population, an important component of the phytoplankton, will provide a historical perspective of an aspect of the lake biota. Weekly samples were taken during the filling of Town Lake (June-July) and monthly samples were taken once the lake was filled (July-December). This report will provide a survey of the diatoms during the first six-months of Town Lake's existence.

2:30 - 2:45  THE EFFECTS OF SILICON DEPLETION ON LIPID METABOLISM IN THE DIATOM CHAETOCEROS MUELLERI

Nancy Engel, Karen McGinnis, and Milton Sommerfeld. (Arizona State University, Tempe, AZ)

Research regarding microalgae as a bio-fuel feedstock has been ongoing for many years. Potential products from algal feedstocks include pseudo vegetable oil (PVO), ester fuel, gasoline, methane, and ethanol (Neenan et al., 1986). Numerous microalgae, including multiple species of diatoms, have been examined as possible lipid sources. In an attempt to enhance lipid synthesis, microalgae have been subjected to physiological stress by limiting nutrients such as nitrogen, phosphorus, and silicon (Taguchi et al., 1987). The response time for lipid accumulation in various species of diatoms is reduced with silicon deficiency compared to other nutrients evaluated (Werner 1977). The rapid response time may reflect the importance of silicon in diatom reproduction. The objective of this study was to determine the effects of silicon-depletion on growth rate, intracellular lipid accumulation, and lipid composition in *Chaetoceros muelleri*. Lipid yield in *Chaetoceros* increased with
silicon-depletion, whereas growth rate decreased. Fatty acid composition under these conditions was evaluated using gas chromatography mass spectrometry (GC/MS) analysis. Silicon-depletion resulted in an increase in short chain saturated fatty acids and a decrease in long chain polyunsaturated fatty acids. Western blot analysis was used to determine if the relative amounts of fatty acid biosynthetic proteins differed between silicon-deplete and -replete cultures.

2:45 - 3:00  BASELINE STUDY OF THE BATS OF KARTCHNER CAVERNS STATE PARK, ARIZONA

Debbie C. Buecher (Cave Research Foundation, Tucson, AZ)

Kartchner Caverns, a recently developed cave in southeastern Arizona, is a summer maternity roost for approximately 1000-2000 cave myotis (Myotis velifer). The pregnant females first arrive at the cave in late April, give birth in June, and have left by mid-September. These bats are an important element in the cave ecosystem because their excrement introduces nutrients, which support a complex invertebrate cave fauna. Bat population densities and emergence behavior were monitored between 1988-1997. Because bats are easily disturbed by human intrusion into their roost, the baseline study was accomplished using low-disturbance techniques in an effort to provide the greatest amount of data with the least disturbance to the bat colony.

3:00 - 3:30  COFFEE BREAK - ATRIUM OF HARVILL BUILDING

3:30 -3:45  PREDICTING THE EFFECTS OF KARTCHNER CAVERNS DEVELOPMENT ON BAT POPULATIONS IN THE WHETSTONE MOUNTAINS

Ronnie Sidner, Ph.D. (Ecological Consulting, Tucson, AZ)

Development of Kartchner Caverns State Park at the base of the Whetstone Mountains has initiated a transformation in southeastern Arizona where previously there had been only very small towns, large ranches, and much primitive backcountry. There are new businesses, large properties subdivided for private home lots, new houses under construction, and a two-lane road from I-10 to Sierra Vista has burgeoned into a four-lane highway. All these changes will impact wildlife in the Whetstones. The effects of this transformation on some species, although significant, will be difficult to verify. Prior to the pre-development studies at Kartchner Caverns, only one species of bat from the Whetstone Mountains was known from published references, compared to published lists from the nearby Santa Rita, Huachuca, Rincon, and Catalina mountain ranges (with 17, 18, 20, and 21 species of bats, respectively). When I participated in the baseline study at Kartchner Caverns, we enumerated a list of nine species of bats from the immediate area of the Caverns (and thus the Whetstones). Potential effects to bat populations following development include potentially
positive factors such as increased availability of drinking water, increased nutrients at
hummingbird feeders and insects at lights, and artificial roostsites in buildings. Negative
factors include increased pesticides and predators, and significant loss of natural roostsites
due to disturbance by increased numbers of hikers and explorers.
Chemistry Section

SESSION I: 8:00

Room: 240

Chairperson: Paul Smolenyak

8:00 - 8:20 ASYMMETRIC SYNTHESIS OF 2,7-DIAMINOSUBERIC ACID
Shane Ellison, Mike Scott, Edgar Civitello (Northern Arizona University, Flagstaff, AZ)

Peptides play a diverse role within the human body as hormones, neuromodulators, neurotransmitters, and transcription factors. Synthetic peptides and their analogs show excellent potential in the treatment and diagnosis of disease including cancer, infection, and thrombosis. Modified amino acids are essential in the development of these therapeutic peptides. The focus of our research is the synthesis of modified amino acids to optimize many key properties of peptides such as metabolic stability, biodistribution, and bioavailability. Specifically, an approach toward synthetic alteration of cystine-containing peptides such as somatostatin, oxytocin, and calcitonin is presented. To achieve this a 2,7-diaminosuberic acid (Dsa) derivative will be synthesized. Dsa is a modified amino acid that is expected to increase the metabolic stability of peptides containing a biologically labile cystine disulfide bond. It is designed to replace the disulfide bond with a more stable "dicarba" analogue. A stereochemically pure and selectively protected Dsa derivative, suitable for peptide synthesis, has not been previously reported. Our goal is to synthesize such a derivative and demonstrate its utility in the synthesis of a "dicarba" analog of a peptide drug.

8:20 - 8:40 THE SYNTHESIS OF CHROMIUM(III)-DNA-PROTEIN CROSSLINK MODELS
Rick Lenieke, Karin Haebe, Diane Stearns, Ph.D., Edgar Civitello, Ph.D. (Northern Arizona University, Flagstaff, AZ)

Chromium(VI) is a human lung carcinogen that is genotoxic and mutagenic. However, the molecular mechanism of Cr(VI)-induced DNA damage is poorly understood. Studies show that Cr(VI) is unreactive towards DNA, unless a reducing agent is present. Once inside the cell, Cr(VI) undergoes reduction to Cr(V), Cr(IV), and the final product of Cr(III). Cr(III)-DNA adducts are found in cells and animals exposed to Cr(VI), but their structures are unknown.

We are testing the hypothesis that Cr(III) is responsible for the formation of Cr(VI)-induced DNA adducts, rather than Cr(V) or Cr(IV). Our goal is to synthesize a series of dinucleotide-peptide conjugates to model the possible Cr(III) coordination environments in these adducts. The project involves the development of solution-phase methods for both
peptide and DNA synthesis, as well as a method for their conjugation. Several peptide-DNA conjugates will be synthesized to optimize the stability of the chromium complex. For our first target we chose to incorporate two guanines (dGpG) as the dinucleotide because they are known to bind metals. The peptide sequence Histidine-Glycine, was also chosen for its known ability to bind chromium. Connection of these two pieces through the phosphate backbone of dGpG gives the target peptide-DNA ligand.

From these models, structural and chemical information can be obtained to aid in the isolation and characterization of Cr-DNA adducts formed in vivo and in cultured cells. This new understanding will help to identify biomarkers to assess human chromium exposure, and will help to clarify how Cr(VI) causes cancer.

8:40 - 9:00 CHROMIUM(III) DIETARY SUPPLEMENTS CAUSE MITOCHONDRIAL DAMAGE IN CHINESE HAMSTER OVARY AA8 CELLS

Kevine Manygoats and Diane Stearns (Northern Arizona University, Flagstaff, AZ)

Chromium(VI) is a human carcinogen and is reduced intracellularly to Chromium(III). Cr(III) can cause DNA damage and mutations in vivo. We hypothesize that Cr(III) also causes structural damage to mitochondria. Transmission electron microscopy is currently being utilized to analyze subcellular structural damage caused by two Cr(III) complexes, Cr(III) picolinate and Cr(III) chloride hexahydrate, and the free ligand, picolinic acid. Chinese hamster ovary AA8 cells were exposed to Cr(III) complexes and picolinic acid for 48 hours. Observed structural damage consisted of swollen/engorged mitochondria and degraded cristae. Ct(III) complexed are currently being widely used by humans as a dietary supplement and their safety has not been thoroughly investigated.

9:00 - 9:20 *.CHROMIUM GLUTATHIONE COMPOUNDS: MODELS FOR BIOLOGICALLY ACTIVE CHROMIUM

Brian Picard and Dr. Diane Stearns (Northern Arizona University, Flagstaff, AZ)

Chromium(VI) has been shown to cause lung cancer, but the mechanism of action is still unknown. We hypothesize that chromium(III) is the ultimate DNA damaging agent. Chromium(VI) enters the cells and is reduced by biomolecules such as glutathione, cysteine, and ascorbate. It has been shown that glutathione and cysteine are the major chelators of chromium(III) in chromium(VI) treated cells. The chromium(VI) is reduced to chromium(V), chromium(IV), and radicals and ultimately to chromium(III), which is the chelation product. No current knowledge is known about the exact chemical structure of the products. The focus of this thesis research is to synthesize chromium(III) complexes of both cysteine and glutathione products as well as to characterize these compounds using a variety of sensitive instrumentation such as nuclear magnetic resonance, infrared spectroscopy, and mass spectroscopy. Products of the reaction between chromium(VI) glutathione will be
compared to those of the reaction of chromium(III). These compounds will then be used to help elucidate the process by which chromium(VI) induces cancer.

9:20 - 9:40  FIBER-OPTIC SPR: DEVELOPMENT OF LOW COST, FIELD PORTABLE INSTRUMENTATION FOR ENVIRONMENTAL AND ON-LINE INDUSTRIAL ANALYSIS.

LA Obando, KS Booksh (Arizona State University, Tempe, AZ)

Three aspects of multi-mode fiber optic SPR probes have been studied: (1) the development, use and unique properties of straight and tapered probes, (2) the analysis of pesticides using functionalized SPR probes and (3) the assembly and packaging of a robust, low cost, field portable system. Three variations of the SPR fiber optic probe geometry have been developed. The fiber optic probes have been used to determine PAH concentration and refractive index of solutions such as sucrose, ethanol and sodium chloride using traditional and novel techniques. Tapering the probe tips can be used to shift and select the wavelength of SPR. Therefore, probes can be tailored to maximize features such as dynamic range and sensitivity for a specific application. Probe tapering results in increased information to noise ratios, more than four-fold increase in sensor sensitivity, and multiple resonance features that enhance calibration using multivariate techniques. These probes are ideal for use in environmental systems as they are easily coupled to an inexpensive spectroscopic system designed in the lab. Tests show that a low cost, portable system (11.6nm resolution) has comparable performance to a high-resolution system (2.4nm resolution). Any precision and accuracy that may be lost in using low cost equipment is regained by using multivariate calibration techniques. SPR fiber optic, multimode probes represent portable SPR sensing systems for environmental and on-line industrial applications.

9:40 - 10:00  FIBER OPTIC PROBES FOR DEEP-SEA EXPLORATION

ML Nahorniak, KS Booksh (Arizona State University, Tempe, AZ)

Abundant biological activity is present in hydrothermal seafloor systems known as black smokers. These cracks in the earth’s surface vent superheated water containing large amounts of hydrogen sulfide and metal ions into the sea. It is hypothesized that the reaction between iron (II) sulfide and hydrogen sulfide, resulting in the formation of pyrite, may provide the energy necessary to support microbial ecology. A fiber optic probe has been designed to monitor substances formed in a static catalytic reactor, and eventually in an artificial black smoker, under extreme pressures and temperatures using Raman spectroscopy. In addition, an SPR (surface plasmon resonance) fiber-optic probe for salinity measurements has been developed and preliminary results obtained.

10:00 - 10:30  COFFEE BREAK - ATRIUM OF HARVILL BUILDING
10:30 - 10:50 THE WAVEGUIDE RESONANCE (WGR) SENSOR: AN IMPROVEMENT ON CONVENTIONAL SURFACE PLASMON RESONANCE (SPR)

John Bradshaw, Sergio Mendes, Scott Saavedra (University of Arizona, Tucson, AZ)

Surface Plasmon Resonance (SPR) has been widely used as a bioanalytical sensor platform for several years. Its popularity is due to its ability to measure very small changes in the refractive index caused by the interaction of molecules adsorbed at the metal film surface with the exponentially decaying evanescent field created by the surface plasmon. We have developed a device that is related to, but is more sensitive than conventional SPR. This device consists of a conventional SPR silver film over coated with a thin dielectric layer of high optical quality, producing a laminate waveguide structure with enhanced resonance profile characteristics. One enhancement is that the waveguide resonance (WGR) device displays narrower resonances and an improved sensitivity over conventional SPR. Another enhancement is that this device couples both TE and TM polarized resonances, whereas conventional SPR only couples TM. The use of both TE and TM polarized resonances adds information content to the WGR technique which is unattainable with SPR.

10:50 - 11:10 FORMATION AND CHARACTERIZATION OF STABLE SUPPORTED PHOSPHOLIPID BILAYERS

Eric Ross, John Conboy, Sanchao Liu, Scott Saavedra, David O’Obrien (University of Arizona, Tucson, AZ)

The utility of phospholipid bilayers as biocompatible surfaces is hampered by the low stability that these structure exhibit. Towards their use in such applications as biosensing platforms it is desired to design a phospholipid bilayer structure that withstands the transfer from aqueous to atmospheric environments. An approach used in our laboratory is the use of lipid monomers that allow the upper and lower leaflets of the bilayer to be crosslinked through polymerizable moities in the lipid tail groups. This study focuses on the use of vesicle fusion to form phospholipid bilayers before polymerization of the films. The phospholipids used in this study are sorbyl and denoyl modified phosphatidylcholines. The bilayer structures are characterized by a number of techniques and a discussion of their use as biocompatible surfaces is included.

11:10 - 11:30 LOW COLLISION ENERGY QUANTITATION OF METHYL / HYDROXY TERMINATED SELF-ASSEMBLED MONOLAYERS.

Darrin L. Smith, Vicki H. Wysocki (University of Arizona, Tucson, AZ)

Low energy ion-surface collisions (<100 eV) monitored with a tandem quadrupole mass spectrometer are used to qualitatively and quantitatively characterize self-assembled monolayer (SAMs) surfaces. For example, mixed self-assembled monolayers consisting of
HS(CH₂)₁₁CH₃ and HS(CH₂)₁₁OH were prepared by spontaneous adsorption with varying ratios of the thiol mixture (in THF) onto Au (111) surfaces. In addition, an asymmetrical disulfide that was composed of the two individual thiol chains mentioned above was used to prepare a 50/50 surface. The surfaces were subjected to a 20 eV ion-surface collision with molecular pyrazine ion, M⁺ (m/z 80). At 20 eV collision energy, a reaction occurs between the molecular pyrazine ion and available hydrogen atoms on the terminal portion of the target film. This produces a reaction peak, MH⁺ (m/z 81). Also during the collision, the M⁺ and MH⁺ ions gain sufficient internal energy to fragment. The resulting fragmentation peaks at m/z 53 and m/z 54 correspond to fragments that undergo a neutral loss of HCN from the M⁺ ion and the MH⁺ ion, respectively. The integrated peak areas were then used to generate a reaction quotient, (MH⁺ + 54) : (M⁺ + 53), that is a measure of the availability of hydrogen atoms. It is observed that by increasing the concentration of HS(CH₂)₁₁OH in solution, the reaction quotient also increases. This quotient is used to quantitate a series of these mixed SAM surfaces over a range of %OH surface composition.

11:30 -1:40 ANNUAL ACADEMY AWARDS LUNCHEON AND BUSINESS MEETING - PLAZA INTERNATIONAL HOTEL

SESSION II: 1:40

ROOM: 240

Chairperson: Paul Smolenyak

1:40 - 2:00 *ATMOSPHERIC LEAD DEPOSITION AT THE MOHAVE POWER PLANT IN LAUGHLIN, NEVADA

Jens-Uwe Kuhn, and Richard D. Foust, Jr. (Northern Arizona University, Flagstaff, AZ)

Atmospheric lead deposition from the coal-fired Mohave Power Plant has been measured by analyzing surface and sub-surface soil samples. The dried samples were sieved to isolate only those components that pass through a 200 mesh Tyler Standard Scale screen. The samples were prepared for analysis using either a nitric acid / hydrogen peroxide digestion procedure, or a mixed acid digestion procedure, or a potassium hydroxide fusion procedure. They were then analyzed by GFAAS and ICP-MS. The highest lead soil concentration of 27.84 μg/g was found at a distance of 6.21 km from the power plant. The lead content of soil was found to reach a baseline level of approximately 11 μg/g, indicating the natural level of lead in the soil, at a distance of approximately 20 km from the plant. Regression analysis of the data found by GFAAS demonstrates a significant correlation (r² = 0.94) between distance from the power plant and lead concentration in the soil samples. Lead isotope ratios of the coal and the soil samples will be measured by ICP-MS to determine the cause of the elevated lead levels.
2:00 - 2:20  VARIFICATION OF LEAD CONTAMINATION SOURCES THROUGH ISOTOPIC IDENTIFICATION

Kim Givler (Northern Arizona University, Flagstaff, AZ)

Lead, one of the most widespread contaminants in the environment, has been found to concentrate on the smallest particles of fly ash released as a result of coal combustion for the purpose of power production. These small particles are able to escape even when environmental control devices are present, and atmospheric deposition of the lead is known to have detrimental effects on surrounding environments. Lead levels in soils surrounding the Mohave Power Plant near Laughlin, Nevada are reaching near-toxic levels, but the source of contamination must be proven before any action can be taken to remedy the problem. One means of identifying sources of lead pollution is through analysis of isotopic ratios. This project is focused on isotopic identification of lead in coal mined from Black Mesa, the same coal used to fire the Mohave Power Plant. When compared with results of isotopic identification in soils and plants near the power plant, the extent of atmospheric deposition occurring as a result of power production at Mohave will be determined. Should the results prove that the power plant is the primary source of lead pollution, incentive will be provided to enforce higher standards of environmental control on this plant and others like it worldwide.

2:20 - 2:40  *TRACE METAL TRANSPORT IN ARID ENVIRONMENTS

Kenneth Neely, Christopher Lewers, Gordon Southam, Richard D. Foust, Jr. (Northern Arizona University, Flagstaff, AZ)

Atomic absorption spectroscopy and ICP-MS spectroscopy have been used to measure trace metal concentrations in the Paria River which flows from southern Utah through north central Arizona to the Colorado River at Lee’s Ferry. We have measured dissolved, suspended and total concentrations of Al, Be, Cr, Fe, Pb, Mn, As, Ag, Zn, U and Se, as well as concentrations of these metals in sediments. Samples were collected on ten trips at seven sites, spanning a period 1.5 years. Solution concentrations are controlled by natural carbonate levels, which keep dissolved concentrations low for most metals. Suspended concentrations are highly elevated during periods of high flow during spring runoff and summer monsoons. The primary mechanism for transport of these metals in the Paria River watershed appears to be as suspended sediments.

2:40 - 3:00  ATMOSPHERIC HEAVY METAL DEPOSITION IN THE VICINITY OF THE NAVAJO POWER PLANT, PAGE ARIZONA

T. N. Thomas and J. Regner (Northern Arizona University, Flagstaff, AZ)

Atmospheric particulate deposition has been acknowledged as a major source of heavy metal pollution in most northern European countries. The most common source of the
metal laden particulate in stack emissions is from coal burning power plants. One such power plant, the Navajo Power Plant near Page, Arizona has been operating without the use of stack scrubbers for the past 25 years. Prior to the advent of the plant operation, a study was conducted at NAU that investigated the amounts of heavy metals in the soil and in plants (common snakeweed) near the power plant. The earlier work studied the concentrations of Cd, Cr, Zn, Fe, V, Mn and Cu over the first 55 months of operation. This project revisited the same sample collection sites to evaluate whether metal concentrations had changed significantly over the past twenty years. Concentrations of Cd, Cr, Zn, Fe and V have been found to be similar the highest values measured in the 1970s at these same locations.

3:00 -3:30 COFFEE BREAK - ATRIUM OF HARVILL BUILDING

3:30 - 3:50 THE EFFECT OF STRUCTURAL DIFFERENCES ON PEPTIDE FRAGMENTATION MECHANISMS.

L. Breci, G. Tsapraulis, T. Vaisar*, V. H. Wysocki (University of Arizona, Tucson, AZ) (*Molecumetics, Ltd., Bellevue, WA)

Product ion spectra in tandem mass spectrometry are used extensively to identify proteins by sequencing the amino acids contained in a peptide produced by enzymatic digestion. Certain combinations of amino acids can have an impact on product ion spectra by forming intense ions (suppressing other fragments) or by not forming certain identifying ions. This problem has become more important as high-throughput analysis of proteins relies upon computer algorithms to compare actual spectra to theoretical spectra. Gas-phase peptide structure has an effect on the ions formed in a mass spectrometer. Small peptides were investigated by incorporating a known structural difference (either an L- or D- amino acid stereoisomer) as a central residue and comparing spectral results. Experiments were performed on both a tandem quadrupole mass spectrometer using surface induced dissociation and an ion trap instrument using collision-induced dissociation. Differences were observed between the spectra of L- and D- containing peptide pairs when the peptide backbone nitrogen was alkylated in the case of the peptide pairs AV(L or D)PLG, AV(L or D)PipLG, and AV(L or D)(N-me)ALG. An increase in basicity is one factor in directed fragmentation of proline containing peptides, which are observed to fragment N-terminal, but not C-terminal, to the proline residue. However, piperidine (Pip) and N-methyl alanine (Nme-A) which also have increased basicity show cleavage on both sides of those residues and differences are observed between the L- and D isomers. Possible fragmenting structures and mechanisms have been predicted for these peptides.
3:50 - 4:10  A STUDY OF THE INTERFACIAL PROPERTIES OF POLYMER-CLAY NANOCOMPOSITES

Brett Lahner, Michael P. Eastman (Northern Arizona University, Flagstaff, AZ) Robin Helburn (Research Triangle Institute, Research Triangle Park, NC)

Clays are layered silicate materials which form interesting composite materials with polymers. These composites have useful mechanical, thermal, and electrochemical characteristics. The electrochemical properties of layered silicate-polymer nanocomposite materials may be studied by observing the behavior of clay-modified electrodes during cyclic voltammetry. Clays normally swell when placed in aqueous solutions. This swelling can be related to the change in current amplitude, which follows a time^1/2 relationship. The swelling rates of metal-substituted Laponite® and hectorite clays were investigated under conditions of the presence and absence of polyaniline which was polymerized in situ in the clay interlayers and on the surface of the clay. These swelling rates were used to gauge the effect that the intercalated polymer has on the interfacial properties of the clay-electrode system.

4:10 - 4:30  REMOVAL OF URANIUM AND LEAD FROM NATURAL WATERS BY ADSORPTION/COPRECIPITATION WITH CALCIUM HYDROXYAPATITE.

James A. Jordan, Jeff Hom and Michael E. Ketterer

Recent studies have demonstrated that dissolved Pb and U can be efficiently removed from natural waters via adsorption and/or coprecipitation with a gelatinous form of freshly precipitated calcium hydroxyapatite (CaHAP). The CaHAP is readily and inexpensively synthesized by mixing aqueous calcium chloride and sodium phosphate solutions. In typical water experiments, ~ 0.50 g of wet gel are added to 50 mL water and the mixture is briefly shaken and allowed to settle for 24 hours. Quadrupole inductively coupled plasma mass spectrometry (ICPMS) measurements demonstrate that > 95% of the original U and Pb content is removed through this treatment. This process has been demonstrated with natural waters from the Colorado River, and tap water from Flagstaff, AZ and Las Vegas, NV. Current studies are examining the efficacy of U and Pb removal from waters in the presence of a variety of aqueous salts. Our primary focus is to study the effects of ionic strength, pH, and the presence of complexing agents. Future studies will involve construction of drinking water treatment cartridges for low-cost treatment of waters containing elevated U and Pb. We also anticipate construction and testing of a synthetic aquifer for determining the feasibility of in situ remediation of contaminated groundwater.
Arsenic concentrations in Montezuma Well, located in Montezuma National Monument are unusually high for a natural water source at 100 PPB. Bacteria in the water of Montezuma Well may be involved in transforming the arsenic from arsenate or arsenite to organic arsenic, most likely a methylated form of arsenic. Bacterial samples were collected and identified in an effort to understand the role that microbes may play in converting arsenic form oxidized forms to organic arsenic. The arsenic forms present were determined by high performance liquid chromatograph, followed by graphite furnace atomic absorption spectroscopy. Bacterial samples were collected in sterile containers, and then grown on agar plates under aerobic and anaerobic conditions to determine the types of microbes present.
Conservation Section

SESSION I: 8:00 A.M.

ROOM: 130

Chairperson: Jim deVos

8:00 - 8:15 DISTRIBUTION, MOVEMENTS, AND PREDATION OF LITTLE COLORADO SPINEDACE

Michael Sweetser, Anthony Robinson, and Scott Bryan (Arizona Game and Fish Department, Phoenix, AZ)

The Little Colorado spinedace (Lepidomeda vittata), a threatened minnow native to eastern Arizona, is dispersed throughout the upper Little Colorado River (LCR) basin in the White Mountains. For the past 4 years we sampled Rudd Creek, Nutrioso Creek, and the LCR with an emphasis to determine the effects non-native trout have on this cyprinid species. Sampling was conducted using a backpack electrofisher in all 3 water systems and a canoe shocker in portions of Nutrioso Creek and in the LCR. The objectives of this paper are to: 1) document if rainbow trout stocked into Nelson Reservoir disperse into Nutrioso Creek, 2) determine the distributions of Little Colorado spinedace and non-native salmonids within the waters sampled, 3) document large-scale movements of spinedace we marked with fluorescent elastomeres and coded wire tags, and 4) determine the incidence of predation by trout species. Over 4 years, only 1 marked trout was captured in Nutrioso Creek below the dam and none above the lake, indicating minimal dispersal out of the reservoir during this period. Spinedace were distributed throughout all 3 study streams. Trout were quantifiable in each stream the first year of sampling but very minimal thereafter. We recaptured very few marked spinedace, and those that we did were recaptured within 1 km of their original location. Piscivory by trout was minimal. Of the 69 gastric-intestinal tracts removed from captured salmonids, 33% of 18 brown trout consumed fish (1 Little Colorado spinedace), 4% of 46 rainbow trout consumed fish, and 25% of 4 brook trout consumed fish.

8:15 - 8:30 ESTABLISHMENT OF ATRIPLEX SHRUBS EVALUATED UNDER A LINE-SOURCE SPRINKLER IRRIGATION SYSTEM DURING THE SUMMER AND WINTER

Carolyn Watson (University of Arizona, Tucson, AZ), Bruce Roundy (Brigham Young University, Provo, UT), Steve Smith (University of Arizona, Tucson, AZ) Bruce Munda and Mark Pater, (Plant Materials, Tucson, AZ)

A line-source sprinkler irrigation system was used to estimate water requirements for establishing seedlings and/or transplants of Atriplex canescens, Atriplex polycarpa, and Atriplex lentiformis populations under field conditions in southern Arizona. During the
During the 1993 winter, stand establishment was not increased under cumulative precipitation and irrigation amounts greater than 10 cm compared to 7 cm of precipitation. During the 1994 winter, supplemental irrigations increased the probability of seedling emergence and stand establishment was higher under total water amounts greater than 10 cm. Differences between years in establishment response to the water application gradient were attributed to the number of consecutive days when soil moisture at 1 to 3-cm depth was high for optimal seedling emergence.

8:30 - 8:45 MAMMAL DISTRIBUTION AND HABITAT ASSOCIATION IN CENTRAL SONORA USING CAMERA TRAPS

Gustavo Lorenzana Piña (CESUES, Hermosillo, Sonora, Mexico), Carlos A. Lopez Gonzalez (Denver Zoological Foundation, Denver, CO)

The mammalian fauna of the State of Sonora, Mexico has been poorly documented despite its proximity to the United States. From July to November of 1999 we began field work to document the distribution and habitat association of mammals using camera traps “Camtrakker”, these were located between 1 to 5 km apart for a total of 239 trap/nights. We obtained 81 records of 14 different species; 3 birds and 11 mammals. Mammals recorded were coyote (n = 15), gray fox (n = 10), bobcat (n = 2), cougar (n = 4), hooded skunk (n = 2), spotted skunk (n = 3), coati (n = 1), white-tailed deer (n = 15), cattle (n = 23), rock squirrel (n = 1), and desert cottontail (n = 1). Wild mammals were associated to oak woodlands (48.1%), tropical thornscrub (32.7%) and juniper-oak woodlands (19.2%). Mammals were recorded under a canopy cover < 25% (n = 13), 26-50% (n = 14), 51-75% (n = 25) and > 76% (n = 2). These information should give a baseline for an inventory of large mammals in the montanus region of Sonora.

8:45 - 9:00 SONORAN OCELOTS: CAN THEY MAKE IT TO ARIZONA?

Carlos A. López González (Denver Zoological Foundation, Denver, CO), David E. Brown (Arizona State University, Tempe, AZ), Gustavo Lorenzana Piña (CESUES, Hermosillo, Sonora, Mexico)

Ocelot distribution in the Southwestern United States is poorly understood and can almost be denied, with only two specimens taken in Arizona, both reportedly males. From July 1998 to October 1999 we documented kill sites for ocelots in the Mexican State of Sonora. This survey resulted in 33 records, most of them (79%) killed after 1990. The rest of the records were obtained from old hunting books or photographs. The majority (81%) of these animals were killed in Sinaloan thornscrub – a habitat that does not occur in Arizona. Another 12% were killed in Madrean evergreen woodlands, and the remaining 6% in Sinaloan tropical deciduous forest. Although three ocelots have been taken in Sonora within 40 km of the Arizona border, all were males. The closest known population of ocelots to Arizona is approximately 215 km south of the U.S. border. Dispersal distances are unknown
for this habitat, but in other areas average less than 20 km. It is therefore unlikely that a female ocelots ever occurred in Arizona or that they will arrive on their own.

9:00 - 9:15 EVALUATION OF FOUR DIFFERENT RADIO-COLLARS FOR THE TASSEL-EARED SQUIRREL

MariAnn M. Koloszar, Norris L. Dodd (Arizona Game and Fish Department, Phoenix, AZ), Melissa F. Lema (Northern Arizona University, Flagstaff, AZ), and Danny D. Decker (Telonics Inc., Mesa, AZ)

We monitored seasonal tassel-eared squirrel (Sciurus aberti) movements at two 60 ha study sites in north-central Arizona during 1996 - 1997. During that time, 55 tassel-eared squirrels were collared with Telonics Model CHP-3P radio transmitter collars, weighing approximately 18 grams with a battery life of 10.5 months. We began trapping adult squirrels in August 1996. In October 1996, juvenile squirrels were also radio-collared. We initially used electric cable ties for collar material with a polymeric cast for the transmitter housing. We redesigned the cast from a flat design to one shaped to conform around the squirrels' necks. During our trapping, four different collar configurations were evaluated during a 7-month period before we found one that was not susceptible to breakage, chewing by squirrels, too heavy for the squirrels, and difficult to install. We experienced four trial and errors before we produced a radio-collar that satisfied the squirrels and us. In this paper we will describe the different designs and the final product that performed best during our tassel-eared squirrel radio telemetry studies, as well as the evolutionary process that led us to that final product.

9:15 - 9:30 IMPACTS OF HUMAN ACTIVITIES ON MONTEZUMA QUAIL (Cyrtonyx montezumae mearnsi) IN SOUTHEASTERN ARIZONA: PRELIMINARY RESULTS

Kirby D. Bristow, and Richard A. Ockenfels (Arizona Game and Fish Department, Phoenix, AZ)

We investigated the impacts of hunting and public land livestock grazing on Montezuma quail (Cyrtonyx montezumae) populations in oak woodlands and semi-desert grasslands of southeastern Arizona. We used pointing dogs to survey quail in 2 control areas (protected from both hunting and livestock grazing) and 3 treated areas that were open to hunting and public land livestock grazing as administered by the United States Forest Service. We conducted surveys immediately prior to and after the normal hunting seasons (November-February) of 1997 through 2000. Pre-hunt quail numbers were higher (p< 0.10) in treated areas than in control areas. Post-hunt quail numbers were not different (p< 0.10) between control and treated areas. The percent change in quail numbers between pre-hunt and post-hunt surveys was greater (p> 0.10) in treated areas than in control areas. This suggests that treated areas had a greater potential to produce quail and control areas had a greater potential to maintain quail. Differences in survival, habitat, movement patterns, and
suggests that treated areas had a greater potential to produce quail and control areas had a greater potential to maintain quail. Differences in survival, habitat, movement patterns, and dispersal may explain such differences in survey results. Current levels of hunting and grazing pressure likely do not significantly impact Montezuma quail populations in southeastern Arizona. Future research on movement and dispersal patterns, as well as cause specific mortality, could provide information to better explain the role of hunting and grazing pressure on population dynamics of Montezuma quail.

9:30 - 9:45 USE OF REMOTE CAMERA SYSTEMS TO ASSESS DIET, PREY DELIVERY RATES, AND BEHAVIOR OF NORTHERN GOSHAWKS (ACCIPITER GENTILIS) ON THE APACHE-SITGREAVES FOREST IN EAST CENTRAL ARIZONA; BENEFITS AND CONSTRAINTS TO THIS TECHNOLOGY

Andi S. Rogers (University of Arizona, Tucson, AZ and Arizona Game and Fish Department, Phoenix, AZ)

From June 10 to July 30, 1999 we operated five remote camera systems in active northern goshawk nests. Each system was comprised of an Electro-optics TM EOD-1000 remote video camera, a time-lapse video recorder (Panasonic TM AG-1070 DC or Sony TM SVT-DL224), and one 64 amp/hour battery (Optima TM lead acid, deep cycle). 70 videotapes yielded approximately 1600 hours of nest video. Nest video was used to investigate diet, prey delivery rates, and behavior of adult and nestling goshawks. Of the five camera systems, three were placed in ponderosa pine dominated habitat and two in mixed conifer drainages. Preliminary results comparing prey delivery rates, diet, and behaviors for two of the five nests will be presented. In addition, methodologies, advantages, and disadvantages of remote videography will be discussed.

9:45 - 10:00 CHARACTERISTICS OF SUMMER ROOST SITES SELECTED BY MALE MERRIAM'S TURKEYS IN NORTH-CENTRAL ARIZONA

Timothy D. Rogers, and Brian F. Wakeling (Arizona Game and Fish Department, Phoenix, AZ)

We collected roost site data from male Merriam's turkeys (Meleagris gallopavo merriami) in the Coconino National Forest of north-central Arizona during the summers of 1996-97. Thirty roost sites were located by following radio marked gobblers. Thirty additional random plots were selected for comparison. Turkeys selected ponderosa pine for roosting with a mean dbh of 52.8 cm. Roost sites had larger diameter ponderosa pine (P = 0.007) and greater ponderosa pine basal area (P = 0.022) than random plots. Roosting sites occurred on steeper slopes than did random plots (P < 0.001). Overhead canopy presence at site center was more common (F = 17.739, 1 df, P < 0.001) and canopy completeness was greater (P < 0.001) at roosting sites than at random plots. The height to first canopy was greater (P = 0.003) and distance to opening was further (P < 0.001) for roosting sites than for
random plots. Roosting sites had greater ground cover from conifer trees within the 0-45.9 cm and 46-91.9 cm height categories ($P < 0.001$ and $P = 0.003$, respectively) than did random plots. Roosting sites were selected in the upper third of steep (>30%) slopes of wide (>100 m) canyons in greater proportion than available on random plots. Additionally, turkeys did not roost in single-storied stands of ponderosa pine and avoided roosting in proximity to human-induced trails and roads ($F = 16.147$, 1 df, $P < 0.001$). We developed a logistic regression model that correctly classified 80.8% of roosting sites and random plots. Greater short (<46 cm tall) cover from conifer trees, greater ponderosa pine basal area, and greater slope were the best predictors of roosting habitat. This model may be used to identify potential roosting sites if known roosting sites are fewer than desired.

10:00 - 10:30 COFFEE BREAK - ATRIUM OF HARVILL BUILDING

10:30 - 10:45 DESERT BIGHORN ON PUSCH RIDGE, WE WATCHED THE EXTIRPATION

James C. deVos, Jr. (Arizona Game and Fish Department, Phoenix, AZ)

The desert bighorn sheep (*Ovis canadensis mexicana*) occupied most southwestern mountain ranges prior to European settlement. Due to a variety of factors including introduction of diseases, competition for food resources, excessive harvest for subsistence purposes, and land alterations, many sheep populations were extirpated or greatly reduced in population size in the early 1900s. The Santa Catalina Mountains, in Central Arizona was one of the last mountain ranges in Arizona where commercial harvest occurred. Until the early 1970s, a large population of desert bighorn persisted in this area. Researchers documented a number of changes that were occurring in the area of the mountain occupied by sheep including increased vegetative cover due to fire suppression and increased human presence. I wrote a report in 1978 that predicted the extirpation of this bighorn population unless active management, including the reintroduction of fire and limiting habitat encroachment by human was implemented. Few of these recommendations were implemented and bighorn no longer are a viable component of the mountain system where they were once abundant. In the Tucson Basin, there were several groups of bighorn that comprised a metapopulation and, in all likelihood, in a short period of time, all of these groups will be extirpated.

10:45 - 11:00 THE SPORT FISH AND WILDLIFE RESTORATION OUTREACH PROGRAM IN ARIZONA. WHAT IS THIS BEAST AND WHAT ARE WE GOING TO DO WITH IT IN THE FUTURE?

Tom McMahon (Arizona Game and Fish Department, Phoenix, AZ)

"Outreach" has become a word used lately by federal and state wildlife agencies to describe their efforts in marketing the opportunities they have to offer concerning hunting and fishing. However, outreach really means much more to the future survival of wildlife
agencies than simply promoting our products and services to our current constituents. Our outreach efforts, whether they are for hunting, boating, or non-game wildlife, should transfer our agency values, information, and skills about the activities and mission of the Department to all of our customers (whether they be current or potential, direct or indirect). In turn, this should assist our customers go from simple awareness of wildlife issues to responsible action and enhance public involvement to gain economic, political, and philosophical support for our agencies. This is a tall order for agencies made up primarily of biologists, researchers, and technicians who believe that they “got in this business” to manage wildlife, not people. So, taking a look at what we have done recently with the Sport Fish and Wildlife Restoration Outreach Program in Arizona, where are we heading? And is this “Beast” that we have created manageable and worthwhile?

11:00 - 11:15 BREEDING BIRD RESPONSE TO JUNIPER EXPANSION IN NORTHERN ARIZONA GRASSLANDS

Steven S. Rosenstock (Arizona Game and Fish Department, Phoenix, AZ)

Encroachment of woody vegetation is an important and ongoing habitat change in Southwestern grasslands. In northern Arizona, one seed juniper (*Juniperus monosperma*) has become widespread and abundant in areas historically occupied by grassland communities. While the causes of juniper expansion remain a source of debate, effects upon wildlife are likely, and have received little attention. From 1997-1998, I studied the responses of breeding birds to one-seed juniper (*J. monosperma*) woodland expansion at two study sites in northern Arizona. I sampled breeding bird assemblages in three successional stages along the grassland-woodland gradient: open grassland, grassland undergoing early stages of juniper establishment, and developing woodland. Bird communities and species showed strong, consistent responses to woodland expansion. Species composition varied greatly among successional stages and was most different between endpoints of the successional gradient. Ground-nesting grassland species predominated in open grassland, but declined or disappeared as tree density increased. Tree and cavity nesting species increased with woodland succession and were most abundant in developing woodlands. The point at which juniper encroachment reduces grassland avifauna may define a useful treatment threshold for managers seeking to restore and enhance grassland habitats.

11:15 - 11:30 REPRODUCTIVE SUCCESS OF WESTERN BLUEBIRDS IN UNRESTORED AND RESTORED FORESTS; A PRELIMINARY COMPARISON

Heather L. Germaine, and S. S. Germaine (Arizona Game and Fish Department, Phoenix, AZ)

Western bluebirds (*Sialia mexicana*) have historically been described as birds of open forest areas with nests most often associated with oak (*Quercus* spp.) and ponderosa pine (*Pinus ponderosa*). Recent declines of western bluebird populations have been attributed to
the removal of decadent trees and increased interspecific competition for nest sites. In addition, long-term and widespread fire suppression in southwestern ponderosa pine forests has resulted in younger, denser stands than historically present. Intensive thinning, burning and native reseeding are being used to experimentally restore ponderosa pine forests to emulate conditions present prior to Euro-American settlement. We examined the effects of forest restoration on the reproductive success of western bluebirds. We monitored 20 western bluebird nests; 11 were in unrestored forests and 9 were in restored forests. Nests contained from 4-7 eggs, from which 3-7 nestlings hatched per nest. Nest success was 55% and 100% in the unrestored and restored forests, respectively. Nest material was examined for the presence of *Protocalliphora* (blow fly) larva. Eighteen percent (n = 2) of nests in unrestored forests were infested with an average of 3 puparia per nest, 78% (n = 7) of nests in restored forests were infested with an average of 13.9 puparia per nest. Preliminary data suggests that while nest success is greater in open forests, increased infestations of blow fly larva in these areas may reduce overall health of fledglings.

11:30 - 1:40 ANNUAL ACADEMY AWARDS LUNCHEON AND BUSINESS MEETING - PLAZA INTERNATIONAL HOTEL

SESSION II 1:45

ROOM: 130

Chairperson: Jim deVos

1:45 - 2:00 ENVIRONMENTAL CHARACTERISTICS OF MULE DEER BED SITES IN CURRENT-CONDITION AND RESTORED PONDEROSA PINE FOREST: A PRELIMINARY ASSESSMENT

Stephen S. Germaine, H. L. Germaine, T. Gehr, and D. Brown (Arizona Game and Fish Department, Phoenix, AZ)

We developed descriptive models to identify environmental variables which best classified mule deer day-beds located in current-condition and restored ponderosa pine forests. We observed >19 mule deer in 177 beds during the summers of 1998 and 1999. Upon observation, micro-climate data were collected in bed sites; data describing topography, land form, and habitat structure were collected within 2 weeks. Data from 1998 (n = 117) were submitted to a discriminate analysis to identify variables that best characterized bed sites between forest types. Number of oak trees surrounding beds and horizontal screening (hiding) distance loaded into a model that correctly classified 84.0% of all bed sites. Data from 1999 (n = 60) would not normalize, therefore were submitted to logistic regression analysis. Number of oak trees surrounding beds, horizontal screening distance, and number of all trees surrounding beds correctly classified 83.5% of all bed sites.
Median relative dominance of oaks around beds was 0.0 in current-condition forests and >80% in restored forests in both years. Median screening distance was greater in restored forest by 8.1 m in 1998, and 2.8 m in 1999. Number of trees surrounding beds did not differ between forest types. Female mule deer day-bedded in restored forest patches, but bed site characteristics differed between current-condition and restored forest types. Retention of entire oak stands in restored areas is critical for day bedding mule deer.

2:00 - 2:15 OTOLITHS USED TO AGE ROUNDTAIL CHUB, GILA ROBUSTA

Lorraine D. Avenetti, Mark J. Brouder, and Diana D. Rogers (Arizona Game and Fish Department, Phoenix, AZ)

A reliable means of aging fish is essential in describing characteristics of fish populations (i.e., annual survival, size and age at maturity, and changes in growth rates). Investigators have attempted to age roundtail chub using scales, but the validity of this technique has been questioned because of poor annulus formation. We extracted sagittal otoliths from varying sizes of fish (n = 280) over a two year period to determine whether or not this bony structure could be used to accurately age roundtail chub. Additionally, we used known-age (hatchery reared) roundtail chub to validate annulus formation and use of this technique. We also examined whether or not bias among readers was present (i.e., under or over aging) as well as, the precision among readers. All otoliths examined had distinct, contrasting patterns of alternating translucent (summer) and opaque (winter) zones. Each opaque zone was treated as an annulus and counted. Based on known-age fish and marginal increment analysis, annuli (opaque zones) were deposited once a year, coinciding with the onset of spawning. Known-age roundtail chub were accurately aged 100% of the time by all readers, and based on age-bias graphs, no apparent under or over-aging of roundtail chub was present. In addition, ages assigned by three independent readers to wild-caught fish were in exact agreement 89% of the time and within one year 94% of the time. Because distinct annuli were present and validated using known-age fish, we believe that the use of otoliths is a valid and accurate method of aging roundtail chub.

2:15 - 2:30 COMPETITIVE INTERACTIONS AMONG CRAYFISH, A SMALL PREY FISH, AND A PREDATORY SALMONID

Scott D. Bryan, Anthony T. Robinson, and Michael G. Sweetser (Arizona Game and Fish Department, Phoenix, AZ)

Many studies involving threatened or endangered species target a single predator, or cause, which contributes to the decline of a species. However, in most cases, it is not a single factor but rather the influence of several factors that are negatively impacting the species in question. Our study examined the effect of multiple predators, rainbow trout (Oncorhynchus mykiss) or Apache trout (Oncorhynchus apache) and crayfish (Orconectes virilis), on the behavior of the federally threatened Little Colorado spinedace (Lepidomeda viuata). We used experiments in artificial living streams to observe: 1) refuge use by spinedace in the
presence of crayfish and trout species; 2) spinedace activity (movements between vertical zones) in the presence of the two predators; 3) diel behavior of each species; and 4) predation by trout and crayfish. Results show that spinedace decreased their activity rates and use of refuge in the presence of crayfish. Spinedace showed few behavioral changes in the presence of the two trout species; activity rates did not change and movements in and out of cover decreased. When all three organisms occurred together, spinedace decreased activity rates and use of cover. Diel behavior of spinedace only changed when crayfish were present; movement in vertical zones decreased at night. Only a single spinedace was consumed over the course of the experiments, it was preyed upon by crayfish. Our results indicate that spinedace avoided crayfish and "froze" in their presence, while trout did not cause a significant change in spinedace behavior. When both predators were present, spinedace "schooled" in an open area devoid of predators, but apparently did not feel as threatened by the trout as they were by crayfish. We conclude that crayfish may play an important role in the decline of some native fishes, especially Little Colorado spinedace, and efforts should be made to control or eliminate crayfish populations.

3:00 - 3:30 COFFEE BREAK - ATRIUM OF HARVILL BUILDING
Geography - Geology Section

SESSION I: 8:30 A. M.

ROOM: 313

Chairperson: Robert Altschul

8:30-8:50 MAPPING SONORAN DESERT VEGETATION USING LANDSAT THEMATIC MAPPER AND ERS-1 RADAR SATELLITE IMAGERY

Scott Shupe (University of Arizona, Tucson, AZ)

Sonoran Desert vegetation in southwest Arizona was mapped using a co-registered dataset that included a summer 1993 Landsat Thematic Mapper (TM) scene, two 1993 ERS-1 C-band radar scenes (one spring and one summer), and elevation, slope, and aspect layers. A maximum likelihood classifier was employed. The classifier was trained using vegetation classes that were created through multivariate ordination and clustering of 1993 field data from the U.S. Army Yuma Proving Ground (YPG). A major goal of this study was to determine if satellite radar could improve vegetation classification accuracy, given the problems of sparse vegetation and soil and rock reflectance in desert regions. Remote sensing analysis showed that radar imagery is of use in detecting vegetation, especially in riparian areas. Classification accuracy of ERS-1 imagery in combination with Landsat TM imagery was higher than the classification accuracy of Landsat TM alone. Classification accuracy also improved with the addition of elevation, slope, and aspect layers. These results indicate that desert vegetation classification accuracy over a regional scale can be improved by using a multi-layer dataset.

8:50-9:10 EOLIAN MODIFICATION OF MORAINE SOILS, WHISKEY BASIN, WYOMING

Michael Applegarth (Arizona State University, Tempe, AZ), Dennis Dahms (University of Northern Iowa, Cedar Falls, IA)

Eolian processes modify soil development on piedmont moraines in the Wind River Range, Wyoming at Whiskey Basin by eroding fragile topsoils and depositing transported sediments. Particle size data, including clay, and pedogenic silts, and carbonate content extracted from the soil data derived from two moraine catenas each of Pinedale (oxygen isotope stage 2, ~15-20 ka) and Bull Lake (oxygen isotope stage 6, 100-130 ka) ages reveal an insight into eolian modification of these soils when subjected to regression techniques. Wind appears to play a role in delivering clay-sized particles to the soils here, and carbonates do not appear to be a material significantly added by wind to these soils. Furthermore, on average, common A horizon properties of Pinedale age soils here do not vary significantly
from that of common A horizon properties of corresponding Bull Lake age soils. No variation between average A horizon properties of Pinedale and Bull Lake age soils suggests that if indeed Bull Lake A horizons are erstwhile B horizons enough time has passed to allow these horizons to assume A horizon qualities.

9:10 - 9:30  MONITORING REGIONAL TRANSFORMATION IN A BINATIONAL CONTEXT

Vera Pavlakovich-Kochi and Meagan E. Cahill (The University of Arizona, Tucson, AZ)

Arizona and Sonora established a formal transborder economic development strategy with a purpose to facilitate economic integration, increase competitiveness in global economy and improve quality of life. This paper describes the process of translation of specific goals of this binational strategic economic development vision into a set of measurable indicators. The challenges of unequal data availability (accessibility) in different national contexts are highlighted and practical solutions to measuring “apples and oranges” are presented. The preliminary findings in four major groups of indicators are discussed: (a) region’s competitiveness in the NAFTA and global markets; (b) transborder economic integration; (c) performance of the region’s leading sectors, and (d) region’s quality of life. Implications for policy- and decision-making and border research in general are outlined.


Krystyna Stave and Kate Lederle (UNLV, Las Vegas, NV)

This project characterizes and compares land use/land cover change in the Las Vegas Valley over the past 25 years with changes over the same period in water quality parameters at the outlet of the Las Vegas Wash to Lake Mead. The purpose of the project is to examine environmental changes resulting from urban growth in Las Vegas. This is the first step in a larger project examining the processes underlying the dynamics of urban change. This presentation describes the type and characteristics of data used, types of analyses, and initial findings.

10:00 - 10:30  COFFEE BREAK - ATRIUM OF HARVILL BUILDING
10:30 - 10:45 THUMB BUTTE: A VENT-CONCEALING FLOW REMNANT?

Beth Nichols Boyd (Yavapai College, Prescott, AZ)

Thumb Butte is an isolated outcrop of volcanic rock which forms a prominent landmark on the southwestern edge of Prescott, AZ. Underlain by Proterozoic granodiorites and surrounded by seemingly unrelated basaltic flows of low viscosity and great areal extent, Thumb Butte’s geological and petrogenetic affinities have been uncertain. A goal of this study was to determine these relationships, through field study, petrology/geochemistry and determination of its age. A groundmass concentrate yielded an Ar-Ar age of $14.79 \pm 0.05$ Ma. Geochemical analysis shows Thumb Butte to be a latite, with exceptionally high levels of Sr and Ba. Its alkaline chemistry and distinctive trace-element signature, as well as its mid-Miocene age, seem to place Thumb Butte securely within the Hickey Formation, a suite of largely basaltic volcanic rocks erupted in central Arizona between roughly 15 and 10 Ma. Hickey Formation volcanics typically exhibit compositional trends which start alkaline and intermediate in composition and become tholeiitic through time, therefore Thumb Butte is most likely to be an early phase in an eruptive cycle which became more typically basaltic through time in this area.

10:45 - 11:00 ALLUVIAL FAN DEPOSITIONAL EVENTS IDENTIFIED BY COSMOGENIC DATING

Sarah E. Robinson and J. Ramon Arrowsmith (Geology Dept., Arizona State University, Tempe, AZ)

Cosmogenic dating analyses not only provide numeric ages on several individual alluvial fan deposits of the White Tank Mountain piedmont, AZ, but have also identified several additional depositional events in two sediment columns.

Field studies and analysis of remote sensing data resulted in a Quaternary map of area. The three major Quaternary units are Old (O) which is greater than 1000 ka, Middle (M) which is 10-1000 ka, and Young (Y) which is less than 10 ka. Ages were determined through relative dating techniques. To determine numerical ages we have sampled for the cosmogenic nuclides $^{10}$Be and $^{26}$Al in two depth profiles: one 8.8 meters deep in the O deposit and a second 5.4 meters deep in the oldest M deposit.

From the $^{10}$Be and $^{26}$Al data, three depositional events have been identified in the O deposit sediment column. The cosmogenic dating analysis has also identified a package of older gravels, similar to those in the O deposit, in the deepest parts of the M profile; this indicates that the M gravels form a thin veneer (1-3 meters) on top of older gravels.
11:00 - 11:15 ASSESSMENT OF ALLUVIAL FAN FLOOD HAZARDS: AN EXAMPLE FROM WEST-CENTRAL ARIZONA

Ted Lehman (JE Fuller Hydrology / Geomorphology, Tempe, AZ), Philip Pearthree and Tim Orr (Arizona Geological Survey, Tucson, AZ)

Widespread inundation, local high-velocity flow, and uncertainty in flow paths during floods on alluvial fans present a significant geologic hazard on piedmonts surrounding urban areas of the western U.S. Alluvial-fan flooding occurred on Tiger Wash in west-central Arizona in Sept. 1997 as a result of heavy rainfall associated with dissipating tropical storm Nora. We analyzed the effects this flood to evaluate the efficacy of surficial geologic mapping in delineating alluvial fan flood hazard areas. We (1) mapped and described surficial geologic deposits using pre-flood aerial photos; (2) mapped and characterized inundation that occurred during the 1997 flood; (3) compared pre-and post-flood aerial photos to document channel changes; and (4) reconstructed peak discharges in channels at several key localities. About 95 percent of the 1997 flood inundation occurred in areas that were covered by late Holocene deposits prior to the flood. Flood flow was conveyed in channels and narrow overbank areas the upper part of the distributary system. Broad sheetflood inundation indicative of alluvial fan flooding occurred farther downstream in flow expansions nested in the larger distributary system. Several large new channels developed and substantial channel modification occurred throughout the system.

11:15 - 11:30 THE EVALUATION OF THE DISPLACEMENT HISTORY OF A FAULTED QUATERNARY BASALT, WUPATKI NATIONAL MONUMENT, ARIZONA

Lee Amoroso (Arizona State University, Tempe, AZ)

The displacement history of a fault at Arrowhead graben at Wupatki National Monument, Arizona is being studied using both geomorphology and cosmogenic isotope chronology. Weathering rind thickness distribution and scarp morphology was used to characterize the amount and timing of displacement on the basalt fault scarp. The variation of rind thickness on the scarp did not follow a simple model of increasing thickness on the older (higher) part of the scarp, which suggests that the exposure history of this scarp is complicated. The rind thickness distribution and morphology of the scarp imply that spalling of thin basalt sheets and chemical weathering were the primary agents of scarp degradation. One interpretation of the rind study is that this scarp may have had a history of periodic displacement followed by a long period of scarp degradation. This is in general agreement with other fault studies on the southern Colorado Plateau that recurrence intervals may be from 5 to 100 ky. Core samples from the scarp are being processed for analysis of $^{36}$Cl abundance. A numerical model to calculate $^{36}$Cl accumulation in a basalt scarp will be presented. Numerical modeling of $^{36}$Cl accumulation in the scarp for different displacement histories will be compared with the measured accumulation to evaluate earthquake recurrence models for this fault.
11:30 - 1:40  ANNUAL ACADEMY AWARDS LUNCHEON AND BUSINESS MEETING - PLAZA INTERNATIONAL HOTEL

SESSION II: 1:45

ROOM: 313

Chairperson: Phil Pearthree

1:45 - 2:00  SURFICIAL GEOLOGY AND GEOARCHAEOLOGY OF GROWLER VALLEY, GOLDWATER AIR FORCE RANGE, SOUTHWESTERN ARIZONA

Philip A. Pearthree (Arizona Geological Survey, Tucson, AZ) and Andrea K. Freeman (University of Calgary, Calgary, Alberta)

Recent geologic and archaeological investigations in Growler Valley southwest of Gila Bend have explored the links between surficial geology and geomorphology and Hohokam occupation of this arid region. The area consists of narrow, steep mountain ranges, broad piedmonts covered alluvial and eolian deposits, and wide axial valley floors. Upper piedmonts are covered primarily by Pleistocene alluvial fans with gravel pavements. Lower piedmonts are covered by fine-grained Holocene alluvial fans and eolian deposits that grade to very fine-grained axial valley floodplains. Prevalence of eolian deposits on eastern piedmonts suggests that fine-grained sediment is blown from the axial valley floodplain by prevailing westerly winds. Prehistoric people prospected for stone tools on rock pavements of upper piedmonts, but occupation features are concentrated along washes and in the axial floodplains. Exposures in an arroyo system along Growler Wash indicate that at least 1 m of aggradation occurred while the Hohokam at least sporadically occupied this area between 900 and 1400 A.D., and then minimal aggradation occurred until the development of the arroyo in the 1900's. Possible water diversion berms and an occurrence of corn pollen imply that agriculture was at least attempted on Daniels Wash.

2:00 - 2:30  SOIL-STRATIGRAPHIC RELATIONSHIPS OF HOLOCENE DUNES ON THE KAIBITO PLATEAU, NAVAJO INDIAN RESERVATION, NORTHERN ARIZONA

Kirk C. Anderson (NAU and Navajo Nation Archaeology Department, Flagstaff AZ) and L. Theodore Neff (Navajo Nation Archaeology Department, Flagstaff, AZ)

Soil-stratigraphy exposed in backhoe trenches and archaeological excavations reveals several periods of eolian activity and soil formation during the Holocene. Cross-bedded dunes contain intercalated soils with redder hues, angular blocky structure, bioturbation castes, and slight carbonate enrichment. Soil development on dunes may indicate continued but lower energy eolian additions on stable surfaces. Soil age-estimates are based on
radiocarbon-dated charcoal from archaeological features and natural deposits. Ages for the oldest, archaeologically sterile dunes are about 10,400 to 9200 cal BP. Inset into the older dunes are 4400 cal BP alluvial gravel, sand, and clay deposits representing locally wetter conditions. Near Tuba City, archaeological materials are associated with soils at 8500, 7400, 6000, and 2200 cal BP. Middle Holocene dune sands occur between early and latest archaic cultural materials at nearly every locale. Soil-stratigraphic characteristics indicate much of the Holocene was dominated by active eolian processes punctuated by short periods of dune stability and soil formation. The association of archaeological features with soils may indicate landscape stability during periods of prehistoric occupation, or a preference for locally stable landforms.

2:30 - 2:45  BASEMENT FABRICS IN SOUTHEASTERN NEW MEXICO: FAULT REACTIVATION, BASINAL ARCHITECTURE, NEOTECTONICS, AND NATURAL RESOURCE MANAGEMENT

Robert R. Casavant (University of Arizona, Tucson, AZ)

Integration of subsurface and geomorphic data sets in east-central and southeastern New Mexico reveals that northeast- and northwest-trending basement strike-slip fault fabrics developed in the Paleozoic have continued to play a major role in the structural and stratigraphic architecture of major Cenozoic sedimentary basins in the region. This subsurface-geomorphic investigation is unique in that it provides clear linkage between deep-seated fault fabrics and landscape evolution in southeastern New Mexico. The most common surface expressions of basement shear zones in southeastern New Mexico are geomorphic lineaments that link disparities in the drainage patterns with anomalies in the longitudinal profiles of streams and changes in trend or abrupt termination in the axes of mountain ranges and basin features. The spatial linkage between deep-seated architecture and geomorphic fabrics in this region suggests that subtle neotectonic deformation may be active in the region. In fact, the reactivation of such long-lived shear zones throughout the southern Cordillera may be the rule, rather than the exception. This study supports the idea that highly deformed intracratonic settings, although located far inboard from plate margins, often remain tectonically active throughout geologic time.

2:45 - 3:00  PRELIMINARY ANALYSIS OF BASEMENT FABRICS TAKEN FROM LANDSAT SATELLITE IMAGERY—NEW MEXICO AND ARIZONA

Casavant, Robert R. (University of Arizona, Tucson, AZ) and Horstman, Kevin C. (Consulting Geologist, Tucson, AZ)

Analysis of satellite mosaics covering New Mexico and eastern Arizona reveals three dominant classes of surface geomorphic lineaments that trend approximately northeast, west-northwest and north-northeast. These lineaments are postulated as representing long-lived basement wrench fault fabrics based on their regional scale,
persistence across a variety of structural and geomorphic terrain and spatial correlations to known wrench fault systems defined by detailed subsurface and surface mapping. Recent studies across east-central and southeastern New Mexico reveal that these wrench fault fabrics have played a major role in the structural and stratigraphic evolution of the region with many faults being related to Precambrian structure. The number of lineaments is greater than the number of large faults that are currently presented on regional geologic maps. Areas where faulting on the regional geologic maps do not match with the satellite analysis appeared to coincide mostly with Laramide thrusts and Basin and Range normal faults. Landsat image lineaments seemed more commonly associated with the offset and/or abrupt termination of mountain ranges and basinal axes (e.g. accommodation zones or transfer faults).

3:00 - 3:30 COFFEE BREAK - ATRIUM OF HARVILL BUILDING

3:30 - 3:45 SOIL-STRATIGRAPHIC RELATIONSHIPS OF HOLOCENE DUNES ON THE KAIBITO PLATEAU, NAVAJO INDIAN RESERVATION, NORTHERN ARIZONA

Kirk C. Anderson and L. Theodore Neff (NAU and Navajo Nation Archaeology Department, Flagstaff, AZ)

Soil-stratigraphy exposed in backhoe tranches and archaeological excavations reveals several periods of eolian activity and soil formation during the Holocene. Cross-bedded dunes contain intercalated soils with redder hues, angular blocky structure, bioturbation casts, and slight carbonate enrichment. Soil development on dunes may indicate continued but lower energy eolian additions on stable surfaces. Soil age-estimates are based on radiocarbon-dated charcoal from archaeological features and natural deposits. Ages for the oldest, archaeologically sterile dunes are about 10,400 to 9200 cal BP. Inset into the older dunes are 4400 BP alluvial gravel, sand and clay deposits representing locally wetter conditions. Near Tuba City, archaeological materials are associated with soils at 8500, 7400, 6000, and 2200 cal BP. Middle Holocene dune sands occur between early and latest archaic cultural materials at nearly every locale. Soil-stratigraphic characteristics indicate much of the Holocene was dominated by active eolian processes punctuated by short periods of dune stability and soil formation. The association of archaeological features with soils may indicate landscape stability during periods of prehistoric occupation, or a preference for locally stable landforms.
Hydrology Section

SESSION I

ROOM: 411

Chairperson: Don Young

8:00 - 8:30 BACTERIOLOGICAL WATER QUALITY TREND ANALYSIS IN OAK CREEK CANYON, ARIZONA

Boris Poff and Aregai Tecle (School of Forestry, NAU, Flagstaff, AZ.)

The purpose of this paper is to analyze the temporal and spatial distribution of bacterial contamination in Oak Creek near Slide Rock State Park. Oak Creek Canyon is one of the most beautiful and picturesque landscapes in the Southwest. It has a magnificent landscape, highly diversified riparian fauna and flora and an invigorating climate, resulting in several thousand people visiting the canyon each week. Recreational activities include hiking, mountain biking, rock climbing, camping, fishing and swimming. These numerous activities have led to water quality concerns in the creek. Technicians of the Slide Rock State Park have been monitoring bacteriological contaminants in the creek running through the park since 1995. Stream water sample analyses at various times have indicated the amount of bacteria in the stream rising well above acceptable levels. There are a number of possible sources for the contamination, including livestock and wildlife grazing within the forests above the creek, private residences inside the canyon, the large number of tourists visiting Oak Creek Canyon for recreational purposes, and or the different facilities catering to the needs of the tourists. This paper intends to indicate whether and if how much of the water contamination originated upstream from the park and how much was contributed by the tourists themselves while visiting the park.

8:30 - 9:00 SPATIAL VARIABILITY AND MODEL COMPLEXITY IN EROSION PREDICTION ON A SEMIARID RANGELAND WATERSHED

Howard Evan Canfield (USDA-NRCS, Window Rock, AZ)

For different model complexities on the 4.4 ha. USDA-ARS Lucky Hills Experimental Watershed near Tombstone Arizona. Erosion processes are clearly scale-dependent with hillslope erosion processes differing from channel erosion processes. For this reason, hydrologic models used to predict erosion should account for this variability. In this case, erosion was modeled using several different scales of model complexity in an event-based spatially distributed, hydrologic model. In the most complex case, the actual spatial complexity observed in the field was used. This resulted in rills with upslope contributing areas of about 200 square meters. However, runoff could be modeled with a much less complex spatial variability. A simpler model complexity with an upslope...
contributing area of 5000 square meters modeled runoff as well as the complex case (a factor of 25 more complex). Since runoff is thought to drive erosion, one might expect that this less complex description of watershed complexity would be adequate for modeling erosion. However, the most complex representation of the watershed was significantly better for modeling erosion than less complex representations. This indicates that erosion models must represent the spatial complexity of channel to hillslope observed in the field in order to adequately describe the erosion process.

9:00 - 9:30 WATERSHED CHARACTERISTICS OF OAK SAVANNAS IN THE SOUTHWESTERN BORDERLANDS

Gerald J. Gottfried and Daniel G. Neary (USDA Forest Service, Rocky Mountain Research Station, Flagstaff, AZ) and Ronald J. Bemis (USDA Natural Resources Conservation Service, Douglas, AZ)

Oak or encinal woodlands and savannas cover approximately 80,350 km² in the southwestern United States and northern Mexico. However, there is relatively little information available about these lands to aid in their management. Twelve small watersheds on the east slope of the Peloncillo Mountains in southwestern New Mexico have been selected to study the hydrology and ecology of oak savannas and to evaluate the impacts of cool season and warm season fires on a number of ecosystem components. Fire was the most important natural disturbance in these ecosystems prior to European settlement; however, fires are less frequent now because of the impacts of past over-grazing on the native herbaceous vegetation and fire suppression activities. Some areas currently have high fuel accumulations that could contribute to stand replacing wildfires. Prescribed burning is seen as a technique to restore the natural processes within the savannas; however, there are questions about the effects of burning season and fire intensities on this ecosystem. Scientists from several organizations will be studying the impacts of prescribed burning on streamflow, sedimentation, side-slope erosion, soil and water chemistry, vegetation, small mammals, and arthropods. Preliminary hydrological physical, biological, and climatological information are presented.

9:30 - 10:00 INITIAL ABSTRACTION AND LOSS IN THE CURVE NUMBER METHOD

Richard H. Hawkins (University of Arizona, Tucson, AZ) and Ali Vali Khojeini (University of Tehran, Karaj, Iran)

The Runoff Curve Number Method is widely used to generate rainfall excess in hydraulic design and environmental impact analysis. An important premise is that Initial Abstraction, Ia - or rainfall prior to the onset of direct runoff - is 0.2 of the storage coefficient, S. This assumption, previously unchallenged, is explored using small watershed rainfall-runoff data from 84 watersheds in four general regions. The best-fit value of the ratio Ia/S, here called "lambda" (λ), is found for both natural and "ordered" (or frequency matched) rainfall-runoff pairs. For larger storms, the majority of the data shows λ somewhat
less than 0.2, with a median in the vicinity of 0.08 for ordered data pairs, and a median of 0.00 for natural data. Considerable variation in Ia/S is found between watersheds and between events within individual watersheds. Some interpretations in the interests of applied hydrology practices are also given.

10:00 - 10:30 COFFEE BREAK - ATRIUM OF HARVILL BUILDING

10:30 - 11:00 A WATER BUDGET FOR EMORY OAK WOODLANDS: AN INITIAL APPROXIMATION

Peter F. Ffolliott (University of Arizona, Tucson, AZ)

Recent investigations of the hydrologic characteristics of Emory oak woodlands in southeastern Arizona allow an initial approximation of a water budget to be made by examining water storage points and flows of water within and between these storage points. Components of the water budget considered in these investigations include interception and throughfall, transpiration, and infiltration. Stormflow has not been measured; however, estimates have been obtained by applying the Soil Conservation Service method. Analysis of this water budget show that the largest component is transpiration. Alterations in the structure of these woodlands by harvesting trees also changes the relative significance of the transpiration component. Management implications are presented.

11:00 - 11:30 HABITAT UTILIZATION BY TWO NATIVE, THREATENED FISH SPECIES, NEW MEXICO

John N. Rinne and Brian Deason (Rocky Mountain Research Station, Flagstaff, AZ)

Fish sampling was conducted on the upper Gila River, New Mexico between March and December 1999. Velocity and depth of water, substrate, and stream gradients were measured at each macrohabitat site sampled for fishes. Habitat occupation of two native threatened fish species, spikedace (Meda fulgida) and loach minnow (Rhinichthys cobitis) was determined and its characteristics described. Spikedace were most commonly collected in glide-run and low gradient riffle habitats (mean gradient = 0.54%). In contrast, loach minnow predominantly were collected in high gradient (mean gradient = 1.24%) riffle habitats. Velocities in turn paralleled gradient and ranged from 4.3 to 74.8 cm/sec for spikedace and from 19.4 to 112.5 cm/sec for loach minnow. Spikedace were most commonly found over sand-gravel (21 and 55%, respectively) substrates and loach minnow over gravel-pebble (38 and 32%, respectively). There was a significant difference between gradients (P = 0.0001), velocities (P = 0.0066), and depths (P = 0.0009) where loach minnow were present and absent. By comparison, there was a significant (P = 0.0139) difference in gradient only between where spikedace were present and absent, but not for velocities and depths where present and absent.
11:30 - 1:40  ANNUAL ACADEMY AWARDS LUNCHEON AND BUSINESS MEETING - PLAZA INTERNATIONAL HOTEL

SESSION II: 2:00

ROOM: 411

Chairperson: Don Young

2:00 - 2:30  EFFECT OF ROCK AND GREEN WASTE MULCHES ON SOIL MOISTURE AND TEMPERATURE

D.F. Post, J.P. Dubay, and A.D. Matthias (University of Arizona, Tucson, AZ)

A study was conducted at Tucson, AZ to evaluate how rock and green waste mulches placed on the soil's surface affect soil moisture and temperature. The mulch cover was added to 5 m² plots, and we used the natural rainfall and an irrigated condition with 15 cm of water applied every 14 - 18 days. Data were collected bi-weekly at 10, 25 and 50 cm depths between March 1998 and January 1999. The site was kept free of vegetation. The water measurements for the no-mulch (control) plots showed there was a mean of 4.9 and 7.6 cm of water in the soil to a depth of 35 cm for the natural rainfall and irrigated conditions. The mean water content in the mulch covered plots were 6.7 and 8.2 cm, 6.9 and 8.5 cm, 6.8 and 8.5 cm, and 7.5 and 9.0 cm for the buff granite, white rock, green waste (3.8 cm thick) and green waste (6.4 cm thick), respectively, for the natural rainfall and irrigated conditions. This was a mean of 37% (buff granite) to 53% (green mulch, 6.4 cm) more water in the 0 to 35 cm soil depth under the mulched plots for the natural rainfall condition. For the irrigated plots there was 8 to 18% more water under the mulched plots. The mean soil temperatures to a depth of 50 cm were 23.1 and 21.0EC for the natural rainfall and irrigated no-mulch plots. The natural rainfall and irrigated mulched plots were warmer for the buff granite (24.3 and 22.8EC) and cooler for the white rock (20.8 and 20.0EC), the 3.8 cm green waste (20.8 and 19.7EC) and the 6.4 cm green waste (20.8 and 20.3EC).

2:30 - 3:00  AN EVALUATION OF METHODS TO MEASURE SOIL HYDRAULIC CONDUCTIVITY

M. H. Bagour and D. F. Post (University of Arizona, Tucson, AZ)

The steady state infiltration rates (Ksat) were measured on five Tucson Basin soils using the in-field single ring, double ring and compact constant head permeameter methods and with soil cores in the laboratory. The soil textures ranged from loamy sand to clay loam, and two water qualities were evaluated, the local water and 0.005 M CaSO₄ solution. Three in-field replications were completed on each soil. The mean C.V. for these measurements were 26, 27, and 29% for the single ring, double ring, and constant head permeameter, respectively. The mean intake Ksat measurements for the five soils (15 measurements) were
3.3, 2.6, and 1.2 cm/hr for the single ring, double ring, and the compact constant head permeameter, respectively, and 2.4 cm/hr for the lab cores. At two sites, disc tension permeameter measurements were made, and the mean readings for these two sites were 1.5, 0.8, 0.5, 1.4 and 0.9 cm/hr for the single ring, double ring, compact constant head permeameter, lab cores, and disc tension permeameter. The mean values reported above appear to be comparable for some methods; however, there are significant differences between the $K_{sat}$ for the different quality waters, and the variability among the replicates for a specific site were great. We concluded the double ring method was the better in-field method because the results agreed better with $K_{sat}$ predictions of professional soil scientists and with experimental results obtained for similar soils.

3:00 - 3:30  COFFEE BREAK - ATRIUM OF HARVILL BUILDING

3:30 - 4:00  ACCESSING WATERSHED-RELATED DATA SETS THROUGH THE WORLD WIDE WEB

Malchus B. Baker, Jr. (USDA Forest Service, Flagstaff, AZ), Daniel P. Huebner (USDA Forest Service, Flagstaff, AZ), and Peter F. Ffolliott (University of Arizona, Tucson, AZ)

Computer technologies facilitate the storage, updating, retrieval, and summarization of watershed-related data sets by managers in planning and implementing operational watershed management practices, projects, and programs; by research in developing, testing, and validating predictive models of resource responses; by decision-makers in selecting the best course of action from a set of alternatives; and educators in teaching the principles of effective land stewardship. Such use of computer technologies is illustrated with multi-resource data sets obtained on the Beaver Creek watershed in north-central Arizona. Applications of computer technologies to document, store, and retrieve images, publication, and reports using key words, dates, and locations are also presented.

4:00 - 4:30  FLASH FLOODING FOLLOWING WILDFIRES IN ARIZONA: THE CARR FIRE

Daniel G. Neary and Robert E. Lefevre (Rocky Mountain Research Station, Flagstaff, AZ and Coronado National Forest, Tucson, AZ)

One of the main problems with post-wildfire burned area emergency rehabilitation (BAER) in the Southwest is the occurrence of high intensity, early monsoon thunderstorms immediately after the fire season. The Carr Fire burned 2,873 ha on the east flanks of the Huachuca Mountains in southeastern Arizona from June 18 - 23, 1977. About 1,942 ha of moderately-to-severely burned area in the ponderosa pine - mixed conifer and oak woodland - grassland vegetation types were seeded immediately after the fire for erosion control. On July 12, 1977, a short-duration high-intensity rainfall event produced high peak flows in two canyons within the Carr Fire boundary. The wildfire, steep slopes (>60%), and shallow soils in the 182 ha Marshall Canyon contributed to peak flows of 62 – 68 m$^3$/sec. The adjacent,
but larger (667 ha) Carr Canyon produced a peak flow of only 10 m$^3$/sec. Resource damages were limited to channel scour, debris and sediment deposition, a road washout, destruction of some septic tank fields, and one small building demolition. The post-fire BAER treatments were not able to mitigate the effects of this type of storm.

4:30 - 5:00  IMPACT OF PONDEROSA PINE RESTORATION TREATMENTS ON WATERSHED CONDITION

Daniel G. Neary (Rocky Mountain Research Station, Flagstaff, AZ)

Watershed condition was assessed on ponderosa pine stands in the 134 ha Fort Valley Research and Demonstration restoration project. This project is part of the Grand Canyon Forest Foundation wildland-urban interface fire risk reduction program around Flagstaff, AZ. Three restoration treatments were imposed based on the presence of current or indicators of past old ponderosa pine stems. Demonstration plots (13-17 ha) were harvested by means of a whole-tree harvesting system (WT) or a cut-to-length (CTL) mechanized system. Soil disturbance was assessed on randomly located 200 x 200 m grids within each of 12 plots (3 replications of a control plus 3 restoration treatments). The overall condition of all untreated plots was good, with few areas of rock or roads. Nearly all mineral soil in the untreated controls was covered by a well-developed litter layer. Watershed condition was not affected by restoration treatment. The main factor producing degradation in watershed condition was the harvesting system. Harvesting using the WT system had greater areas of disturbed soil, roads, and slash piles, and a lower watershed condition rating. Multiple passes by tracked and tired vehicles (feller-bunchers, skidders, delimiters, and loaders) produced higher levels of soil disturbance.

5:00 - 5:30  GROUNDWATER MOVEMENT AND WATER CHEMISTRY AT BRYCE CANYON NATIONAL PARK

Llyn Doremus and David Kreamer (UNLV, Las Vegas, NV)

Discharge measurements collected at Bryce Canyon National Park (BCNP) for this study and for previous investigations indicate a northward migration of groundwater that discharges predominantly to springs on the northeast side of the Park. Limited data is available from springs on the west side of the Park. Tritium concentrations of 6-8 picocuries/liter on selected east side springs indicate extended subsurface travel times, while 57 picocuries/liter on Yovimpa Spring on the southwest indicates shorter travel times. Water chemistry data reflect the dominant influence of the carbonate lithology of the Claron Formation. The noticeable differences in sulfate content are attributable to high reaction with the marine sediments of the John Henry Member and Tibbet Canyon Member of that Formation. The reducing chemical conditions measured in Sheep Creek and Park Well #1q water samples are likely present also in the Yellow Creek vicinity. Hydrogen sulfide production from a reducing environment is the likely source of the “stinky” conditions observed as the well drilled by Marine in 1963 and in some of the springs discharging at Yellow Creek.
UNDERGRADUATE MICROBIOLOGY: A PROBLEM-BASED APPROACH

William P. Baker, Kim Cooper, Kathryn Leyva and Cynthia L. Thomas
(Midwestern University, Glendale, AZ)

Understanding virology is an important part of instructional units in microbiology, human health, biology and biotechnology. Research and experience, however, indicate that the topic is a difficult one for many students. We have found that the methods and applications of virology can be effectively demonstrated using an investigative laboratory exercise in which students act as scientists. The procedure outlined is designed for use as a problem-based learning (PBL) activity. Students investigated the presence of coliphage in field-collected samples by direct plaque assay. Instructors may use the PBL activity provided or create their own. Results indicate that adapting activities to fit topics being presented enhances instruction and student satisfaction. It also provides an important model for students to emulate.

CYCLIC IRRIGATION OF TURFGRASS USING A SHALLOW SALINE AQUIFER

Chris Schaan (University of Nevada Las Vegas, Las Vegas NV), Dale Devitt (University of Nevada Reno, Las Vegas, NV), Robert L. Morris (University of Nevada Las Vegas Cooperative Extension, Las Vegas, NV)

Utilization of poor quality waters in the urban landscape has the potential of saving large quantities of good quality water for higher priority uses. Bermudagrass in particular is well suited to be irrigated with poorer quality water. A two year field study was conducted to determine the long-term effects of applying shallow saline aquifer water to two turfgrass sports fields. The water (2-4 dSm⁻¹) was applied using cyclic irrigation during peak demand months (May-Oct). Treatments consisted of cycling saline water through existing irrigation systems. Saline substitution of fresh water was set at 1, 2, 3 and 4 times per 7 irrigation events. Irrigations were applied using an ET feedback system and imposing a leaching fraction of 0.15. Turf color and cover, canopy temperature, bulk soil conductivity, soil moisture, leaf water potential, tissue moisture content and stomatal conductance were monitored on a bimonthly basis during the peak demand months. All plots were instrumented with tensiometers and salinity sensors. Soil samples were taken yearly from each plot in a 5 x 5 grid fashion and analyzed for soluble salts. Contour maps were developed using geostatistical techniques.
INHERITANCE OF TWO CUTICULAR PIGMENTATION PATTERNS IN A MARINE ISOPOD, *PARACERCEIS SCULPTA*: HOLMES (CRUSTACEA: ISOPODA: SPHAEROMATIDAE)

Saundra Embry and S. Shuster (Northern Arizona University, Flagstaff, AZ)

Cuticular pigmentation is highly variable in *Paracerceis sculpta*, a Gulf of California isopod. Individuals exhibiting the pattern we call *L2r* have red pigmentation on the lateral margins of each of their sixth and seventh body segments. Individuals exhibiting the pattern we call *3rs* have three bands of red pigmentation running the length of their bodies; one medially and one on each lateral body margin. Over a 10-year period, *L2r* and *3rs* represented respectively, 0.1% and 0.3% of all field collected individuals (N=5,191). The frequencies of these markers in males and in females were proportional to the population frequencies of each sex (N_{females}/N_{males} = 1.49; X^2 = 0.22 and 1.72, P > 0.5). In the laboratory, marked and unmarked parents were crossed in all possible combinations for each character. Ratios of marked and unmarked progeny conformed to the expectations of Mendelian inheritance, indicating that both markers are controlled by dominant, autosomal alleles. Adult expression of *3rs* also conformed to Mendelian expectations within families despite observed biases in family sex ratio caused by other genetic factors. Our results indicate that these markers are autosomal, and are consistent with other studies documenting heritable pigmentation patterns in this species.

URBAN LAKES - RELATIONSHIPS BETWEEN SOURCE WATER, LAKE AGE, WATER QUALITY AND BIOTA M.

Compton, J. Hunter, and M. Sommerfeld (Arizona State University, Tempe, AZ)

More than 50 urban lake systems exist in Maricopa County. The urban lakes were created to serve recreational, aesthetic, and flood control purposes, and were generally constructed in an opportunistic manner whenever water rights could be secured. Although individual lake owner's associations have conducted some level of aquatic monitoring over the years, little effort has been made to bring preexisting data sets together or to systematically investigate the lakes. The objective of this study was to determine how water chemistry, primary production, and algal populations in the urban lakes are related to lake age, water source, and other lake characteristics. To achieve the objectives of this study six urban lakes were selected to maximize variations in age and water source (canal, well, effluent). Monthly water sampling, over the course of 1999, examined a variety of physiochemical parameters, including major ions, nutrients, selected metals and organics. Water samples were also examined for algal biomass and genera composition. Selected data will be presented to compare aspects of the biology and chemistry for the six lakes.
10:00 - 10:30 AN EVALUATION OF METHODS TO MEASURE SOIL HYDRAULIC CONDUCTIVITY

M. H. Bagour and D. F. Post (University of Arizona, Tucson, AZ)

The steady state infiltration rates ($K_{sat}$) were measured on five Tucson Basin soils using the in-field single ring, double ring and compact constant head permeameter methods and with soil cores in the laboratory. The soil textures ranged from loamy sand to clay loam, and two water qualities were evaluated, the local water and 0.005 M CaSO$_4$ solution. Three in-field replications were completed on each soil. The mean C.V. for these measurements were 26, 27, and 29% for the single ring, double ring, and constant head permeameter, respectively. The mean intake $K_{sat}$ measurements for the five soils (15 measurements) were 3.3, 2.6, and 1.2 cm/hr for the single ring, double ring, and the compact constant head permeameter, respectively, and 2.4 cm/hr for the lab cores. At two sites, disc tension permeameter measurements were made, and the mean readings for these two sites were 1.5, 0.8, 0.5, 1.4 and 0.9 cm/hr for the single ring, double ring, compact constant head permeameter, lab cores, and disc tension permeameter. The mean values reported above appear to be comparable for some methods; however, there are significant differences between the $K_{sat}$ for the different quality waters, and the variability among the replicates for a specific site were great. We concluded the double ring method was the better in-field method because the results agreed better with $K_{sat}$ predictions of professional soil scientists and with experimental results obtained for similar soils.

10:00 - 10:30 HYDROGEOCHEMISTRY OF THE RINCON VALLEY, ARIZONA

Joy Gillick (University of Arizona, Tucson, AZ)

The isotope hydrology of the Rincon Valley is examined as part of an ongoing study to establish a hydrochemical baseline for the Tucson Basin, and to identify specific recharge sources for the groundwater of Rincon Valley. Water from the Rincon Valley has $\delta^{18}O$ values within the range of -8 to -11 permil. The $\deltaD$ values fall within the range of -60 to -75. The relatively narrow range of stable oxygen and hydrogen isotope values necessitates the use of other environmental isotope tracers. Sulfur isotope values coupled with tritium levels proved to be most useful in differentiating recharge sources. Water recharged directly through infiltration along streams and washes has $\delta^{34}S$ values that indicate short contact-times with the local crystalline rock and possible anthropogenic sources of sulfur, $< 5$ permil, and tritium levels indicating post-1950's recharge, $> 3$TU. Mountain-front recharge water has $\delta^{34}S$ values that indicate long contact-times with the local crystalline rock, $> 7$ permil, and tritium levels that are below the detection limit, indicating pre-1950's recharge. Streambed infiltration usually dominates along washes, but mountain-front recharge may be substantial along the margin of the valley.
ELECTED

Owen Davis ................................................................. President
Don Young ................................................................. Past President
Kathy Lauckner ............................................................. President Elect
Betsy Cooper ................................................................. Recording Secretary
Peggy Pollack ............................................................ Membership Secretary
Karen Conzelman .......................................................... Treasurer
R. Roy Johnson ........................................................... Director, Southern Arizona
Robert Reavis .......................................................... Director, Central Arizona
Jim de Vos ............................................................... Director, Central Arizona
Norm Thomas ............................................................ Director, Northern Arizona
Aregai Telle ............................................................ Director, Northern Arizona
Chuck Douglas ............................................................. Director, Nevada

APPOINTED

Gordon Johnson .......................................................... Permanent Secretary
Donald J. Pinkava .............................................................. Editor, Journal
Stephen Williams ............................................................ Editor, Newsletter
Betsy Cooper ................................................................. Editor, Proceedings
Bill Doerge ................................................................. Director of the Junior Academy

SECTION CHAIRS

Jeffrey S. Dean ................................................................. Anthropology
Robert Bowker ................................................................. Biology
Paul E. Smolenyak ........................................................... Chemistry
Jim de Vos ............................................................... Conservation
Robert Altschul ............................................................. Geography
Philip Pearthree ............................................................. Geology
Don W. Young ............................................................ Hydrology
Robert Reavis and Andrew Comrie .................................... Poster Session
Richard J. Greenberg ........................................................ Science Education
COMMITTEE ROSTER

BUD ELLIS SCHOLARSHIP
Peggy Pollak

MEMBERSHIP
Peggy Pollak

R. M. HARRIS AWARD
Donald J. Pinkava

OUTSTANDING SCIENCE TEACHER
Roberta Williams

GRANTS-IN-AID
GRADUATE
Ron Dorn

BUDGET
Karen Conzelman

BEST STUDENT PAPER
Owen Davis

NOMINATING
Owen Davis
Don Young

NECROLOGY
Peggy Pollak

PUBLICITY
Robert Reavis

PROGRAM
Owen Davis
Andrew Comrie
R. Roy Johnson
Stuart Marsh
Kennith Foster

GRANTS-IN-AID
HIGH SCHOOL
Ron Dorn

BUD ELLIS OUTSTANDING
SERVICE AWARD
Bud Ellis
Steve Williams
Eleanor Davey
Sandra Wardwell
REPORT OF THE PRESIDENT

The year passed quickly for this President. It was a gratifying year in which I learned a lot more about the workings academy and grew to appreciate even more the Officers that make it work. I join preceding ANAS Presidents in acknowledging their hard work, and in expressing my sincere gratitude. I will depart from my predecessors by not naming them individually. They have worked very effectively as a team, and it is that teamwork that deserves my highest praise.

This year's accomplishments of the Board of Governors are many, but I will recount only a few that will effect the future of the Academy most positively. First, there is the transition of Editors of the Journal. Don Pinkava has stepped down as Editor after many years of welcome service, and Tony Brazel has taken over in a smooth transition that will capitalize on past strengths, and develop new ones. Tony's job will be made easier by the creation of an Editorial Board, that will distribute many of the day-to-day tasks of editorship.

Second, the Academy has created an electronic membership database that will allow it to better serve our membership and document our history as it unfolds. This was a group effort, began by Jim deVos, and brought to fruition by Betsy Cooper, Steve Williams, Karen Conzelman, and Robert Reavis. It is in good shape, and ready to pass onto the Membership Secretary. The database has allowed us to put a membership list on the ANAS web site, for those members who so desired, and it has underscored, for this President, our shortcomings in documenting our past.

Last year's Presidential Report, by Don Young, highlighted the need for an Academy Historian. This position is called-for in our By-Laws, but has not been filled for many years. Our history is steadily slipping away because this office goes vacant. The problem was highlighted for me in the deliberations of this year's ANAS Fellows Committee. Their efforts were guided by the membership directory, which records which members are ANAS Fellows. Two of the nominees for Fellow were, in fact already Fellows. The mistake in the database was easily corrected, but the mistake underscores our collective lack of memory in appreciating those who serve the Academy.

ANAS exists, "to stimulate scientific research and education (ANAS By-Laws)," and in so doing it bestows special status on those who have "successfully engaged in recognized scientific work or who "have " made significant contributions to the Academy." To forget this recognition by ANAS is to overlook our charter. I apologize to those two ANAS Fellows. I salute the Board of Governors, and the Academy for its many accomplishments in 1999-2000, and I urge it to even greater efforts. Don't let this year's accomplishments -- and those of previous years -- be forgotten. Find a Historian for ANAS.

Owen Kent Davis
President, ANAS
MINUTES OF THE ARIZONA-NEVADA ACADEMY OF SCIENCE ANNUAL MEETING, FLAGSTAFF, ARIZONA, APRIL 17, 1999

1. Call to Order

Don Young opened the Annual Meeting at 12:15. He acknowledged the contributions made by the local committee and the Academy Board and committee members in arranging the Annual Meeting. Then he introduced Aregai Tecle, the chair of the local committee.

Dr. Tecle thanked the USDA Forest Service, the Engineering Department and the School of Forestry for the rooms made available for the meetings. He introduced the guest speaker, Charles Connell, Provost of Northern Arizona University, who addressed the members of the luncheon on change: how change affects university life; how it affects students and faculty.

The business meeting was called to order by Don Young at 1:07. Peggy Pollak made the motion that the by law amendments be accepted. Karen Conzelman seconded the motion; the motion passed.

2. Presentation of Awards

The Bud Ellis Scholarship Award was given to Dawn Crider of Alhambra High School. She plans to attend the University of Arizona where she will major in molecular biology. She hopes ultimately to go to medical school.

The Outstanding Science Teacher Awards were presented by Steve Williams for Roberta Williams, who could not be present. Winner of the high school division was John Nyhoff of Ray High School in Kearny, Arizona. Greg Stumpf, physical science teacher at Prescott Mile High Middle School in Prescott, Arizona was the winner for the middle school division. Patrick Vollman from Palo Christi Elementary School in Kingman, was the elementary school winner.

The Bud Ellis Outstanding Service Award was given to R. M. Harris for his efforts in establishing the Arizona Academy of Science.

Gordon Johnson spoke about the high School Grants-in-Aid. These are $100 awards for each of four high school students to help finance science projects. There were no applicants this year so no awards are being given.

Don Pinkava presented the R. M. Harris Award for and Outstanding Paper in the Journal to Jennifer Mills of the Department of Geography, who as an undergraduate studied and wrote an outstanding paper comparing two kinds of rock formation in Papago Park. The title of her paper is "Relating Micrometer-Scale Weathering to Landform Morphology at Papago Park, Phoenix, Arizona."

Bill Doerge, Director of the Junior Academy spoke to the students regarding the Junior Academy sessions and thanked them for their efforts.
3. Election of Officers

Don Young announced the slate of officers.

President-elect: Kathy Lauckner of the Harvey Reid Center for Environmental Studies, University of Nevada

Recording Secretary: Betsy Cooper, Department of Biology, Glendale Community College

Membership Secretary: Peggy Pollak, Department of Biology, Northern Arizona University

Treasurer: Karen Conzelman, Department of Biology, Glendale Community College

It was moved and seconded that the slate be accepted. The motion was passed.

Aregai Tecle was nominated from the floor as Director from Northern Arizona. Gordon Johnson moved and Don Young seconded that Dr. Tecle be made a Director. The motion was passed.

4. Assumption of the Presidency

Don introduced Owen Davis as the new president of the Arizona-Nevada Academy of Science. Owen reported that the ANAS now has a web page and invited everyone to look at it. He commented that the Academy has two main branches of interest: 1) supporting research, and 2) supporting education. The Academy is doing a superb job supporting science education, but it needs to improve and extend its efforts in supporting research. We must work to strengthen the Academy's role in research through its publication efforts. The latest issue of the Journal is just out! Volume 32 and 2 floral issues will be coming out this year and perhaps a third issue of the Journal. In addition, we must recognize individuals who currently contribute and who have in the past contributed to science in Arizona and Nevada. We must reactivate the Fellows program. The Fellows present at the meeting were asked to stand and be acknowledged.

Owen adjourned the meeting at 1:35 P.M.

Respectfully submitted
Betsy Cooper
Recording Secretary
REPORT OF THE PERMANENT SECRETARY

Under the leadership of President Owen Davis the Academy has made great strides forward during the past year. Historical records have been updated, membership files have been redone, Journal subscriber lists have been combined, and the financial support needed for grants and awards provided by the Academy has been given a more solid foundation. Board members, too, should be congratulated for the progress being made.

It has been a privilege for me to have served the Arizona-Nevada Academy of Science as Permanent Secretary for the past, approximately, five years. Changing circumstances now make it difficult for me to fulfill the responsibilities of the office in a satisfactory manner. As a result I will be submitting my resignation as Permanent Secretary effective on or about July 1, 2000. I hope to be able to assist in the transition and transfer of duties to the new Permanent Secretary. My thanks to the Academy for providing this opportunity and my appreciation to Board Members for their generous assistance and cooperation during my tenure as Permanent Secretary.

Respectfully Submitted,
Gordon Johnson

REPORT OF THE MEMBERSHIP SECRETARY

The Arizona-Nevada Academy of Sciences has about 254 active members (127 have paid dues for 2000). This includes 21 Life Members, 38 Emeritus Members, 47 Fellows and 8 new members.

Respectfully submitted,
Betsy Cooper

REPORT OF THE FELLOWS COMMITTEE

Based on their standing in the scientific community and service to the Academy, the following members are recommended to be named Fellows of ANAS:

Vic Baker, University of Arizona
Jan Bowers, United States Geological Survey
Owen Davis, University of Arizona
Don Post, University of Arizona

ANAS Fellows Committee
Dean Blinn
Stuart Marsh
Ray Turner
REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee submitted the following slate of candidates for 2000 - 2001:

President
Owen Davis, Univ. of Arizona-Geology Dept.

President-Elect
Jim DeVos, Arizona Game and Fish Department

Recording Secretary
Betsy Cooper, GCC

Membership Secretary
Ingrid Novodvorsky , Univ. of Arizona-Physics Dept.

Treasurer
Karen Conzelman, GCC-Biology Dept

Directors
Southern District
Robert Scarborough, Arizona-Sonora Desert Museum

Central District
[replacement for Jim DeVos?]
Carl Reiber, UNLV

Northern District
Norm Thomas, NAU

New Appointments:
Editor of Journal
Tony Brazel, ASU-Climatology Lab

Director of Junior Academy
Lynnette Hoff

Respectfully submitted
Don Young, Chair

BUD ELLIS SCHOLARSHIP AWARD

The Bud Ellis Scholarship Committee has selected Douglas Jarczyk as the 2000 recipient. There were nine completed applications and Doug was a clear standout. He attends Ironwood High School and plans to attend ASU to study chemical engineering.

Respectfully submitted
Peggy Pollak
ARIZONA-NEVADA ACADEMY OF SCIENCE OUTSTANDING SCIENCE TEACHER AWARD

Awards are being given to outstanding teachers in three divisions: elementary school, Middle School and High School

Elementary (K-5)
Debby McWilliams
Coolidge Intermediate
Coolidge, AZ

Ms. McWilliams is a fifth grade teacher "who is an advocate of small groupings and never seems to run out of ideas". "Life is her laboratory! Everything has meaning! Her students are taught to observe and question what makes things "tick". Students and parents love her". In addition to her exciting classroom activities, Ms. McWilliams runs an after school Science Club for 4th-6th graders, the Science Olympics, Science Fair and Star Lab. She has developed a I-Q Science/Erudito internet project, mentored student teachers, worked on the science curriculum for her district and is involved in the Central Arizona Math and Science program.

Middle School (6-8 grade)
Celia Cameron
Buckeye Elementary District #33
Buckeye, AZ

Ms. Cameron is an eighth grade physical science teacher. She was awarded a grant from the Dial Corporation for Project Arid. Project Arid is a science project combining technology, agricultural sciences, and community involvement to teach earth science in grades 2-6. The project allowed students to see actual scientist from the university at work and work along side of them. Farmers allowed their fields to become laboratories for the children and worked as mentors in and out of the classroom. She now is incorporating an internet component into the project which will enable students to "adopt: a farming community somewhere else in the world. She has also been involved with the districts science curriculum and Arizona IQ Science Program. She is a tireless advocate for science teaching method reform and her daily lessons are filled with inquiry and discovery learning methodology and assessment.

High School (9-12 grade)
Larry Dukerich
Dobson High School
Mesa, AZ

Mr. Dukerich is a physics teacher. He has been instrumental in changing the districts physics curriculum from a textbook centered program to a student centered program. He allows his students the enhance their learning in physics by allowing them to "inquire" about how things work rather than being told how they work. His labs are unique in that students
are not given canned instruction sheets to follow and collect data which support expected results. Instead, he demonstrates the phenomenon to be investigated and solicits from the students a list of relevant variable. The list is pared down to ones that can be done and frequently, students perform related but not identical experiments. He currently co-chairs the school’s North Central Outcomes Accreditation Technology Committee, is department head for the science department, and is president of the AZ section of the American Association of Physics Teachers. He developed the school’s internet home page and is active with an NSF sponsored physics program that involves preparing inservice and pre-service physics teachers.

Respectfully submitted,
Roberta Williams

HIGH SCHOOL GRANTS-IN-AID COMMITTEE

Awards of $100 were given to each of the following high school students:

Bridget Sellers, Smith Valley Schools, Smith, Nevada. Bridget is investigating the "Prolonged Effects of Aerosols Used on Small Farms and Ranches" under the direction of Randi Hunewill, her high school science teacher.

Diane Eisenbacher, Saint Mary's High School, Phoenix, Arizona. Diane is investigating the "Effects of Methanol on the Coleus Blume Plant" under the direction of Don Galen, her high school science teacher.

Respectfully submitted,
Gordon Johnson

GRADUATE GRANTS-IN-AID COMMITTEE

Two awards were given to the following graduate students who met the November 15, 1999 deadline for applications:

Jeffrey Brasher of the Botany Department at Arizona State University and Jeffrey Rousch also of the Department of Botany at Arizona State University.

Awards of $250 were given to each of the following graduate students submitting applications by the March 15, 2000 deadline:

Joseph Gilbert, Department of Geoscience, University of Nevada, Las Vegas. His research project is the "Structural Geometry and Kinematics of Mesozoic Contraction and Cenozoic Extension; Tectonic Implications for the Central Nevada Thrust Belt, Pancake Range,"
Central Nevada." He will be working under the guidance of his major professor, Wanda J. Taylor.

Ilse Schiefelbein, Department of Geoscience, University of Nevada, Las Vegas. Her research project is the "Fault Segmentation, Linkage, and Earthquake Hazards: Examples from the Sevier Fault, Southwestern Utah." She will be working under the guidance of her major professor, Wanda J. Taylor.

Respectfully submitted,
Gordon Johnson,
Ron Dorn

REPORT OF THE NECROLOGY COMMITTEE

It is with deep regret that we report the death of several members of the Arizona-Nevada Academy of Science.

DR. STANLEY ALCORN who was born June 18, 1926 in Modesto, California, passed away on April 18, 1999. He studied agriculture at Modesto Junior College and plant pathology at the University of California, Berkeley, where he received his B.S. and Ph.D. Dr. Alcorn went on to teach at the University of Arizona. He was President of various scientific societies including Guayule Society and Sigma Xi and belonged to the American Association for the Advancement of Science. Dr. Alcorn was an Emeritus member of the ANAS.

DR. GERALD A. COLE, 81, of Chandler, a retired professor Emeritus of Zoology at Arizona State University, died June 22, 1999. He was born in Hartford, Connecticut and was a World War II veteran.

DR. ROBERT M. HARRIS, born December 5, 1921 in Atlantic City, New Jersey, passed away January 12, 2000 after a courageous battle with lung cancer. Dr. Harris attended Philadelphia College of Pharmacy and Science and obtained a Ph.D. from UCLA. Dr. Harris was Professor Emeritus of the University of Arizona, recipient of the prestigious Salgo-Noren Foundation Teaching Excellence Award, a member of the U of A Hall of Fame and received the Outstanding Service Award from the Arizona-Nevada Academy of Science. Dr. Harris was author of numerous textbook in Genetics and botany and was a long time Editor of the Journal for the Arizona-Nevada Academy of Science.

JULIAN D. HAYDEN died of the long-term effects of emphysema at age 87 on March 6, 1998. He was an "amateur archeologist," never associated with an academic program, but nonetheless author of archeological books, including "Sierra Pinacata (U of A Press)," "Excavations, 1940, at the University Indian Ruins (SW Monuments Assoc.)," and "The Short, Swift Time of Gods on Earth (with D. Bahr, Univ. Calif. Press)." He was born in January 1911, in Hamilton Montana, and as a young man worked on the early excavations of many of Arizona's most important archeological sites, including Casa Grande, Kiet Siel, Snaketown, and Ventana Cave. He was the world's foremost authority on the archeology of the Sierra Pinacate, south of Gila, Arizona, which he first visited in 1958.
DR. TROY L. PEWE, a world-renowned Arizona State University geologist whose pioneering work on expanding soil, giant earth cracks and the consequences of groundwater pumping has helped shape Valley development, died on October 21, 1999, at the age of 81. Dr. Pewe received his Ph.D. in Geology from Stanford University in 1952 and moved to Alaska where he was an associate professor of Geology at the University of Alaska and served with the U. S. Geological Survey. Dr. Pewe came to ASU in 1965. He was head of the ASU Geology Department until 1976 and worked as a Professor Emeritus after his retirement in 1988.

Submitted by
Betsy Cooper
Steve Williams
REPORT OF THE TREASURER  
1999

Operating and Short Term Reserve Fund (Vanguard Prime Money Market Fund)

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<tr>
<th>Description</th>
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<tr>
<td>Account Value on 12/31/98</td>
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<td>Transferred to General Fund</td>
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<td>Dividend Deposits</td>
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<td>Account Value on 12/31/99</td>
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Goethe Educational Endowment Fund (Vanguard Index 500 Mutual Fund)

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<tr>
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<tr>
<td>Transferred Donations</td>
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<tr>
<td>Dividends</td>
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<td>Capital Gains</td>
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<td>Account Value on 12/31/99 (147.222 shares at $135.33/share)</td>
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General Fund

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<tr>
<td>December 31, 1998 Balance</td>
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<tr>
<td>Transferred to ASU Account</td>
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<tr>
<td>Transferred to Goethe Educational Endowment Fund</td>
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<tr>
<td>Transferred from Short Term Reserve Fund</td>
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<tr>
<td>Deposits</td>
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<td>Expenses</td>
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ASU General Fund

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Market Value of Assets (as of December 31, 1999)  
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<tr>
<td></td>
<td>Postage</td>
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<td>Grants-in-Aid, High School:</td>
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<td>Coffee Breaks</td>
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