# Abstracts

## Biological Sciences - Aquatic

### Whites Gulch Stream Stabilization and Fisheries Enhancement Project [AFS]

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In 1995, a portion of an Upper Missouri Westslope cutthroat (UMWCT) stream, currently one of the two remaining in the Big Belts Range east of Canyon Ferry Reservoir, Broadwater County, Montana, was reclaimed. Turn of the century ground sluicing followed by massive gold dredge operations in the mid-1 940's had left 3,000 feet of Whites Gulch perched in a ditch between some 100,000 cubic yards of overburden material and the north valley slope. The south side of the valley remained deeply excavated, filling with water and later, with brook trout (*Salvelinus fontinalis*). Thus, the hydrologic and ecological balance at the site remained precariously altered for years. The inevitable consequence was a massive headcut above the dredged valley triggered by springtime rainstorms in 1993. The result was 700 feet of deeply incised channel marked by 20 to 30 foot vertical walls that provided ponded nonnative brook trout direct access into cutthroat habitat immediately upstream. At this scale, reclamation planning and implementation demanded the combined resources of local, state, and federal agencies working in concert with private consultants. Recognizing the unstable conditions and on-going degradation in Whites Gulch and the value of local UMWCT, the only viable option was to restore long-term hydrologic stability by recreating the valley floodplain and channel to historic geomorphic conditions. To protect and preserve the remnant cutthroat (*Oncorhynchus clarki lewisi*) population from invasive brook trout, project planners had to include provisions for a barrier to segregate the two species. Valuable lessons in stream restoration planning and implementation are always in store for all parties involved in reclamation efforts at this level. Whites Gulch was not without its problems. More emphasis on building flexibility into construction scheduling including funding for post-construction design adjustments and maintenance are absolutely necessary to ensure that QC/QA considerations are met. However, determined efforts by all parties to reach well defined goals at Whites Gulch are paying off. Early monitoring indicates this project to be a conservation success for the physical and biological aspects in and above the project area.

*Title footnote indicates organization, location and date presentation was made:*

AFS *Montana Chapter of the American Fisheries Society Annual Meeting, Bozeman, MT, Feb. 5-6, 1997*
MAS *Montana Academy of Sciences Annual Meeting, Billings, MT, April 11-12, 1997*
TWS *Society of American Foresters Joint Annual Meeting with TWS as above.*
*Montana Chapter of the Wildlife Society Annual Meeting, Missoula, MT, March 5-7, 1997*
SAF

## Distribution of Whirling Disease in Montana[AFS]

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The detection of whirling disease (WD), a parasitic infection of salmonids, in the Madison River, southwest Montana, in December 1994 and its subsequent link to a 90% decline in the river's wild rainbow trout, prompted a statewide testing program to map the disease's distribution in Montana's streams, rivers, lakes, ponds and reservoirs. More than 400 sites were tested by fall 1996. Whirling disease is more widespread than anticipated; at least 42 waters in the Clark Fork, Flathead and upper Missouri drainages are infested. Testing failed to detect WD-positive waters in the Yellowstone, Kootenai and St. Mary's drainages. Whirling disease is moving downstream from known headwater outbreaks in the Missouri and Clark Fork drainages. However, within the disease's current distribution, are isolated positive sites that are surrounded by "clean" waters. Infected hatchery fish and fish-eating birds have likely contributed to the introduction and spread of WD in Montana. Other transport mechanisms are possible but unlikely.

## Efficacy of Special Regulations on the Big Hole River [AFS]

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Three Big Hole River study sections, southwest Montana, were analyzed to determine the efficacy of a special regulation in increasing numbers of larger brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) over the 1981 - 1996 period. The regulation requires the release of trout in the 13 - 22 inch range and restricts the method to the use of artificials. Boat-mounted mobile anode electrofishing sampling was conducted annually in March in two study sections to determine brown trout populations. Rainbow trout sampling was conducted in September in three study sections. Population estimates were determined by log - likelihood analysis of mark - recapture data. Brown trout density and standing crop fluctuated in the control section but exhibited increasing trends under special regulation. Thirteen inch and larger and 18 inch and larger brown trout were higher in the special regulation section. Brown trout data suggest that the "slot limit" was effective in increasing the percentage of the standing crop accounted for by both 13 inch and larger and 18 inch and larger fish. Rainbow trout densities and standing crops fluctuated with recruitment in all three sections. Numbers of 13 inch and larger rainbow trout exhibited increasing trends within all three sections. Sixteen inch and larger rainbow trout attained the highest densities and increase in the control section. Data suggest that the "slot limit" was ineffective in increasing the percentage of the standing crop accounted for by the 13 inch and larger or 16 inch and larger rainbow trout.

## Riparian and Wetland Ecological Health Evaluation of Selected Streams on the Charles M. Russell National Wildlife Refuge [TWS]

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Between August 7 and October 15, 1995, the Riparian and Wetland Research Program of the University of Montana evaluated 113 stream segments on the Charles M. Russell National Wildlife Refuge (CMR NWR) in northcentral Montana. The evaluations provided USDI Fish and Wildlife Service managers on the CMR NWR with information to help them appraise their current management practices, and to help them develop strategies to meet objectives regarding riparian and wetland health on the refuge. Sixteen factors relating to hydrology and streambank, geology and soils, and riparian vegetation were scored for each stream reach. Based on the scores, the reach was classified as functioning, functioning at risk, or nonfunctional. Sixty-nine percent of evaluated stream segments scored in the nonfunctional category. Evidence from livestock exclosures and adjacent ownerships suggests that current livestock grazing practices may be inappropriate for some CMR NWR streams given the fragile soils that occupy much of the land area. Other factors affecting health scores may include water removal (via stock ponds and upstream irrigation withdrawals) and the absence of beaver (*Castor canadensis*).

## Sustainable versus Unsustainable Conservation Efforts Along the Peruvian Coast [TWS]

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In December 1996, a study was initiated with the goals of balancing the needs of marine wildlife (fur seals, sea lions, and penguins) with the needs of a local artisanal fishermen at Punta San Juan, Peru (15° 22' S 75° 11'W). Original plans were to collect data on 1) foraging locations of those marine predators are most heavily exploited (directly and indirectly) by the fishery and 2) locations where local fisherman capture their marine resources (i.e. fish, eggs, mollusks). With these data we planned to identify locations of heaviest overlap and interaction, and propose regulations to limit fishing in areas of marginal productivity value for the fisherman, yet high mortality rates for the wildlife, especially in the case of the Humboldt penguin, a species listed under CITES appendix I. Despite our ability to accurately collect data, integrate them into a simple, easily understandable series of overlap charts, and derive legal regulations prohibiting fishing under certain conditions, this approach will be received with scepticism. I will now outline a newer approach to conservation of the Peruvian marine ecosystem, which attempts to better integrate the ideas and life-styles of the local fishing community. I will describe the history of the

conservation of the living resources of the marine upwelling system in Peru, and provide examples of how small attitude changes in the conservationist can produce a large change in the desired results.

### Assessing Functional Health of a Riparian Site [TWS]

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An increased public awareness of the benefits of the need for ecosystem functional health has driven a movement to identify factors that operate on the landscape to enhance or degrade natural ecologic function. In cooperation with various agencies, we have developed a rapid assessment procedure for evaluating functional health of a stream reach and its associated riparian zone. The procedure quantifies an array of parameters indicating the ability of different aspects of the system to function. These quantities are weighted and factored into a formula to produce a comparative rating of riparian functional health. A land manager can use the evaluation to: 1) assess present functional health of a stream reach, 2) identify specific factors needing remedial attention, and/or 3) through repeated evaluation as a monitoring tool for assessing effectiveness of management change. The procedure, designed for use by land management professionals as well as landowners with minimal training, can be used to evaluate health of a 200 ft representative reach of stream in about 2 hours. The evaluation does not require precise measurements, but instead relies on visual estimations of readily observable parameters grouped into three categories of factors: vegetation, soils/geology, and hydrology/streambank. Estimates of ten such factors are used to develop an overall health rating. With minimal training, evaluators using this procedure have demonstrated success at calibrating their observational skills to attain consistent and repeatable results.

## Biological Sciences - Terrestrial

### Who gets parasitized by Brown-headed Cowbirds?
### The importance of everyday host activity [TWS]

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The recent range expansion of the Brown-headed Cowbird (*Molothrus ater*) in North America has introduced brood parasitism as a new selective force for many host species. High parasitism rates cause greatly reduced reproductive success for many species. Parasitism rates vary dramatically among species, but factors affecting the probability of parasitism remain poorly understood. Cowbirds are thought to find nests by watching adult behavior, and nest defense behavior correlate with parasitism rates among some species. Other more prominent behaviors (e.g. nest-

building visits, mate-feeding, vocalizations) centered around the nest during early nesting phases may also serve as cues to nest searching cowbirds. I test an "everyday activity" hypothesis in which pairs more active around their nests during the early nesting phases have a higher probability of being parasitized than less active pairs. I measured behaviors of American Redstarts (*Setophaga ruticella*), Yellow Warblers (*Dendroica petechia*), Dusky Flycatchers (*Empidonax oberholseri*), and Warbling Vireos (*Vireo gilvus*) nesting in the same habitat but differing in parasitism rates. I find a positive correlation between male singing rates near nests and parasitism across species. Within species, too, parasitized males sing more than unparasitized males. Female activity and frequency of nest visitation appear uncorrelated or inversely correlated with parasitism. These data suggest that cowbirds may exploit male behaviors when searching for nests and that we might expect the frequencies of such behaviors to change over time in response to parasitism pressure.

## Dispersal and Genetic Relationships of Recolonizing Wolves in the Rockies [TWS]

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Gray wolves (*Canis lupus*) have recently recolonized western Montana, southeastern British Columbia, and southwestern Alberta, 50 years after their systematic extirpation from the region. Recovery of recolonizing wolf populations depends on successful dispersal from source populations, subsequent reproduction, and maintenance of genetic variation. We tagged 56 wolves in the Glacier National Park area during 1984-1996. We used a combination of telemetry and field data to determine the characteristics of dispersers, including age, sex, season of dispersal, longevity, dispersal distance, direction traveled, temporary associations with other packs, and reproductive success. Thirty-two of the tagged wolves dispersed 20-832 km from their natal home range. Fourteen dispersers produced at least one litter of pups each. Gene flow due to dispersal must be maintained to prevent a population bottleneck and consequent reduced genetic variation. We used DNA microsatellite genotyping to examine the genetic relationship of recolonizing Rocky Mountain wolves. For genetic analyses, we combined samples from adjacent Canadian wolf studies, Montana wolves tagged by the U.S. Fish and Wildlife Service, and our data (n=91). We found high genetic variation, measured in terms of heterozygosity and allelic diversity, indicating a lack of a founding population bottleneck. To maintain high genetic variation, gene flow between wolf subpopulations must be assured through dispersal. Combining field data with genetic analyses yielded information that neither study alone could determine, including the synergetic synthesis of long dispersal distances, high dispersal rates, and adequate gene flow among colonizers.

## Spatial Changes In Habitat Use By Elk In Western Montana [TWS]

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Comparing radio locations of cow elk (*Cervus elaphus*) taken from 1977-1983 and 1993-1996 revealed changes in landscape use. Yearlong, calving season, summer, rut, and hunting season patterns of use for two adjacent elk herds were examined by comparing the relative use of grid cells overlaid upon the study area. These changes span the time frame from before logging was initiated in the upper Chamberlain Creek drainage, in westcentral Montana, through 15 years of logging activity to the present. This presentation represents only a portion of the Chamberlain Creek Elk Study, which is investigating the long-term effects of habitat fragmentation on elk habitat use and home ranges.

## Small mammals in burned and unburned habitats on the Beartooth Wildlife Management Area [TWS]

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Small mammal trapping was conducted on the Beartooth Wildlife Management Area near Wolf Creek, Lewis and Clark County, Montana, to determine species occurrence by habitat type, and to survey for special interest or concern species. Seven traplines using Sherman live traps, snap traps, and pitfall traps were run during August and September, 1996. Three traplines were located in areas that were partially or severely burned during the 1990 fire. A total of 414 mammals were captured with eleven species represented. Captures/100 trap-nights ranged from 3.1 in burned ponderosa pine forest to 46.3 in willow-riparian habitat. Species richness was highest in unburned cottonwood riparian (n=6) and burned aspen habitats (n=7), lowest in intermountain grassland habitat (n=3), and intermediate in unburned Douglas-fir-ponderosa pine forest (n=5) burned ponderosa pine (n=4) and unburned willow-riparian habitats (n=4). Trapping results compared favorably with those from studies conducted by the Montana Nongame Program in similar unburned ponderosa pine habitats. Results suggest that small mammal productivity and diversity in burned habitats is variable, but generally comparable with similar unburned habitats in Montana. However, forest obligates such as the Red-backed Vole (*Clethrionomys gapperi*) were absent from 6-year post-burned areas. Riparian and aspen habitats supported the highest diversity and density of small mammals, further emphasizing the importance of properly managing these habitats to maintain their high species diversity and productivity.

## A LANDSCAPE PERSPECTIVE ON THE EFFECTS OF CLEARCUTTING ON BIRDS IN CEDAR/HEMLOCK FORESTS [TWS]

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Landscape patterns in cedar/hemlock forests in northern Idaho have been modified by clearcutting. I investigated the effects of these changes in landscape patterns on birds by examining bird distribution and nesting success (1992-1994) in three landscapes: (1) a continuous old-growth forest landscape, (2) an old-growth landscape with recently embedded clearcuts, and (3) a landscape composed of selectively harvested forest fragments and older clearcuts. Three species (Brown Creeper (*Certhia familiaris*), Winter Wren (*Traglodytes traglodytes*), and Golden-crowned Kinglet (*Ragulus satrapa*)) were clearly associated with continuous old-growth cedar/hemlock; these may be interior forest species. Twenty species were associated with landscapes fragmented by clearcuts. Surprisingly, many forest species were as abundant or more abundant in clearcut landscapes as in continuous forest. Probability of daily nest success did not differ significantly between the continuous and modified old-growth landscapes for five species. The trend for four of these five species (all cavity-nesters), however, was lower nesting success in the modified landscape, with lower nesting success on clearcut edges than in interiors. Management recommendations are tentative, because the nesting success data is based on small samples and only two landscapes. Maintaining continuous, unlogged, old-growth cedar/hemlock forest is a reasonable, conservative strategy for maintaining interior-associated birds. But this study indicates that more research is needed on nesting success of birds, especially cavity nesters, in clearcut landscapes to ascertain whether leaving trees and snags in clearcuts is a good universal strategy for maintaining cavity nesting birds.

## HABITAT USE AND BEHAVIORAL ACCLIMATION BY BIGHORN SHEEP INTRODUCED IN NORTH UNIT OF THE THEODORE ROOSEVELT NATIONAL PARK [TWS]

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Nineteen radio-collared California bighorn sheep (*Ovis canadensis californiana*) (14 ewes/5 rams) were introduced in the North Unit (Mckenzie County, North Dakota) on January 26, 1996 and monitored at 2-3 day intervals with the use of telemetry equipment for one year. Since their introduction, sheep have slowly increased their range inside and outside the park boundaries. The predictions of the North Unit bighorn sheep Geographical Information System (GIS) habitat model were generally validated by field observations. Sheep activities were focused in *Stipa comata/Carex filifolia* and *Artemesia tridentata/Agropyron smithii* habitat types. Vegetation analysis suggests percent utilization for areas used by sheep averaged 62% before the study animals moved to other foraging territories. Plant species composition in sites identified as used was highly variable. The physiographic type most frequently used

by the sheep was the Badlands type. Feeding was heaviest during the mid-morning and late evening hours for the entire year. Bighorn sheep interaction with other ungulate species (*Bison bison* and *Odocoileus hemionus*) and predators was frequent and rare, respectively. Sheep generally habituated to the presence of humans. Fourteen adult ewes produced eight lambs in 1996, three of which died of undetermined causes.

## Assessing Gray Wolf Restoration in Idaho: Progress after Two Years [TWS]

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At least 29 of 35 gray wolves (*Canis lupus*) translocated to central Idaho and released on-site at selected backcountry locations in 1995 and 1996 have survived into winter, 1997. Two wolves died as a result of human-caused mortality; 1 of apparent starvation, 1 wolf death remains under investigation, and the status of 2 wolves is unknown. Of 29 regularly monitored wolves, at least 18 have joined with other radioed and non-radioed wolves (N=4) to form 11 potential breeding pairs. Three potential breeding pairs are located north of the Salmon River and 8 potential breeding pairs are distributed to the south. Nine wolves of reproductive age remain alone within the experimental area: a male and female remain north of the Salmon River and 5 males and 2 females are south. Translocated wolves did not reproduce in 1995 but 3 litters were produced during 1996. Radioed wolves have been located from fixed-wing aircraft every 10 days (approximate) since July, 1996 but once every 3 weeks prior to that time. Wolves moved extensively within the experimental area from 1995 through winter, 1996. However, only 5 of 33 wolves have permanently vacated or dispersed long distances outside the experimental area. Paired wolves were increasingly predictable in their movements during summer, 1996 but less so during winter, 1996-1997. Wolves preyed on elk (*Cerus elaphus*), moose (*Alces alces*), mule deer (*Odocoileus hemionus*) , beaver (*Castor canadensis*), and domestic sheep and cattle. We responded to 9 livestock depredation incidents; 3 were confirmed wolf depredations. The distribution of Canadian wolves released in Idaho is similar to the distribution of historical wolf reports during the past 70 years. Surveys in 8 areas where wolves were known to occur in 1996 found hunter and outfitters were accepting or positive about their return to Idaho. On the ground management following wolf restoration has proven more complex and time consuming than anticipated.

## Production and Survival of Elk Calves in Response to Habitat Improvement in Northwest Montana: Methodology [TWS]

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The purpose of my study is to learn the effects of winter range habitat improvement on elk (*Cervus elaphus*) pregnancy rates and calf survival in the Southfork of the Flathead river. Habitat enhancement is often done to mitigate losses to wildlife. The enhancement at Firefighter Mountain, completed in the summer of 1996, was done to mitigate the loss of elk winter range that resulted from the construction of Hungry Horse Dam. Determination of pregnancy uses a radio-immuno assay of fecal steroids. These assays successfully determined pregnancy in 10 elk during my first field season. Vaginal implants are being used to find out timing and location of birth sites in adult cow elk. Previous use of vaginal implants by researchers on ungulates has met with mixed and often poor results. Recently, a new type was developed for white-tailed deer (*Odocoileus virginianus*) and used with high success. This new design has been adopted and adjusted for elk. The implants consist of an inert plastic base from a progesterone implant, designed for domestic swine, attached to a radio transmitter. Although my sample size was small (n=5), retention rates were 100%, and I could determine time and place of parturition. Preliminary results are positive on the effectiveness of these methods.

## Trends in Bison Management: What it Means for the Species [TWS]

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We have observed several common trends in recent literature and conferences on commercial bison production. These include: artificial seeding of native range, pest/parasite treatment, feedlot "finishing", dehorning, small herd sizes, highly skewed sex ratios, and culling or other selection based on subjective characteristics. The rationale for these activities is rarely articulated, and appears to be a carry over from the livestock industry. However, these techniques add unnecessary expense and labor when applied to bison. We argue that they are biologically and ecologically counterproductive as well. The history of ungulate domestication and management suggests that producers are forcing a native ungulate adapted to North American grassland ecosystems, with few pests/parasites/diseases, high reproductive

capability and low natural mortality into an artificial, expensive, labor intensive management system. We recommend producers adapt specific management strategies and activities to bison ecology and behavior, rather than vice versa. These strategies include: large herds on adequate acreages of native range, natural sex ratio , maintaining older age classes, exchange of yearlings between herds, random harvest strategies, and minimizing disease treatments. Strong artificial selection will likely result in another poorly adapted, less successful ungulate. Managers of public bison herds are in a unique position to preserve bison as a wild ungulate becau e they are not under the economic constraints of private producers. However, a review of public herd management shows there is a need to apply knowledge of conservation biology to bison management on public lands.

## Dietary overlap of wolves and cougars within and near Glacier National Park, Montana [TWS]

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We compared patterns of prey selection among wolves *(Canis lupus)*, cougars *(Puma concolor)*, and humans to ascertain the effects of wolf recolonization and multiple predators on prey and on each other. Characteristics of prey selected by wolves and cougars in the same ecosystem have not been reported. White-tailed deer *(Odocoileus virginianus)* made up the greatest proportion of both wolf (0.83) and cougar diets (0.87), but elk *(Cervus elaphus)* and moose *(Alces alces)* made up a larger proportion of wolf (0.14, 0.03, respectively) than cougar (0.06, 0.02, respectively) diets. Wolves and cougars selected the same age classes in both deer and elk. They both selected older and younger deer and elk than human hunters did. They both selected fewer males than hunters did and they both selected more fawns and more males than expected based on availability. Cougar predation on elk was more male-biased than was wolf predation on elk. Cougars generally killed animals in poorer condition than wolves did, especially in elk. These data may be used by predator/prey managers to anticipate effects of wolf and cougar presence on populations of prey and may also be used to determine potential impacts of one predator on the other. We suggest possible management alternatives to mitigate effects.

## The Effects of Wolf Colonization on Coyote Behavior, Movements and Food Habits [TWS]

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The Flathead area in western Montana is one of the last ecosystems in the United States still containing a full complement of mammalian predators and their prey. Recolonizing wolves (*Canis lupus*) may affect congeneric coyotes (*C. latrans*) by altering food habits, social behavior, movements and habitat use. We examined the effects of colonizing wolves in northwestern Montana on the resident coyote population. Radio-collared wolves and coyotes were monitored from June 1994 through December 1996 to determine home ranges and movements. Home ranges for eleven coyotes were distributed between the two wolf pack territories or on the edge of the territories, and did not overlap with core wolf areas. Locations for a 24-hour period on one canid were used to determine if temporal partitioning occurred between the canids. Coyote movement was the greatest between 1100-1400 and wolf movement between 0200-0400 hours. Some food partitioning does occur in that coyote diets consist of small mammals (i.e. snowshoe hare (*Lepus americanus*) and microtines), however, white-tailed deer (*Odocoileus virginianus*) are also consumed. Elk and white-tailed deer comprise the main diet of the wolf packs. Complex interrelationships between the predators in the North Fork occurs as well as interrelationships between the predators and the prey. Predators in fact account for 80 percent of the coyote mortality in the North Fork. Wolf presence may be beneficial to coyotes as a source of additional food through scavenging, but it also appears that the wolves are affecting coyote distribution and survival.

## Tracking Elk Hunters with the Global Positioning System [TWS]

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In a study of elk-hunter behavior in western Montana, we used battery powered Global Positioning System (GPS) units to record hunter locations at 15-second intervals during 99 hunting expeditions in 1993, 1994, and 1995. Subsequent analysis within a Geographic Information System (GIS) enabled us to determine time and motion budgets for hunter effort, estimate the departure distance from roads and hunting camps, and evaluate the influence of closed roads on elk hunting techniques. Hunter locations were overlaid on other GIS layers to determine time spent in different vegetation classes and identify topographic situations selected for hunting. Hunters averaged 4.7 hours per hunt, while moving at a speed of 40 m/min for a distance of 10.7 km. Only half of all hunters got more than 2.5 km from their starting point, and only 5 percent went more than 5 km. The average distance from the nearest road while hunting was only 267 m, and hunters on foot spent 26 percent of their hunting time on roads. Hunters who spent the most time on roads also

recorded the greatest distances from their starting points. Sixty percent of all hunting was done on slopes less steep than the study area average, and westerly aspects were favored. Among the forest types available to them, hunters selected open Douglas-fir and Western Larch while avoiding Lodgepole pine and Sagebrush.

## Demography and Trend of a Local Grizzly Bear Population in a Source-sink Landscape. [TWS]

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Demographic characteristics and local population trend of grizzly bears *(Ursus arctos horribilis)* were studied in the Swan Mountains of western Montana during 1987-1996 using capture and telemetry methods. We captured 50 grizzly bears in 108 capture episodes (1 bear/72 snare-nights). Using radio collared bears only, there were between 19 and 30 bears in the 1,457 km$^2$ study area each year (=1.6 bears/100 km$^2$). Density of bears in a 692 km$^2$ high-use area termed the Core Area averaged 2.5 bears/100 km$^2$. Twenty-eight cubs were produced from 17 litters for a mean litter size of 1.64 $\pm$ 0.12 cubs/litter. The reproductive rate for female cubs was estimated to be 0.389 $\pm$ 0.104. We obtained 170 bear/years of censored telemetry data from all classes of radioed grizzly bears, 25 of which died. The observed annual total mortality rate of 13.4 percent for all classes was higher than those found in expanding brown bear populations. Most mortalities occurred in roaded areas near private lands at the edge of the study area (Rural Zone) that exhibited a lower bear density than the Core Area. Dispersal movements of young females were confined to areas near the natal home range, away from the Rural Zone, while young males were more likely to utilize the Rural Zone. Using a derivation of Lotka's equation, our estimate of lambda during the entire study was 1.009 (95 percent confidence interval = 0.896 - 1.096). There was a 59 percent probability that the population was stable to increasing, a 55 percent probability that the population was increasing, and a 41 percent probability of population decline. The spatial occupancy of the Core Area suggested that the study area was at or near capacity under present landscape conditions. Differential bear densities within the study area, movement patterns, spatial occupancy, and vital rate characteristics suggested a "source-sink" situation.

# Effects of Selective Hunting on Pronghorn Behavior at Fort Belknap Indian Reservation [TWS]

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Sport hunting usually is not considered to impact wildlife populations negatively. However, trophy hunting, a highly selective form of hunting, raises some concern among biologists because a distinct group of males is removed from the population. Among other effects, selective hunting can produce changes in breeding patterns. The objective of this study was to investigate effects of a selective hunt, which occurred during the breeding season, on behavior patterns of male pronghorns (*Antilocapra americana*). We compared demographic variables, activity patterns, and interaction rates among individually recognized males that were subjected to light, moderate and heavy amounts of hunting pressure at Fort Belknap Indian Reservation in northcentral Montana. Although group size, time budgets and interaction rates changed from the prerut time period to the rut, males living in areas subjected to the three treatments did not vary significantly in the amount of time they spent active, walking or reclining, nor did they vary in interaction rates. The number of fawns present in a male's group, however, was lowest in areas that received the heaviest hunting pressure. We conclude the trophy hunt, which is restricted to a maximum of 100 tags, did not adversely affect the reproductive activity of pronghorns in this population. However, biologists should continue to monitor age structure, sex ratio, and productivity in order to detect any changes that may occur as a result of the hunt. Furthermore, genetic diversity should be monitored to detect any changes that may result from a loss of prime males from the population.

# Montana Black-footed Ferret Reintroductions, 1994-1996 [TWS]

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Black-footed ferrets *(Mustela niaripes)* reached the brink of extinction in the 1980s. Successful captive-breeding efforts have produced ferrets for release in the wild in 4 states since 1991. Montana reintroductions to establish a wild population began in 1994 with the release of 40 ferrets, another 36 in 1995, and 43 in 1996. Releases were on black-tailed prairie dog *(Cynomvs ludovicianus)* colonies on the UL Bend National Wildlife Refuge in southern Phillips County, northcentral Montana. Five wildborn kits from 3 litters were observed during 1995 and 18 from 7-8 litters in 1996. Approximately 35 animals were in this population during December 1996. Many variables affected success including; ferret age and rearing method, predator management, and habitat quality. Ferret kits pre-conditioned prior to release survived better than naive counterparts. Short-term ferret survival was apparently increased by exclusion of coyotes *(Canis latrans)* from release sites with electrified netting and/or lethal coyote control, but significantly higher survival through the following breeding season was not evident. We present and discuss results from these reintroductions and current assessments of techniques to establish wild black-footed ferret populations .

## Cougar Food Habits, Prey Selection, and Predation Rates in the Northern Yellowstone Ecosystem [TWS]

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Cougar (*Puma concolor*) predation was studied from 1987 to 1996 in northern Yellowstone National Park and vicinity. Eighty-eight cougars were captured, 84 were radio-collared, and kills of 46 individuals were documented. Elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) comprised 98 percent of prey biomass and 81 percent of 302 cougar kills. Bighorn sheep (*Ovis canadensis*), moose (*Alces alces*), and pronghorn (*Antilocapra americana*) represented less than 5 percent of cougar kills. Among deer and elk, elk calves were the most important prey, mule deer were intermediate, and cow and bull elk were the least important prey relative to their availability. Predation rates averaged 9.4 days per ungulate kill and varied by cougar hunting experience (measured by age), weight, and ambient air temperature. Cougars killed only 2-3 percent of elk and 3-5 percent of deer on the study area each year. Migratory behavior, habitat use patterns, and the size of prey reduced the effects of cougar predation. Cougars did not effectively limit growth rates of elk and moose populations on the study area, because cougars selected their young preferentially to adults. Strong limitation of mule deer populations was more likely, because all sex-age classes were preyed upon more equitably. Our results indicated that altering the structure of cougar populations (e.g., by hunting) could change the influence of cougars on the numbers and sex-age structure of their ungulate prey. In other words, if the age structure of a cougar population in an area is skewed toward adults, cougar predation would more likely occur on larger ungulates such as elk over deer.

[1]Deceased

## Numerical and Functional Responses of a Generalist Predator: Field Examination of a Simple Predator-Prey System [TWS]

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Many predators exhibit numerical and functional responses to fluctuating prey densities. Although it is often practical to measure the numerical response in field settings, functional responses are usually determined in laboratory experiments

because quantifying the components of predator consumption rates (handling time, search rate) in the field is difficult when predation events are rarely observed. However, more field testing is needed because some species show variable functional responses as ecological conditions (resource distribution, age composition of foraging groups) change. Understanding predator behavior is also prerequisite to interpreting the consequences of predator-prey interactions on community dynamics. We determined the numerical and functional responses of bald eagles (*Haliaeetus leucocephalus*) feeding on spawning kokanee salmon (*Oncorhynchus nerka*) at an autumn migratory concentration in west-central Montana. Bald eagles tracked the fluctuating number of salmon during four of five years. This ability was manifest in immigration and emigration rates, which were similar across years, and appeared facilitated by behavioral (group foraging, communal roosting) and physical attributes (keen eyesight) of bald eagles. Eagles exhibited a Type II functional response. Handling time remained constant across the range of prey densities, whereas attack rate increased with increasing salmon numbers. Functional responses differed between eagle age classes and among foraging modes, which reflected age-specific foraging behavior and suggested that eagles view live and dead salmon as alternative prey types. Overall, bald eagle predation on kokanee salmon is inversely density-dependent over most prey densities.

## Harlequin Duck (*Histrionicus histrionicus*) Behavior and Habitat Use in a Northern Rocky Mountain Stream [TWS]

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The harlequin duck is a valuable case study for behavioral research because only 110 harlequin duck pairs are known to breed in Montana (Genter 1992). In spite of this regional rarity, McDonald Creek, in Glacier National Park (GNP) has the highest known density of harlequins in the intermountain region. The harlequin duck has been listed as Category 2 status, declining trend, under the Endangered Species Act. The USDA Forest Service lists the harlequin duck as a "Sensitive Species" in Region 1 USDA and Montana of Fish, Wildlife and Parks lists it as a "Species of Special Concern". The harlequin duck's vulnerability creates the urgent need to characterize the species habitat use, and define effective riparian assessment practices. Harlequin duck range throughout North America has decreased dramatically from the historical record. Solutions to this decrease are likely to be as varied as the biomes in which the species lives. This study is an initial component of a multidisciplinary, multiorganizational approach to harlequin conservation. This study site is important for harlequin duck research because of the extensive historic data collection at the site during 1973-75 and 1992-1994). This 2-year study began in fall, 1994 with initial habitat use surveys. Observed behavioral responses by males during the breeding season showed significant sensitivity to human presence. Responses by males varied from immediate flight, to stress behaviors such as physical positioning of the male between the intruder and the female, accompanied by repeated headbobbing. Males engaged in courtship displays culminating in mating and intraspecies aggression were significantly less sensitive to human presence. Observed behavioral responses by females during the breeding season, nesting and broodrearing showed less

sensitivity to human presence than the males, although flight or drift responses still occurred at ranges of less than 100 m. Immature ducks before full flight showed less sensitivity to human presence than the females, with flight or drift responses still occurred at ranges of less than 70 m. All classes of harlequin ducks used riparian habitat features such as exposed, in channel boulders for loafing. No classes of this species used study stream reaches with substrates smaller than large gravel.

## Rare Carnivores and Highways: Management Problems and Solutions [TWS]

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The impacts of highways is a serious conservation issue facing rare carnivores (grizzly bear, *Ursus arctos;* gray wolf, *Canis lupus;* wolverine, *Gulo gulo;* lynx, *Lynx canadensis;* fisher, *Martes pennanti*). Carnivores are vulnerable to highways because of their large spatial requirements, which require frequent crossings of busy roads. Highways are habitat and ecosystem issues. Highways affect carnivores by increasing direct and indirect mortality, habitat loss, habitat fragmentation, and displacement. The impacts of highways on carnivores are permanent and severe. The author hypothesizes that: 1) there is an increasing effect on carnivores as the standard of road or highway is increased and 2) that extirpation of rare carnivores in the lower 48 states is partially a factor of highway density. Suggested priorities for reducing highway impacts on carnivores include: 1) educating agency personnel, biologists, engineers, and the public on highway/wildlife impacts; 2) emphasis on research; 3) identification and protection of land corridors; 4) implementation of highway crossing structures; and 5) improving wildlife/highway mitigation policies.

# Integrating Wildlife Conservation And Ecosystem Health: An Example From The Columbia River Basin, USA [SAF]

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The theory and practice of ecosystem management is pivotal to the debate over how to sustain the health and productivity of our environment. Despite substantial and recent effort to implement ecosystem management in the United States and elsewhere, to date considerable uncertainty remains about how to evaluate the historic and natural spatial-temporal variation in ecosystems, secure present and future management options by maintaining essential parts of an ecosystem (including wildlife), analyze wildlife information—habitat, distribution and abundance—that often is insufficient at the ecosystem scale, predict wildlife habitat and other requirements at the ecosystem level to satisfy national and agency legal and policy requirements, and offer recommendations that vary with taxa to ecosystem change—historic and future (i.e., restoration)—at an ecosystem scale that matches both planning strategies and implementation opportunities of land and resource management agencies. Our central goal in assembling this paper is to examine these five aspects—in essence the concept of ecosystem health and its relation to wildlife management—in a contemporary landscape, the Columbia River Basin in the Pacific Northwest of the United States. Our Interagency Working Group report begins with brief description of the extent and ecological significance of the major departures in the nature, distribution and structure of vegetation since intensive European settlement. Second, all vertebrate wildlife species within the Basin are evaluated based on trend, habitat and other information to identify those in need of consideration in management to meet legal and policy requirements. Third, given the lack of habitat and other natural history information for many species, we

describe a process to build and evaluate species' habitat information, recognizing that effects of environmental change on individuals is more easily detected than on populations (although the latter are often needed to meet legal and policy requirements under the Endangered Species Act, the National Forest Management Act and similar legislation). The fourth aspect is not a trivial task whether in scale, theory or practice. Specifically, characterize the distribution and abundance of habitats for species groups (related to geographic scale and species-specific ecology and behavior) and/or individual species; and determine whether such habitats may serve as "sources" of individuals—a consideration to the maintenance of viable species populations—or "sinks" where populations may be expected to decline without regular immigration; and map the results of task four. Unfortunately, most available wildlife and ecosystem theory and scientific literature addresses ecosystem management at a scale far less than that needed to implement, greatly increasing the difficulty in developing reasonable implementation ecosystem management strategies. We conclude with lessons learned in linking ecosystem health and wildlife management.

## Hunter Management Strategies Utilized by Montana Ranchers [TWS]

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A survey of private ranches was conducted to identify practices used in Montana to manage hunters. A questionnaire was sent to 989 ranchers from a population identified as typical working ranches larger than 400 ha. Respondents (42% return) indicated 80 percent had no restrictions or simple permission to hunt on most of their land. Twelve percent of the respondents indicated their ranch was closed to hunting and 12 percent had fee hunting operations or leased to outfitters. Past damage by hunters (42%) and conflicts with hunters (33%) were reasons most cited for closing ranches to hunting. Combinations of strategies were utilized with vehicle restrictions, advanced reservations and check in/out being most common. Ranch size influenced management strategies with 63 percent of ranches under 4000 ha requiring only simple permission to hunt compared to 28 percent of ranches larger than 4000 ha. Sixteen percent of the smaller ranches had 50 percent or more of their land closed compared to 5 percent of the larger ranches. Implications of study results include a need for programs to address landowner concerns and programs to impress upon hunters the importance of their behavior in affecting public access to private land.

## Nesting Success in Deciduous Riparian Habitat: How Landscapes Affect Nest Predation and Brood Parasitism [TWS]

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Effective wildlife conservation programs depend on a thorough understanding of the processes that limit population growth and the scale at which these processes change. In the case of migratory birds, two of the primary processes that limit breeding productivity are nest predation by a host of predators, and brood parasitism by brown-headed cowbirds (*Molothrus ater*). The importance of these processes depend on the behaviors of the predators and brood parasites interacting with their environments over large spatial scales. We examined the relationship between patch size, edge effects and landscape composition in determining nest predation and brood parasitism rates for species nesting in deciduous riparian areas in western Montana. Predation and parasitism were monitored in sixteen riparian areas surrounded by different landscapes, eight of which are primarily forested, and eight of which are dominated by agriculture. Parasitism was strongly related to the density of farms and feedlots, and was higher in the agriculture treatment. However, predation pressure was consistently higher in forested landscapes. Parasitism may be more clearly related to certain landscape metrics because it reflects the behaviors and habitat use of a single species, the brown-headed cowbird. In contrast, predation rates are determined by interactions between predator community composition, predator behaviors, and the nesting patterns of potential prey in different landscapes, creating a more complex system.

## Elk On The Urban Fringe: A Credibility Challenge For Wildlifers [TWS]

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Plausibly 100,000 free-roaming elk (*Cervus elaphus nelsoni*) habitually occupy human settlements or activity centers across western North America on an occasional or seasonal basis. If elk that are conditioned to human presence realize increased survivorship by occupying residential areas and other refugia during hunting season, then numbers of conditioned elk probably are increasing more rapidly than other segments of the Rocky Mountain subspecies. While wildlife managers advocate retention of natural habitats to prevent elk displacement from urban fringe areas in Montana, elk populations are expanding beyond management control in the face of extraordinary human population growth along the Front Range of Colorado. Land developers and governing bodies may find it increasingly difficult to accept the concept of elk habitat loss, and wildlife managers may find the concept increasingly difficult to explain, as the public gains awareness of conditioned elk responses. We present a conceptual framework for understanding and assessing elk responses to urban expansion, based on literature review and experiences with open space

conservation in and around Missoula, Montana. Conflicting observations of elk tolerance and intolerance in response to humans and habitat alterations may be reconciled by understanding that elk adapt behaviorally to maximize reproductive fitness. Elk behavioral responses to human developments may be predicted with improved reliability if managers correctly identify the most important factors that influence reproductive fitness under a given set of circumstances. Input in planning processes should be linked with clearly communicated goals, recognizing that elk survival may be less at issue than diverse human desires.

## Deer Mouse Population Stability, Synchrony, and Biomass Loss in Western Montana, 1994-1996 [TWS]

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Small mammal abundance has been speculated to have causal links to ecological processes ranging from human outbreaks of Hantavirus Pulmonary Syndrome (HPS) to predation on cervid fawns. During a study of hantavirus and deer mouse (*Peromyscus maniculatus*) ecology, we live-trapped 18 one-hectare grids at six sites in western Montana. We trapped monthly during the summers of 1994-1996. During 1994, the monthly minimum number alive (MNA) of deer mice on all grids ranged from 207 to 498 mice and monthly site average MNAs ranging from 0 to 66.7 mice. In 1995 populations were much lower, with monthly grid total MNAs ranging from 84 to 119 mice and monthly site average MNAs ranging from 0 to 16.7 mice. In 1996, populations increased with monthly grid total MNAs ranging from 141 to 452 mice and monthly site average MNAs ranging from 0 to 71.7 mice. In 1994 and 1996 the peak grid MNAs were at Polson and most grid populations increased to a peak in August or September. In 1995 the peak grid MNAs were at Cascade and most grid populations were bimodal with early and late summer peak MNAs. Within-site and between-site population synchrony will be examined. Values for monthly deer mouse biomass loss will be presented and discussed in terms of population stability.

## Wildlife Management on the Fort Belknap Reservation [TWS]

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The goal of wildlife management on Fort Belknap Reservation is to maintain populations within habitat carrying capacity. Harvest management objectives are established within the constraints of the population objectives. Hunting regulations are the primary tool used to fulfill management objectives. Hunting fees for tribal members are set a level comparable to Montana state resident fees. Non-member hunting license fees are market driven. An estimate of receipts for 1995 is $86,500. Other examples of hunting regulations, income generated through license sales and evaluation of harvest management results are provided. Habitat management, law

enforcement, and education are also important components of wildlife management on Fort Belknap. The Fish and Wildlife program has grown from one full-time employee to 6 full-time employees during the past decade.

## Identifying Landscape Elements in Relation to Elk Kill Sites in Western Montana [TWS]

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The landscape elements that influence elk (*Cervus elaphus*) vulnerability during the hunting season were studied in the Chamberlain Creek area of western Montana. Locations of 84 hunter killed elk sites were compared to live elk locations and random points using discriminant function analysis. Elk kill sites could not be differentiated from random points, but locations of live elk were readily differentiated from both elk kill sites and random points. Elk selected elements of the landscape that 1) were not in close proximity to open roads, 2) had low road densities, and 3) contained forested cover in large patches that had not sustained timber harvest treatment within the past 10 years and provided substantial hiding cover.

## There's a Mouse in the House!: The Ecology of the Deer Mouse in Peridomestic Settings [TWS]

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Deer mice (*Peromyscus maniculatus*) are the principle reservoir of the Sin Nombre virus (SNV) that is the etiological agent of hantavirus pulmonary syndrome (HPS). Several studies of SNV in sylvan populations of deer mice are ongoing. However, most human cases of HPS are contracted in buildings (i.e., houses, trailers, barns, granaries, etc.). Unfortunately, virtually nothing is known about the ecology of deer mice in buildings. In October, 1996 we initiated a study to investigate the ecology of deer mice in peridomestic settings in western Montana. These data will be used to further our understanding of the SNV infection cycle in humans. The results of the first 6 months of our research will be discussed.

### Body Composition and Migration Potential of Army Cutworm Moths Taken from Alpine Aggregation Sites in Glacier Park [TWS]

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Grizzly bears (*Ursus arctos horribilis*) consume army cutworm moths (*Euxoa auxiliaris*) from late June through mid-September on alpine talus slopes in Glacier National Park, Montana. To better understand the nutritional importance of army cutworm moths to grizzly bears in Glacier National Park, we determined temporal abundance patterns, body mass, total moisture, total nitrogen, total lipid, and gross energy of moths collected from alpine moth aggregation study sites throughout the summer. Army cutworm moths arrived in the alpine of Glacier National Park in early July in 1994 and in late June in 1995. We did not capture any army cutworm moths after 10 August in 1994 or after 30 July in 1995. Army cutworm moths showed a marked increase in body mass, total moisture, total lipid, and gross energy, and a decrease in total nitrogen over the course of the summer. We calculated that an army cutworm moth flying in late summer through still air, presumably at a speed that minimizes cost of transport, could fly 140 km using body lipid reserves alone.

## Environmental Sciences and Engineering

### Preliminary Study of the Beaverhead River and the Effects of the Dillon Community: Biology [MAS]

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Aquatic macroinvertebrate diversity and abundance are often used as a barometer of the health of riparian ecosystems. Aquatic macroinvertebrate counts, in conjunction with chemical analyses of specific stream reaches, may be useful harbingers of stream degradation. Sixty-two students from the 100 level biology class at WMC-UM participated in the field collection and in the laboratory identification of aquatic macroinvertebrates (to Order) sampled from four stations along the Beaverhead River in southwestern Montana. Stations were approximately 20 feet in length and located within the low water marks in areas with riffles and cobbles. Students collected 3 replicate samples of macroinvertebrates, with a surber stream bottom sampler, within each of the four river stations in January and again in February of 1997. Histograms were plotted to allow comparison of the distribution of invertebrate Orders within and across each of the four river sites. Two species

richness indices, the number of species in a defined sampling unit (S) and Margalef's index (Dmg) and one proportional species abundance index, Simpson's (D) were calculated for each of the four river sites for both January and February. S and Dmg show relatively little change across all four river sites while D indicates a loss of diversity and a shift in species dominance/ evenness characteristics at our most downstream site (below a sewage treatment plant). At this site, aquatic nematodes (Nematoda) are 6 times more abundant than any other aquatic invertebrate Order.

## Preliminary Study of the Beaverhead River and the Effects of the Dillon Community: Chemistry [MAS]

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Students in two Freshman-level college chemistry classes studied water quality of the Beaverhead River, which flows through Dillon, Montana, as a lab component of their classes. This activity had several goals -- to involve beginning-level chemistry students in real scientific research, to offer the community planning boards information that would otherwise not be available, and to provide data for a longer term monitoring of Beaverhead River water quality. Many of the students at this college are studying to become public school teachers, so an additional goal was to provide a model for student research in science classes. Four collections sites were chosen: two upstream from Dillon, one just within the town, and one just downstream of town. Chemical analyses were done using a HACH portable water chemistry lab, with EPA-approved equipment and test procedures. Analyses performed at the water-collection sites included temperature, pH, dissolved oxygen, conductivity, and total dissolved solids. Samples were transported back to the lab and immediately analyzed for ammonium, nitrate, sulphate, and phosphate ions and alkalinity. One group tested the reliability of the results using chemical standards. Our analyses show that the river water is well within drinking-water standards for the analytes studied. It has healthy dissolved oxygen and pH levels and is well buffered. The results of this project provide a "clean" base level for planned continued monitoring of the river.

## Chemical Characterization of Clark Canyon Reservoir, Montana [MAS]

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A preliminary study of the water chemistry of Clark Canyon Reservoir, Montana, was begun. Clark Canyon is located 20 miles south of Dillon, and is filled by Red Rock River and Horse Prairie Creek, and is the source of the Beaverhead River. Clark

Canyon is a rich and popular fishery. Samples were taken at the deepest part of the lake (near the dam) depths of: surface, 5 m, 10 m, 15 m, 20 m, and bottom (approx. 25 m). During the winter, holes were drilled in the ice and a water sampler used. Temperature, pH, dissolved oxygen were measured on site, and the samples were immediately transported back to the lab for analysis. All analyses were done within 48 hours of sampling. Analysis was done with a HACH DR/2000 Spectrophotometer following EPA protocols. Results obtained for several analyses are reported here. The concentrations reported are ranges and averages of samples taken on four different dates. Calibration standards were run to check for accuracy, and all reported results have errors of less than 10%. Sampling dates: 1/5/97, 1/31/97, 2/23/97, 4/17/97. All concentrations are in mg/L except pH and where otherwise noted. Temperature: range 1-6°C, average 4°C. Dissolved oxygen: range 4.7-4.8, average 9.3. Nitrate: range 0.44-1.63, average 0.77. Nitrite: range 0.013-0.030, average 0.020. Sulfate: range 66-88, average 76. Phosphate: range 0.33-2.86, average 0.89. Iron: range 0-0.71, average 0.14. Fluoride: range 0.10-0.69, average 0.40. Chloride: range 6.6-16.5, average 9.8. Ammonia: range O.12-0.37, average O.22. Calcium hardness: range 112-185, average 151. pH: range 7.56-8.64, average 8.10.

## The Atmospheric Missing Link - Where Has All of the $CO^2$ Gone? MAS

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Being able to accurately estimate the global carbon budget is critical to the estimation of future environmental conditions. Comparing known $CO^2$ sources and sinks, modelers have recorded an annual net imbalance of approximately 2.2 gigatons of carbon. It was hypothesized that the oceans were sequestering the "missing" carbon, but testing has resulted in the rejection of that hypothesized. It is assumed that the potential sink must be large and have global distribution to account for such a massive quantity of carbon. After the oceans, the next largest potential sink appears to be the soil. This research analyzed soil samples from a Kansas State University experimental site that had been established for the purpose of examining the effects of elevated $CO^2$ levels on soil carbon content. Treatments examined were ambient and two-times ambient $CO^2$ levels. Particulate Organic Matter (POM) was isolated from whole soil samples using a dispersing agent and mild mechanical disruption of aggregate structure. The POM was then treated with a series of density extractions to isolate distinct phases of the degradation continuum. Dry weight examination revealed increasing POM recovered with exposure to elevated $CO^2$. SEM revealed that the density extraction procedure successfully isolated distinct POM fractions. Carbon analysis revealed that soil carbon levels increased significantly under enhanced $CO^2$ conditions - Rough calculations indicate the deposition of an additional 0.2 kg C/g whole soil per $m^2$ to a depth of 5 cm.

## The Integration of the Sciences at Western Montana College, Dillon, Montana [MAS]

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Western Montana College is a small (1200 students) liberal-arts college located in southwestern Montana. Starting in the fall semester of 1996, the science departments joined forces to form an interdisciplinary department of environmental sciences. This move was motivated by a desire to create an undergraduate program that involves meaningful integration of the sciences. As a result, we eliminated the traditional departments (e.g., biology, chemistry, geology, and physics), and formed a single department focused on field-based, environment-specific education. In order to obtain sufficient background in a particular science discipline, each student will choose a track in biology, chemistry, or geology. However, to provide integration, students will also take several field courses that require them to work as part of an interdisciplinary research team. In addition, each student will do a senior project or professional internship that incorporates several science disciplines. This approach has been tested through several projects incorporating more than five classes. Studies have been started on the effects of past mining in the Birch Creek drainage in the Pioneer Mountain Range, and the effects of the Dillon community on the Beaverhead River. We have also had one student in an internship with the USFS in a study of riparian zones. Another student completed a semester of research at Argonne National Lab in Chicago, IL. That work was in an environmental sciences lab studying the soil as a possible carbon sink for global emissions.

# Forensic Sciences

## Adventures in Baby-sitting: How Not to Treat Your Ward!!! [MAS]

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Perhaps one of the saddest and most tragic cases in recent times occurred during the evening hours of September 9, 1995 in Kalispell, MT. Two and a half year old Joshua Scott Norman died as the result of intentional poisoning at the hands of his teenage (15 years old) baby sitter. Early efforts at denial of any wrong doing on the part of the baby sitter were quickly dispatched through the combined efforts of the State Crime Lab's Medical Examiner, Toxicology Section, and Chemistry Section. The lab was able to show that young Joshua Norman had succumbed to lethal levels of codeine and phenol (one of the active ingredients found in Pine-Sol). The lab's

analytical results provided the investigators of the Kalispell Police Department the necessary tools to challenge the baby sitter's questionable participation. After 10 days of compassionate, though painstaking, interviews the baby sitter confessed to intentionally "dosing" her young ward. Consequently, the baby sitter was remanded to adult court where she pled guilty to homicide. This case, though tragic and heartbreaking as it was, may not have had a successful conclusion if not for the combined efforts and close communications between the State Crime Lab, the Kalispell P.D., the Flathead County Coroner's Office, and the Flathead County Attorney's Office.

## Alcohol: Three Case Studies [MAS]

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A discussion of three recent cases analyzed at the State Crime Lab is presented with relevant scene descriptions, results of the autopsies, and analyses of the samples:

Case 1. The victim is described as an alcoholic 41 year old male who was found with his trousers and underwear around his ankles and dead in a closet of his trailer house. There was no evidence of trauma noted on the body and there was an absence of pornographic materials ruling out an autoerotic episode. Cause of death was not determined at the scene or during the autopsy. Analysis of submitted samples at the laboratory indicated high levels of methanol (0.27 gm/dL; Lethal Levels = 0.02-0.04 gm/dL). Investigating officers returned to the scene and found a gallon bottle of windshield washer fluid that contains 35% methanol under the kitchen sink. Cause of death in this case was due to methanol poisoning and manner of death was suicide.

Case 2. The victim is described as a 75 year old female who was found dead lying in the snow between her residence and her car. Small patches of fresh blood were noted in the snow around her, but there was no evidence of trauma. A cause of death was not determined at the scene or during the autopsy. Analysis of submitted samples indicated the presence of ethanol in both the blood (0.12 gm/dL, Legal Intoxication = 0.10 gm/dL) and urine along with significant glucosuria. Cause of death was attributed to hypothermia and manner of death was accidental with alcohol (ethanol) as a contributing factor.

Case 3. The victim is described as a 36 year old non-drinking female who was found dead lying on the front porch of her home with her coat for a pillow. A small amount of fresh blood was noted oozing from one ear during the autopsy, but no visible signs of trauma were noted. Again in this case no cause of death was apparent at autopsy. However, at autopsy a large fatty liver and brain atrophy were noted. Analysis of submitted samples in this case indicated a very high blood alcohol concentration (0.43 gm/dL; Legal Intoxication = 0.10 gm/dL) and the presence of caffeine in the blood. High levels of glucose were also detected in the urine even though the patient was not diabetic. Cause of death was attributed to hypothermia and manner of death was accidental with acute alcoholism as a contributing factor.

# Mathematics, Statistics and Computer Sciences

## Optimizing an Unconventional Schedule: A Linear Programming Model [MAS]

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Scheduling tutors for the Developmental Mathematics Laboratory as well as laboratory assistants for the computer laboratories of Computing and Information Services and Mathematics Department creates an immense scheduling problem each semester. The individuals who schedule these laboratories, no matter the methods used, waste hours composing semester schedules. All the schedules consist of one-hour shifts; however, restrictions are put on these schedules: students' available hours, placement preference of work study versus non-work study students, possible symmetry or blocking of weekly hours for each student's schedule, and more than one students working the same shift. The complexity of these schedules is directly derived from the scheduler's goal to remain within their budget and to work around their employee's class schedules. Composing these unconventional schedules, by hand, poses different methods of solution and the possibility for reaching a financial or efficient "best" schedule is limited. The method of solution is combining these three sets of scheduling difficulties, with their peculiar requirements, into a linear programming assignment model using LINGO. The model will be implemented by an interface written in Visual Basic.

## Mathematical Infallibility: A Consideration of Crowe's Ten Misconceptions About Mathematics [MAS]

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In recent decades, questions have been raised about the rules of evidence for verifying mathematical truth. Does the use of computer technology expand our options? When is a historical problem such as Fermat's Last Theorem or the Four Color Map Problem considered to be solved? Can modern technology help us to prove the Goldbach Conjecture? Michael J. Crowe, in his "Ten 'laws' concerning patterns of change in the history of mathematics", challenges traditional views of the nature of mathematical truth. He does not, for example, deny that deduction plays a major role in mathematical methodology, but he asserts that it cannot be the sole method of mathematics. He points out that many errors have occurred in work published by mathematicians, thereby raising a question about one aspect of infallibility. He questions the claims that mathematical knowledge has developed in a strictly cumulative manner and that standards of rigor have remained uniform. Rather, he sees strong parallels between the methodology of mathematics and the hypotheticodeductive methodology of science. The history of mathematics has focused on western developments with less attention to non-western mathematics. In

the spirit of Greek mathematics as the beginning of the era of deductive mathematics, it is natural to charge that non-western contributions are "less mathematical". I claim that denigration of the contributions of non-western mathematicians, both in terms of their results and their methodologies, renders a disservice to an understanding of ways of thinking mathematically and will hinder us in our efforts to advance mathematical knowledge.

# Molecular Biology

## Cuticular Hydrocarbons in Caribbean Fruit Flies MAS

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A population of Caribbean fruit flies, *Anastrepha suspensa*, was accidentally transported to Florida in 1965. They have since been a serious pest of many common tropical and subtropical fruits grown in Florida, including citrus fruits. The flies have become a threat to the production of citrus fruits, and every measure possible is being taken to prevent their reproduction. I propose that a sexual dimorphism exists between the cuticular hydrocarbon makeup of males and females. If there is such a dimorphism, then it is likely the result of the existence of sex-pheromones or sex-pheromone components. This would lead to the possibility of controlling *A. suspensa* via a pheromone-synthesis inhibitory compound. The cuticular hydrocarbons of *A. suspensa* males and females were analyzed using simple gas chromatography, mass spectrometry, and dimethyl disulfide derivatives. Possible sex-pheromone compounds were identified as alkadienes from this data in conjunction with bioassays of courtship behavior. Their biosynthetic pathway will be examined to better understand how alkadienes are formed in fruit flies.

## Identification of Novel E-Selectin Ligands Expressed on Human and Bovine Lymphocytes MAS

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Here, we describe novel E-selectin ligands expressed on human and bovine lymphocytes. Leukocyte extravasation into the underlying tissue involves a multi-step process requiring many molecular interactions. E-selectin, a member of the selectin family, is up-regulated and expressed on activated endothelial cells and mediates leukocyte rolling on the activated endothelium via E-selectin ligands expressed on the circulating leukocyte. In this report, we used an E-selectin/Fc chimera to analyze bovine γδ T cell and human lymphocyte E-selectin ligands.

E-selectin chimera specifically stained bovine and human leukocytes by FACS analysis. Immunoprecipitation of biotinylated γδ T cell lysates with chimera resulted in two ligands of 200kD and 250kD. Additionally, chimera immunoprecipitation of biotinylated human lymphocyte lysates resulted in three potential ligands of 120kD, ~220kD, and 260kD. E-selectin ligand immunoprecipitation was specifically inhibited by blocking the chimera with function blocking monoclonal antibody. Lymphocyte E-selectin ligands have proven to be difficult to define in the past, therefore, we have provided preliminary information regarding lymphocyte E-selectin ligand expression.

## Electrophoretic Characteristics of the Lectin from Grasshopper [MAS]

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Grasshopper lectin (GHA) is a C-type (calcium stabilized) glycoprotein that is purified from the insect's hemolymph by means of affinity chromatography and high performance liquid chromatography procedures. The protein is an immunomolecule and serves to opsonize fungal blastopores and perhaps other pathogens toward hemocytic clearance from the hemocoel. This work contributes to the physicochemical characterization of the molecule. Denaturing polyacrylamide gel electrophoresis (SDS-PAGE) is used to study the molecular weight of the homodimer and the (reduced) monomeric subunits. The amount of carbohydrate is estimated by performing SDS-PAGE on enzymatically deglycosylated GHA. The nature of the carbohydrate is examined with Western blotting and specific lectin probes. Results show GHA to be a 72 kD dimer composed of identical 36 kD monomers. Carbohydrate accounts for about 4% by weight of the molecule and is likely composed of 8-10 hexose units per monomer. The carbohydrate is attached via N-linked asparagine.

## Solution Properties of the Partially Oxidized Tetracyanoplatinate(II) and Bis(Oxalato)Platinate(II) [MAS]

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Partial Oxidation of the tetracyanoplatinate(II) and the bis(oxalato)platinate(II) results in copper colored needle like crystals where the platinum atoms are stacked on top of one another like a roll of coins with considerable Pt-Pt bonding characteristics. The platinum atoms in these complexes are in non-integral oxidation states varying from +2.2 to +2.4. These needle like crystals have interesting anisotropic physical properties, most notably they conduct electricity along the Pt-Pt chain some 105 greater than perpendicular to the chain. While the solid state properties of these complexes have been well documented the solution properties

have only recently been studied to any great extent. The use of $^{195}Pt$ nmr and UV-Vis spectroscopies determined the different species present in the reaction solutions. The bis(oxalato)platinate(II) solutions have been thoroughly characterized. These solutions contain various oligomeric platinum species including dimers, trimers, tetramers and pentamers where the platinum oxidation state decreases as the oligomers size increases. The tetracyanoplatinate(II) also consist of oligomeric platinum species in solution. In these solutions only the Pt(III) dimer has been characterized; however, there is some evidence of a paramagnetic trimer. Understanding the solution properties of these oxidation reactions are crucial for controlling the polymerization of the platinum complexes.

## cDNA Sequence, Amino Acid Sequence, and Molecular Model of Grasshopper Lectin (GHA) MAS

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Grasshopper lectin (GHA) is an immuno-molecule with a role in defense and protection mechanisms of the insect. Molecular cloning and DNA sequencing procedures are used to characterize the lectin molecule. A cDNA library constructed in a lambda gt11 expression vector yielded an antibody-positive clone that contained a 300 bp cDNA that was labeled and used to isolate additional positive clones by hybridization to DNA lifts. An 879 bp cDNA fragment coding for the amino portion of the GHA protein was isolated, cloned, and sequenced. The carboxyl region of the protein was obtained through 3' RACE procedures to yield an entire open reading frame coding for a protein of 324 amino acids, followed by a 147 nt 3' NTR. A 1000 nt 5' NTR was identified by 5' RACE procedures. The deduced amino acid sequence shows familial homology when aligned with that of other C-type lectins. The GHA molecule is novel among the invertebrate lectins in that it contains two carbohydrate recognition domains (CRD), presumably having arisen by a gene duplication event. A 3D homology model of one CRD has been generated based on the crystalline structures of two related vertebrate lectins.

## Hydrocarbon Identification and Characterization in *Galerucella calmariensus*, a Biological Control Agent, on *Lythrum salicaria*, a Noxious Wetland Weed MAS

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*Galerucella calmariensis*, a chrysomelide beetle native to Europe, has been introduced into North American wetland ecosystems as a biological control against *Lythrum salicaria* (purple loosestrife), a native of Eurasia. Frequently, exotic plants, removed from natural environmental limitations, aggressively invade and dominate

plant communities. Among other advances, biologists have propagated and relea ed five natural enemies in an attempt to reduce the distribution and impact of Lythrum. Galerucella is a hostspecific, defoliating beetle, which inflicts its greatest damage to plant vigor and seed production during larval stages. Field observations indicate that Galerucella aggregate throughout their life span, but particularly as teneral adults, prior to dispersal, a more thorough understanding of this behavior may prove expedient for integrating biological, chemical, and mechanical control efforts against Lythrum. Toward an end to isolate the aggregation pheromone(s), we have combined gas chromatography and mass spectrometry to characterize cuticular hydrocarbons. To date, 20 to 25 compounds have been identified. Further efforts have centered around isolating the aggregation pheromone(s) by developing an effective method for bioassaying responses to chemical attractants. Here, these measures are described in addition to applicable rearing details.

## NEUROSCIENCES

### THE ROLE OF NT-3 IN THE FORMATION OF THE DORSAL ROOT GANGLION MAS

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The goal of this study is to examine the mechanisms involved in the developing avian Dorsal Root Ganglion (DRG) prior to target-mediated programmed cell death. Previous research has shown the expression of Trk C on a discrete subset of migrating neural crest cells (st. 19). Prior to programmed cell death for post-mitotic neurons (st. 24, E4) Trk C is also expressed on the majority of cells in the developing DRG. We wanted to examine the function of NT-3 on the developing DRG's prior to target-mediated programmed cell death. First we injected NT-3 into embryos and found no increase in cell numbers in brachial DRG (limb-innervating). However, in Cervical DRG (non-limb bud innervating) there was a substantial increase (40%) due to the exogenous NT-3. In a separate set of experiments, we transected the wing buds as soon as they appeared. This resulted in a decrease in cell number in the developing brachial DRG compared to the contralateral DRG with an intact limb bud. Since NT-3 has also been shown to be expressed in the developing limb-buds during DRG differentiation (Hallbook and Lefcort, unpublished results), our results suggest a normal function for NT-3 in maintaining survival and/or promoting proliferation of DRG precursor cells. We are now investigating directly how NT-3 elevates DRG cell numbers and why limb bud ablation decreases cell numbers.

# Pharmacology and Toxicology

## Screening of Peruvian Ethnobotanicals for 5HT1a and 5HT2a Receptor Binding Activity [MAS]

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Late in 1995, plants of ethnobotanical importance were collected in southeastern Peru. Many of these plants have been used by natives for treatment of headache. Since headache, especially migraine, is thought to involve serotonergic mechanisms, we have started to screen crude 70% ethanol extracts for *in vitro* receptor binding activity in two systems, 5HT1a and 5HT2a. About two dozen specimens have been examined. Only three of these specimens have significant activity at 5HTla receptors, but nearly half of the specimens demonstrate substantial binding activity at 5HT2a receptors. As quantified by displacement of tritiated ketanserin, three specimens give approximately 90% binding at 1/100 dilution of the crude extract. These samples have also been tested for concentration-dependent binding and are considered to be lead samples at this time. Protocols for identification of active principles from these high priority samples involve standard solvent partitioning followed by HPLC fractionation. HPLC fractions are then retested pharmacologically. The single highest priority plant, *Petiveria alliacea*, has shown outstanding activity following fractionation. The long-term goal of this work is to develop superior anti-migraine drugs.

## Differential Activation of C6 Glioma Protein Kinase C Isoforms by a Phorbol Ester and Trimethyltin [MAS]

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Trimethyltin (TMT) is a potent neurotoxin that produces delayed, irreversible damage. Damage is usually not evident for 48 hours. Activation of Protein Kinase C (PKC) has been implicated in the neurotoxicity produced by TMT. In a neuronal cell line, TMT causes translocation and activation of PKC within 30 minutes. We used a rat C6 glioma cell line to determine the ability of PKC to translocate in the presence of phorbol 1 2-myristate 1 3-acetate (PMA) or TMT. Further studies were conducted to differentiate specific isozyme involvement. Isoforms were separated by gel electrophoresis and identified by Western blotting with specific monoclonal antibodies. We have identified the presence of the α, β, γ, δ, ε, θ, ζ, λ, and μ isozymes

in our C6 cell line. These isozymes of PKC were evaluated on their responses to PMA and TMT exposure. All of the cPKC and nPKC isoforms translocated to the cell membrane following PMA exposure. The aPKC isozyme were not translocated by this treatment. TMT exposure for up to 1 hour did not translocate any of the PKC isoforms. PKCs $\alpha$, $\delta$, and $\zeta$ were also evaluated after 24 hours of treatment with PMA and TMT. PKCs a and d had down-regulated with the PMA treatment, while no translocation was detected with TMT treatment on any isoform.

## Assessment of Cardiovascular Risk in a Pharmaceutical Sciences Laboratory Course [MAS]

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The current study assessed blood lipid levels in pharmacy students by 4 methods. The measurements were made by a commercial laboratory, by the O-T-C product Advanced Care ™, by the Cholestech ™ LDX Auto-Analyzer System, and by Sigma Kits #352-20 and #352-5 for total cholesterol and HDL fraction, respectively. The possibility that the lipid profiles of male and female pharmacy students might differ from each other and from the general population was also explored. All methods of determining blood total cholesterol and other lipid fractions were comparable and observed differences were attributed to gender. Male pharmacy students (N= 88) had total cholesterol levels of 185.84 ± 1.17 mg/dL which did not differ from those of female students (N= 84) which were 185.60 ± 0.73 mg/dL. Female pharmacy students (N= 77) had higher HDL-C levels (59.64 ± 0.78 mg/dL) than did males (44.47 ± 0.46 mg/dL). Because female students had greater HDL-C levels than their male peers, they also had lower cardiovascular risk ratios defined as the ratio of total cholesterol to HDL-C. Female students (N= 54) also had lower blood triglyceride levels (120.05 ± 6.74 mg/dL) than those (163.6 ± 3.00 mg/dL) of males (N= 55). Our conclusions are that the methods of measuring blood lipids are comparable, that female pharmacy students have a better cardiovascular lipid profile than their male counterparts, and that both groups have a better cardiovascular lipid profile than the general U. S. population.