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# INTERMOUNTAIN JOURNAL OF SCIENCES

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# Potential Effects of Ecosystem Management on Cervids Wintering in Ponderosa Pine Habitats

## Abstract

*Elk* (Cervus elaphus)*, mule deer* (Odocoileus hemionus) *and white-tailed deer* (O. virginianus) *winter in ponderosa pine* (Pinus ponderosa) *habitat types on the Blackfoot-Clearwater Wildlife Management Area (BCWMA) in western Montana. Natural fire has been excluded from these habitats during the 20th century, promoting growth of dense Douglas fir* (Pseudotsuga menziesii) *and ponderosa pine understories. "Ecosystem Management" (EM) prescriptions for restoring natural processes in ponderosa pine types result in widely spaced mature trees, less Douglas fir in forest overstories, and a substantial decrease of conifers in understories. Douglas fir was the dominant forage item for both deer species on the BCWMA throughout the winters of 1991-1993, and remained the primary forage for white-tailed deer during a very mild winter in 1994 when other forages were widely available. Tree lichen* (Alectoria sp.) *was also important winter forage for deer and elk. A decrease in conifers of all size classes could reduce abundance and above-snow availability of lichen, coniferous forage and thermal cover. Of the three cervids, elk appeared least dependent upon canopy closure and coniferous forage. EM prescriptions may benefit elk (excluding security concerns) because of enhanced grass production and availability. Mule deer used habitats with sparse or dense overstory canopies, which provided no evidence that mule deer would benefit from decreased coniferous cover. White-tailed deer used habitats with dense canopies and were most likely to be affected at the population level by typical EM prescriptions. This could be problematic in western Montana where high white-tailed deer numbers may be an asset for recovering populations of scavengers and predators such as the bald eagle* (Haliaeetus leucocephalus) *and gray wolf* (Canis lupus).

**Key words:** elk, mule deer, white-tailed deer, ecosystem management, habitats, ponderosa pine, Douglas-fir, lichen.

## Introduction

The Keystone Forum (1993) defined Ecosystem Management (EM) as "an approach to environmental management that: (1) is at a scale compatible with natural processes, (2) is cognizant of nature's time frames, (3) recognizes social and economic viability within functioning ecosystems, and (4) is realized through effective partnerships among private, local, state, tribal and federal interests; with the goal of preserving, restoring or, where those are not possible, simulating ecosystem integrity as defined by composition, structure and function that also maintain the possibility of sustainable societies and economies."

The U. S. Government has promoted EM to guide the management of federal lands in the 1990s. Evolving EM principles reflect two contrasting

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philosophies: (1) human values should drive land management, and (2) humans are intruders in natural systems (H. Salwasser, U.S. For. Serv., pers. comm.). Ecosystem Management strives for high public participation in decision making, and incorporates a growing public appreciation for retaining ecological components of biological systems, such as habitat for nongame wildlife.

Perpetuating ponderosa pine forests has become an EM objective in western Montana. Prior to the arrival of European settlers, a high frequency of natural fires in these forests prevented high fuel accumulations, which resulted in low fire intensities (Arno 1980). This fire cycle favored growth of large ponderosa pine trees in single-storied stands (Fischer and Bradley 1987). Shade-tolerant Douglas-fir typically occurred in patches that were either missed by frequent fires or regenerated during intervals between fires.

During the past 100 years natural processes in ponderosa pine forests have been increasingly disrupted (Gruell 1983). Most of the largest pines have been harvested for lumber, and fires have been suppressed to protect timber and settlements. These actions have favored the dominance or codominance of Douglas-fir in forests that were historically dominated by ponderosa pine. Shade-tolerant Douglas-fir saplings and poles are now common where forest understories were once sparse across western Montana. An abundance of sapling and pole-sized Douglas-fir increases the probability that stand replacement fires will occur in ponderosa pine communities, which may negatively impact species such as pileated woodpeckers (*Dryocopus pileatus*) (McClelland 1977), western bluebirds (*Sialia mexicana*) (R. Hutto, Univ. of Mont., Missoula, pers. comm.) and flammulated owls (*Otus flammeolus*) (V. Wright, Univ. of Mont., Missoula, pers. comm.).

Ecosystem Management prescriptions in ponderosa pine habitats typically are devised to remove most Douglas-fir, thin pole stands to recruit large pines, leave most large pines, and underburn to open the understory for establishment of pine seedlings. These prescriptions promote commercial harvest of mature Douglas-fir and some ponderosa pine, reduce the risk of stand-replacing wildfires, and result in aesthetically appealing, park-like stands.

Ecosystem Management treatments may attract consent from traditional logging opponents because such treatments are aimed at enhancing natural processes and nongame wildlife populations. Therefore, EM prescriptions in ponderosa pine forests of western Montana could be widely supported and applied across large acreages and mixed ownerships. Since 1992 we have observed increasing commonality of timber harvest prescriptions in ponderosa pine forests owned by the Bitterroot and Lolo National Forests, the Montana Department of Natural Resources and Conservation, Plum Creek Timber Company, and private landowners.

In this paper we explore the potential differential effects of opening forest overstories and understories on wintering elk, mule deer and white-tailed deer. Also, we discuss how EM implementation may affect the abilities of wildlife managers to achieve and balance human demands for the three cervids and associated charismatic species in a modern, fragmented environment.

## Research Basis For Our Perspective

Our observations are based on the senior author's study of cervids on the BCWMA (Baty 1995). The BCWMA, located 72 km east of Missoula, Montana, provided winter range for migratory herds of about 1,000 elk, 1,000 mule deer and 500 white-tailed deer

from 1991 through 1994. Coniferous forest covered 83 percent of the 9,000-ha study area, with the remainder divided between bunchgrass (15%) and aspen (2%) types. Douglas-fir, ponderosa pine, subalpine fir and spruce types comprised 81, 13, 4 and 2 percent of the coniferous forest, respectively. Average overstories of coniferous forest types ranged from 2-53 percent canopy cover and average conifer seedlings ranged from 0-4,870 stems/ha. Generally, forest stands reflected the influences of fire exclusion, livestock exclusion, and sporadic, selective timber harvest over the previous 47 years.

Baty (1995) measured habitat characteristics, and counted elk and deer tracks in snow within 191 vegetation stands along 40 km of evenly spaced transects. Habitat preferences were indicated from 22,268 elk, 23,662 mule deer and 15,741 white-tailed deer track sets counted during January-February 1992-1993. Radio telemetry, aerial surveys and ground observations supplemented track-set indications of cervid distributions. Diets were estimated by personnel at the Wildlife Habitat Laboratory, Washington State University, Pullman using microhistological analysis of fecal composites collected periodically during the winters of 1992-1994.

## Potential Effects On Elk

Elk used forested winter habitats on the BCWMA, but only displayed preference for those with overstory canopy coverages ≤27 percent (Baty 1995). Graminoids comprised 60-82 percent of average elk diets during January and February 1992-1993, while conifers comprised 10-22 percent. General observations indicated that elk groups of <50 individuals used north-facing slopes where dense forest cover intercepted snow and moderated crusting and drifting. However, groups of 500-700 elk were most commonly observed in rough fescue (*Festuca scabrella*) grasslands. Clearcuts on upper-elevation north slopes were rarely used.

The high affinity of elk for graminoid forage and grasslands suggested that elk would likely benefit from increased grass abundance in forest understories following EM treatments. Although graminoids are often unavailable during periods with deep snow, a greater abundance of grass interspersed with sparse overstory cover might improve foraging opportunities overall. Also, the influences of wind and solar warming on exposed slopes following treatments would probably reduce snow depths and intermittently increase grass availability.

## Potential Effects On Deer

Both deer species appeared well adapted to multi-storied Douglas-fir stands. White-tailed deer were most consistent in their preference for habitats with overstory canopy coverages ≥50 percent, and did not show preference for any overstory canopy <41 percent during the most severe winter conditions sampled in February 1993 (Baty 1995). Mule deer consistently preferred open Douglas-fir stands, as well as some of the most densely forested habitats on the study area. Douglas-fir was the highest ranking forage species in the January and February diets of both deer species during 1992 and 1993, comprising 31-59 percent of the estimated monthly diets. Deciduous shrubs, primarily serviceberry (*Amelanchier alnifolia*), comprised only 3-20 percent of the estimated diets for the same period.

Evidence indicated that feeding deer selected Douglas-fir. The highest proportions of Douglas-fir were detected in deer diets during January 1992 and 1993, when deciduous browse and other palatable forages were also available. Likewise, Douglas-fir comprised 18 percent and 32 percent of mule deer and white-tailed deer diets

respectively during a mild weather period with very high forage availability (January 1994) (Baty 1995).

Moderate to densely forested habitats probably provided forage and thermal benefits for both deer species. Proportions of tree lichens in deer diets could not be estimated by fecal analysis because lichen was largely destroyed by laboratory procedures (B. Davitt, Wash. State Univ., pers. comm.). However, lichen appeared to be important winter forage for both deer species (Baty 1995). Lichen was abundant in forests with dense overstories. Deer quickly consumed lichen that fell from the forest canopy to the snow surface during windy conditions. Increasing densities of understory conifers might further enhance winter forage availability by intercepting windblown lichen that would otherwise become buried under snow. Many mule deer occupied winter habitats at the highest elevations on the study area (1,500 m) where snow depth may have limited availability of forage to conifers and lichens. Both deer species also occasionally sought shelter under low, overhanging branches of sapling and pole-sized conifers.

The preference of white-tailed deer for dense overstory canopies on northern winter ranges is well documented (Moen 1976, Mundinger 1980, Peek et al. 1982, Brockmann 1988, Hicks 1990). We assume that repeated observations of preference for thermal cover are indicative of a habitat requirement for maintaining productive white-tailed deer populations in western Montana (Peek et al. 1982).

Extensive mule deer use of forested habitats in winter has also been documented previously (Peek et al. 1982), but may not be fully appreciated. We perceive a concern among managers that forest succession on western Montana winter ranges may be detrimental to mule deer due to forage loss and/or an expanded habitat advantage for sympatric white-tailed deer. Observations on the BCWMA did not support these concerns.

We found mule deer wintering in a diversity of winter habitats, ranging from steep-open shrubfields to closed-canopy forests within a predominately forested landscape. Average wintering densities were conservatively estimated at 11 mule deer/km$^2$ (29 deer/mi$^2$), comparable to mule deer densities in the Missouri River Breaks (Hamlin and Mackie 1989) and Bridger Mountains (Pac et al. 1991). Thus, the forested winter range we studied was reasonably productive for mule deer relative to badlands and mountain-foothill habitats of central and eastern Montana. White-tailed deer appeared poorly adapted to handle snow conditions beyond a narrow geographic range located near the Clearwater River, and offered no possible competition to mule deer in any forest type across about 90 percent of the BCWMA. We found no evidence that thinning of overstory canopies or understory conifers is desirable to enhance the BCWMA winter range for mule deer, and it is plausible that population productivity could decrease due to decreased cover and increased energy expenditures (Parker et al. 1984). We hypothesize that mule deer can benefit substantially from structural and forage diversity provided by dense overstory and understory conifer cover in western Montana. Forest cover may be particularly important in intermountain regions where snow is deep and rarely accompanied by slope-baring winds.

## An EM View Of White-Tailed Deer

We believe that local populations of elk and white-tailed deer are at twentieth century highs, while mule deer populations appear to be at moderate levels. Together, these ungulates form a prey base for a variety of predators, including man. Predation upon elk and deer is influenced by the

desires of human society. The Endangered Species Act provides for the recovery of local bald eagle and gray wolf populations that prey upon or scavenge carcasses of elk and deer. Montanans also hunt these cervids and hunter participation rates approach 50 percent for men and 20 percent for women (Mont. Dep. Fish, Wildl. and Parks, unpubl. data). Accordingly, the Montana Department of Fish, Wildlife and Parks and Lolo National Forest cooperate to maintain a five-week hunting season for unlimited numbers of licensed Montana residents (Hillis et al. 1991:38).

Wolf numbers can be directly related to ungulate biomass (Fuller 1989), and white-tailed deer provided 79-98 percent of the biomass consumed by wolves each month in north-central Minnesota. White-tailed deer were also the primary prey species for wolves in northwest Montana from about 1993-1995 (K. Kunkel and M. Jimenez, Univ. of Mont., Missoula, pers. comm.). If wild prey such as deer are abundant, wolves may live near humans with lowered probability of conflict (M. Jimenez, pers. comm.). Moreover, white-tailed deer are easier to manage near people than elk, they are medium-sized and may appeal to a broader range of carnivores, and they have broader distribution that would benefit territorial predators.

The Blackfoot-Clearwater area is also a principal wintering area for bald eagles along the Mackenzie-Intermountain Flyway, where the birds feed heavily upon livestock and ungulate carrion (McClelland et al. 1994). Road crews and Montana Department of Fish, Wildlife and Parks wardens pile road-killed white-tailed deer in safe feeding locations on and around the study area. Seventeen eagles have been seen together at one local feeding station. Starvation of young eagles in their first winter can be a limiting factor to bald eagle populations, and abundant carrion may increase winter survival of young eagles (McCollough et al. 1994).

We expect that landscape-scale restoration of open, single-storied, ponderosa pine forests in the lower Clearwater drainage would ultimately reduce the white-tailed deer population. Macnab (1985:406) cautioned that a wide margin for error should be provided in the harvest management of prey population levels in the presence of natural predators, noting that heroic measures may be required to recover prey populations once they fall below threshold levels. Accordingly, we view high populations of white-tailed deer as a valuable asset in providing a necessary margin for error in western Montana. Abundant white-tailed deer potentially sustain an increasingly numerous and diverse complement of predators and scavengers, as well as an untold proportion of hunter harvest that might otherwise be transferred to sympatric mule deer and elk populations. A viable EM approach to balancing conflicting human desires within the limits of ecological sustainability should include white-tailed deer population and habitat management strategies that consider the broad social and ecological roles of high deer populations.

## Recommendations

We suggest that the winter habitat needs of white-tailed deer in ponderosa pine forests could be accommodated if: (1) ponderosa pine stands with dense Douglas-fir understories remain interspersed with single-storied stands of mature ponderosa pine on a landscape; (2) size classes of understory Douglas-fir are a mix of seedlings, saplings and poles; (3) multi-storied ponderosa pine/Douglas-fir stands are large enough to function as thermal cover and are well connected across a landscape; and (4) low intensity fire occurs in ponderosa pine stands at

relatively short intervals. These characteristics differ from existing conditions where stands with abundant Douglas-fir saplings and poles are large and continuous, and where fire as a natural process is lacking. Our approach would reduce the risk of stand replacing wildfire across the landscape while retaining large patches of coniferous cover and forage for deer.

This paper does not consider the management of forest cover to buffer cervids from human disturbance during the critical winter period or during hunting season. Baty's (1995) study area was closed to public use from 16 November-14 May annually. Although hunted populations of elk and deer were studied, data were not collected during the September-November hunting season. Our recommendations may require modification to consider security objectives in areas with frequent human disturbance and where security is low.

## Conclusion

An EM approach to the management of elk, mule deer and white-tailed deer habitats in the low-elevation ponderosa pine forests of western Montana requires land and wildlife managers to consider and foresee the broader social and ecological roles of these common species in a modern environment. Under EM, elk and deer have intrinsic value, value as food for a complement of recovering predator and scavenger populations of national and biogeographic importance, and value for numerous consumptive and nonconsumptive human uses and economies. Formulation of a desired future condition for elk and deer abundance must consider the increasing cumulative demands placed upon these species, and must weigh habitat requirements and ecological trade-offs at local and regional scales.

This exercise leads us to conclude that high elk, mule deer and white-tailed deer populations are ecological assets that should be perpetuated to the extent possible in western Montana. Moreover, our evaluation suggests that moderate adjustments in EM prescriptions for restoring or simulating natural processes in low-elevation ponderosa pine forests would perpetuate effective winter habitat for these three cervids. It seems that awareness and acknowledgment of the interrelated social and ecological values of abundant elk and deer are necessary for managers to integrate the winter habitat requirements of these species into EM prescriptions in western Montana.

## Acknowledgments

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Amy C. Nikolaisen

# The Value of Peer Mediation in Reducing Conflict Behaviors

## Abstract

*The purpose of this research project was to determine if a particular peer mediation program reduced incidence of conflict on playgrounds. The difference in observed conflict behaviors at Clancy Elementary School before and after the implementation of the Conflict Management program was examined. The student population (n = 372) of Clancy Elementary consisting of grades K-8 participated in the study. The subjects were observed during recesses before and after the implementation of the Conflict Management program. The data was compared between the two observation periods. Results indicate that the Conflict Management program was effective in reducing conflict behaviors on the playground ($p < 0.05$). Both the numbers and types of conflict behavior were less ($p < 0.05$) after implementation of the Conflict Management program.*

**Key words:** peer mediation, conflict, recess behavior, grades K-8

## Introduction

Elementary educators have taken a new approach at producing students who are capable of functioning effectively in society today (Maruyama 1992). Students interpersonal relationships that occur in school are indicators of present and future adjustment (Steinberg 1991). Educators are now aware that preventive efforts to resolve conflicts must begin early in order for successful resolution (Steinberg 1991). Conflict is a natural part of life and it can be found wherever human interaction occurs (Bondesio 1992). The frequency, intensity, and duration of conflict varies; therefore conflict needs to be managed in a manner that allows the positive aspects to be maximized and the negative aspects minimized (Bondesio 1992).

Kurt Lewin (Maruyama 1992), writing on the topics of child development and education, developed a field theory that has shaped the way many researchers think. Field theory allows researchers to study individuals in social settings, the social forces that influence individuals, and the structures of different environments. This theory provided a basis for the study of education and conflict management (Maruyama 1992).

Lewin (Maruyama 1992) defines conflict as a situation in which forces acting on an individual are opposites in direction and about equal in strength. All conflicts that occur in a social scene have individuals with both a self interest and a common interest (Coombs 1987). Lewin identifies three types of conflict (a) two positive goals that are mutually exclusive of one another, (b) two negative events of which only one can be avoided, or © positive and negative events that are linked (Maruyama 1992). According to McFarland (1992), students tend to use one of the following three styles to handle conflicts (a) the dominating style which is characterized as the fear of losing control and not getting what they want , (b) appeasing styles which are

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usually used by those students who lack self confidence and want to maintain harmonious relationships and, © cooperative styles which are used by those who are not threatened by disagreements and who understand that people have differences of opinions.

Berryman-Fink and Brunner (Papa and Natalle 1989) report a significant difference in conflict behavior of males and females. The behavior of males and females is often based on gender stereotypes (Papa and Natalle 1989). Ashmore and Del Boca (Papa and Natalle 1989) define gender stereotypes as: " the structured sets of beliefs about the personal attributes of women and men." They indicate that males exhibit a dominating and competitive behavior while Shockley-Zalaback (Papa and Natalle 1989) indicates that females use prosocial, compromising, and avoiding styles. Hocker and Willmot's (Papa and Natalle 1989) research supports the theory that males and females choose their behaviors during conflicts partially because of gender identity. Terhune (Papa and Natalle 1989) shows that males have a tendency to exploit or compete, while females want to cooperate and compromise.

Schools must use positive and preventive strategies in helping students resolve conflicts (Satchel 1992). Peer mediation along with traditional means of discipline, such as suspension, provides a solid base for disputants to resolve their conflicts on the playground (Lane and McWhirter 1987). Peer mediation, allows students to practice critical thinking, problem solving, and self discipline (Lane and McWhirter 1992). Professional organizations and previous research on peer mediation has encouraged school counselors to implement peer mediation into their guidance programs (Bowman 1986).

In 1983, Reed (Satchel 1992) reported that an increase in student conflict was linked to both the lack of skills of school personnel to promote conflict management and a lack of policies and programs in the schools to help reduce the number of conflicts. Conflict management teaches students specific skills for arguing effectively, hence conflicts turn into constructive learning experiences (Maruyama 1992). Conflict management allows students to practice the skills of self regulation on a daily basis (Satchel 1992). Self regulation is the ability to behave in a socially accepted manner in the absence of external monitors (Lane and McWhirter 1992).

Both student behavior and school discipline problems have shown improvement as a result of peer mediation (Lane and McWhirter 1992). Other reported benefits are improved academic performance and improved behavior in classrooms (Bowman and Myrick 1987). Kelpp, Halper, and Perry reported in 1986 (Lane and McWhirter 1992) that students participating in these programs have greater credibility regarding student social interaction. McCormick reported in 1988 (Lane and McWhirter 1992) that disputants that are frequently referred for discipline problems eventually exhibited a shift toward cooperation after participating in peer mediation. Conflict management has been shown to drastically decrease the number of discipline events (Lane and McWhirter 1992). The number of discipline events dropped from 83 to 19 after 2 years at a school in Hawaii according to Araki, Takeshita, and Kadomoto in 1989 (Lane and McWhirter 1992). Also, Koch in 1988 reported that at a school in New York, the number of fights decreased by 50 percent (Lane and McWhirter 1992). An Arizona school witnessed a drop of 47 percent in their total number of discipline events per month (Lane and McWhirter 1992). The benefits for both the students and the schools will be more clearly defined as additional program evaluations are developed (Lane and McWhirter 1992).

Researchers have concluded that the process of understanding conflict resolution takes a long time (Steinberg 1991). Therefore, implementing peer mediation programs in schools, conflict resolution can become an integral component of a school's discipline plan (Lane and McWhirter 1992).

The purpose of this study was to determine if the implementation of the Conflict Management program made a difference in observed conflict behaviors at Clancy Elementary School.

## Method

### Subjects

The subjects included the student population ($\underline{n}$ = 372) of Clancy Elementary in Clancy, Montana. The students were in grades kindergarten through eighth. Both males and females were observed.

### Procedure

The peer mediation program in this study is entitled Conflict Management. The program is based on a community mediation model used by the San Francisco Community Board which had five years of experience settling conflicts between neighbors and businesses before introducing it to the schools. Students receive 16 hrs of training and role play practice before they become team mediators on the playground. During the training, the students learn to mediate conflicts by applying communication skills, listening to varying perspectives, evoking mutual contributions to the problem's eventual solution, and paying attention to feelings of all the students involved. Conflict managers work in teams of two to help disputants use proper problem solving skills (Lane and McWhirter 1992). After student managers have been trained, they assist other students in thinking about conflicts, their ideas and feelings, and discovering a solution.

This study began when the mediation program was presented to the Clancy Elementary staff and students. As implementation approached, students were able to vote for themselves or others to become conflict managers. The teachers and school counselor were also allowed to vote for students. The final selection of the student managers was decided by who received the most votes. Sixteen students were trained by adult staff members over a two day period. The students were taught communication skills that involved active listening, reflection of feelings, message clarification, body language, "I messages", brainstorming, and effective problem solving. The adult trainers also used a lot of role-play with the students to teach them the mediation process. The four basic stages of the mediation process are introduction, listening, wants, and solutions. Appendix A provides the basic checklist of the step-by-step sequence of conflict management. After the training was completed, the students were assigned to the lunch recess in pairs. Students were given the instructions to handle conflicts they were approached with by other students or to intervene if they felt they could handle the conflict.

The student body was also educated about conflict management through a series of class instructions about conflict management. The program itself was explained and the valuable benefits of knowing how to use conflict management in everyday life was addressed.

Effectiveness of the Conflict Management program was studied by comparing the type and number of conflicts before versus after the program was implemented. This was accomplished by comparing the means of the conflict behaviors before and after the implementation of the program. I observed student behavior on the playground by walking around the playground area and recording what was seen during morning, lunch, and afternoon recesses. Whenever playground aids had to intervene in conflict, it was reported to the researcher. Two 15-min

sessions during the 30-min morning and afternoon recesses were observed. One 30-min session was observed at lunch recess A total of 30 sessions were observed both before and after the implementation of the Conflict Management Program. The before and after periods included identical time periods.

I recorded the frequency of each of the following conflict behaviors types (CBT) during each playground session.

No outward aggression observed by any student. Students encountered one another, e.g. two students ran for the same ball or swing, but one takes the swing or ball and the other leaves.

1. Aggression by the students was minimal. There was no interference by external monitors necessary to resolve the conflict, e.g. pushing, yelling, and chasing.
2. Physical aggression, loud yelling, and/or arguing were visible. An external monitor stepped in to resolve the conflict.
3. Other variables were recorded included gender of the students, grade level present on the playground, time of the session, date, weather, and day of the week.

Data were analyzed using a one-tailed t-test. The dependent variable was the change in number of conflict behaviors of the students following the implementation of the Conflict Management Program. Each of the three previously discussed behaviors were observed to determine if change occurred. The independent variable was the Conflict Management Program.

A t-test for equality of means was conducted for each type of conflict as well as for the total number of conflicts to determine the change in conflict behavior following implementation of peer mediation as described in the Conflict Management program.

## Results

A comparison of mean composite scores for CBT-1 showed a significant difference in number of incidents before and after the Conflict Management Program was implemented. (Table 1) Comparison of mean composite scores for CBT-2 showed a significant difference in the number of conflicts before and after. Mean composite scores for CBT-3 before and after implementation were also different. T-values of 2.26, 2.57, and 2.38 for the respective conflict behavior types were $p<0.05$ that the results occurred by chance alone. A comparison of mean composite scores for the total number of conflicts before showed a significant difference over the total number of conflicts after the Conflict Management Program was implemented. The composite t-value of 3.15 was $p<0.05$ that the results occurred by chance alone.

***Table 1.*** *Test differences between means of conflict behavior observed before and after implementation of Conflict Management Program.*

| Conflict Type | Before Mean | After Mean | t-value | Significance |
|---|---|---|---|---|
| One* | 0.9333 | 0.2667 | 2.26 | .05 |
| Two** | 3.1000 | 1.7667 | 2.57 | .05 |
| Three*** | 1.2333 | 0.3000 | 2.38 | .05 |
| Total | 5.2667 | 2.3333 | 3.15 | .05 |

* = no outward aggression
** = minimal aggression
physical aggression or loud shouting

The extent of the difference between males and females before and after and the different grade levels before and after becomes clearer by comparing the mean scores for each of the groups tested. Mean scores are based on the total number of behaviors before and after the Conflict Management Program was implemented. Results of these comparisons are included in Table 2.

Mean scores for males (8.0667) and females before (2.4667) compared to mean scores after for males (3.466) and females (1.200) showed a significant decrease in the number of conflicts after the Conflict Management Program was implemented with males showing a more significant reduction than females.

Mean scores for the different grade levels also showed a significant difference. Grades K-3, present on the playground during 1015-1030 hrs and 1400-1415 hrs, had a before mean score of 4.7143 and an after mean score of 2.1667. Grades 4-6, on the playground during these same periods had a before mean of 4.2000 and an after mean of 2.2500. Grades 4-8 on the playground during 1200-12:30 hrs had a before mean of 8.3333 and after mean of 2.8333 and the most significant change of all the grade levels.

## Discussion

Results indicated that the Conflict Management Program significantly reduced the number of conflict behaviors on the playground. The reduction in conflict behaviors were a result of having conflict managers on the playground to help students solve problems and educating the students about conflict management. This study is congruent with previous research done indicating that peer mediation is effective in reducing conflict behavior.

Results like those found in this study have initiated school personnel to begin a new movement in education to bring conflict resolution programs into all schools (Bondesio 1992).

The reason for this movement is clear: everyone involved is taught that conflict resolution is a process for talking about problems, learning more about the views of others, and practicing better communication in a nonviolent, nonjudgemental atmosphere. According to Bondesio (1992), training is much better than just knowledge about conflicts. Training ensures prepared and able conflict managers in the schools. Educators should not ignore the valuable requirement of "people skills" in today's society (McFarland 1992). According to Steinberg (1991), teachers can reinforce "people skills" by means of a problem-solving process. They can help students recognize specific actions that contribute to problems, the necessary skills to negotiate, and how to generate and evaluate varied solutions (Steinberg 1991).

*Table 2. Test differences between males, females, and grade levels before and after implementation of Conflict Management Program.*

| | Mean-Pre | Mean-Post | t-value | Significance |
|---|---|---|---|---|
| Gender | | | | |
| Males | 8.0667 | 3.4667 | 3.19 | .05 |
| Females | 2.4667 | 1.2000 | 2.7 | .05 |
| Grade | | | | |
| K-3 | 4.7143 | 2.1667 | 2.45 | .05 |
| 4-6 | 4.2000 | 2.2500 | 1.36 | .05 |
| 4-8 | 8.333 | 2.8333 | 1.74 | .05 |

Conflict managers are valuable resources to both the classroom and playground. Programs like Conflict Management allow students to train other students to use behaviors that benefit students, counselors, and teachers (Bowman and Myrick 1987). Conflict managers can reach their goal of teaching other students conflict resolution by interrupting conflicts early and resolving them because interpersonal and intergroup conflicts usually begin small and escalate when unresolved (Lane and McWhirter 1992).

Kurt Lewin (Maruyama 1992:165) noted, "It seems easier for society to change education than for education to change society," yet in this case success has occurred in using education to change society. Roderick (1988) emphasized a valuable aspect of school mediation programs, "Young people have many choices besides passivity or aggression for dealing with conflict . . . (through mediation) we give them the skills to make those choices real in their own lives."

Results of this study also supported research relevant to gender differences in conflict behavior. Males had more outward, observable conflicts than females. Most male conflicts at recess could be seen from a distance, while female conflicts had to be viewed close up in order to identify the conflicts. These behaviors were observed following the implementation of the Conflict Management Program which agreed with Papa and Natalle (1981) that it is essential to examine how people behave over time in order to gain a more complete understanding of gender differences in conflict behavior. Holtes and Kahn reported that males see conflict on the basis of strategy and their goal is to maximize their gains (Papa and Natalle 1989). Whereas females in conflict tend to accommodate in order to be social. Females will compete, however, in order not to look like a failure. Roloff and Greenberg (Papa and Natalle 1989) indicated that the only assertive-strategy females prefer to use is verbal aggressiveness, but would prefer to use prosocial means and regression.

A study of high school students by Roloff and Greenberg in 1979 (Papa and Natalle 1989) indicated that at the high school level males prefer aggression, revenge, and verbal aggression to resolve their conflicts. Educators can counteract these typical stereotypes if they interact with students at a young age. Roderick (1988) observed, "At a time when human survival depends on finding alternatives to violence for resolving differences, there is no more compelling mission than for counselors to encourage peer mediation programs so that the healthy development of children may be fostered."

Replication and improvement of this study could include the use of video cameras, more individuals observing student behavior on the playground, and increased amount of observation time.

Further, direct feedback from staff and students would provide researchers an opportunity to use the information to help interpret the results obtained. Additional data taken from other sources besides the playground like the classroom, lunchroom, or home could indicate if the program is effective in improving conflict behavior in other areas of a student's life. Some parents of students involved in peer mediation programs report that conflicts occurring at home are resolved in new and productive ways ( Lane and McWhirter, 1992)

Although conflict is a part of human existence, teachers, counselors, and administrators should be working on ways to reach more students. Peer mediation programs are an ideal way to achieve this goal.

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# Appendix A

## Elementary Conflict Management Process

Introduction and Groundrules

1. Introduce yourselves.
2. Ask if they want to solve the problem.
3. If yes, move to a different area.
4. Get agreement to four rules:
   -do not interrupt
   - no name calling or put downs
   - be as honest as you can
   - agree to solve the problem

Defining the Problem

5. Decide who will talk first.
6. Ask person #1 what happened - RESTATE.
   Ask person #1 how he or she feels and why.
7. Ask person #2 what happened - RESTATE.
   Ask person #2 how he or she feels and why.

Finding Solutions

8. Ask person #1 what he or she can do to resolve the part(s) of the problem for which s/he is responsible.
9. Get agreement from person #2.
10. Ask person #2 what he or she can do to resolve the parts(s) of the problem for which s/he is responsible.
11. Get agreement from person #1.

*Make sure you get a solution for each part of the problem.

12. Ask each disputant what he or she could do differently if the problem happened again.
13. Ask them if the problem is solved.
14. Ask disputants to tell their friends that the conflict has been solved, to prevent rumors from spreading.
15. Congratulate students for their hard work.
16. Fill out the Conflict Manager Report Form.

Oliver Y. K. Chen

# Liu Pyramids and Feedback Iteration Functions on Monoids


## Abstract

*General concepts of n-dimensional Liu pyramids on monoids and their feedback iteration functions are first created and established. Second, general concepts of initial sets and initial conditions are defined in order to connect the Liu pyramids and their feedback iteration functions. Four examples of 1-dimensional Liu pyramids and their feedback iteration functions, initial set, initial conditions are demonstrated. Then, the 2-dimensional case is discussed in detail. Finally, Liu notation is introduced and employed in the discussion of 3- and higher-dimensional cases.*


**Key words:** Liu pyramid, feedback iteration function, monoid, triangle, sequence.
**Mathematics Subject Classification Number:** 08A40

## Introduction

In this paper, general definitions for $n$-dimensional Liu pyramids and their feedback iteration functions on monoids are given in section 1. The relation between them is discussed, namely, given an initial set and a set of initial conditions on it, we will find the Liu pyramid from its feedback iteration functions and vice versa. In section 3, four examples of 1-dimensional pyramids and their feedback iteration functions are demonstrated. In section 4, several special cases of 2-dimensional pyramids on monoids, their subpyramids, and their feedback iteration functions are studied in detail. A proposed problem in the Spring 1994 issue of Math Horizons (published by M.A.A., p. 13, Problem 6) can be answered by Note (4.11) in that section. In section 5, Liu coefficient notation is introduced. Then 3- and higher-dimensional pyramids on monoids, their subpyramids, feedback iteration functions, initial set, initial conditions are discussed.

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## Definitions and Notations

Let $M$ be a nonempty abstract space. Let $W$ be the whole number system, i.e., $W = \{0,1,2,...\}$ with the usual addition and multiplication so that for $a$ and $b$ in $W$, $a - b$ is well defined if and only if $a$ is not less than $b$ (the trichotomy property of the whole numbers that do not form a ring). Let $n$ be a natural number. Let $W^n$ be the $n$-multiple product space of $W$. A mapping

$$Z = \{Z_{x_1,\cdots,x_n}\}_{(x_1,\cdots,x_n) \in W^n}$$

from $W^n$ to $M$ is called a $n$-dimensional Liu pyramid (in honor of Ju-Hsieh Liu [about 1100 A.D.]: refer to Needham and Wang 1959, Temple and Needham 1989) on $M$. Let $I \neq \phi$ be a subset of $W^n$. Let $m$ be a natural number such that $m \leq |I|$ where $|I|$ is the cardinal number of $I$. Let $M^m$ be the $m$-multiple product space of $M$. Let

$$F = \{F_X\}_{X \in W^n}$$

be a set of functions from $M^m$ to $M$ such that $F_X = C_X$ is a constant function for each $X \in I$. We say that $Z$ is a Liu pyramid generated from $F$ with the

initial conditions

$$\{F_X = C_X\}_{X \in I}$$

on $I$ provided

$$Z_X = \begin{cases} F_X & \text{if } X \in I; \\ F_X(Z_{x_1}, \cdots, Z_{x_n}) & \text{otherwise,} \end{cases}$$

where

$$Z_{x_1}, \cdots, Z_{x_n}$$

are predefined or pregenerated elements in $Z$. The set of functions $F$ is called a set of feedback iteration functions for $Z$, $I$ is called the initial set on $W^*$, and

$$\{F_X = C_X\}_{X \in I}$$

is called the set of initial conditions.

## Results

### 1-Dimensional Liu Pyramids: Sequences

When $n = 1$, a 1-dimensional Liu pyramid is usually called a sequence. A few examples are given below:

**Example (3.1).** Let $M$ be a ring with the usual addition and multiplication notations. Let $e$ be the multiplication identity of $M$. Let $I = \{0\}$. Let $m = 1$. Define $F$ as follows:

$$F_X(\alpha) = \begin{cases} e & \text{if } X \in I; \\ (Xe)\alpha & \text{otherwise.} \end{cases}$$

Let

$$Z_X = \begin{cases} F_X & \text{if } X \in I; \\ F_X(Z_{X-1}) & \text{otherwise.} \end{cases}$$

Then we obtain a factorial sequence in the ring.

**Example (3.2).** Let $M$ be the whole number system with the usual addition. Let $I = \{0,1\}$. Let $m = 2$. Let $F$ be defined as below:

$$F_X(\alpha, \beta) = \begin{cases} X & \text{if } X \in I; \\ \alpha + \beta & \text{otherwise.} \end{cases}$$

Let

$$Z_X = \begin{cases} F_X & \text{if } X \in I; \\ F_X(Z_{X-2}, Z_{X-1}) & \text{otherwise.} \end{cases}$$

It yields the Fibonacci number sequence.

**Example (3.3).** Let $M$ be the real field. Let $I = \{0\}$. Let $m = 1$. Let

$$F_X(\alpha) = \begin{cases} X & \text{if } X \in I; \\ \alpha + X^{-4} & \text{otherwise} \end{cases}$$

and

$$Z_X = \begin{cases} F_X & \text{if } X \in I; \\ F_X(Z_{X-1}) & \text{otherwise.} \end{cases}$$

This is the sequence used by Euler (Peitgen and Jürgens and Saupe 1992, Temple and Needham 1989) to estimate $\pi^4/90$.

**Example (3.4).** Let $M$ be the complex field. Let $c$ be a complex number. Let $I = \{0\}$. Let $m = 1$. Let

$$F_X(\alpha) = \begin{cases} X & \text{if } X \in I; \\ \alpha^2 + c & \text{otherwise} \end{cases}$$

and

$$Z_X = \begin{cases} F_X & \text{if } X \in I; \\ F_X(Z_{X-1}) & \text{otherwise.} \end{cases}$$

This is the sequence whose boundedness is used to determine whether the complex number $c$ is in the Mandelbrot set or not.

### 2-Dimensional Liu Pyramids: Triangles

When $n = 2$, the 2-dimensional Liu pyramids are usually called triangles. Let's consider some special cases:

**Definition (4.1).** Let $(M,\#)$ be a monoid. Let notations be the same as in section 2. Let

$$C = \{C_k\}_{k=0}^{\infty}$$

be a sequence on the monoid. Let $I = \{(k,l) \mid kl = 0 \text{ and } k,l \in W\}$. Let $m = 2$. Let

$$F_{k,l}(\alpha,\beta) = \begin{cases} C_{2l} & \text{if } k = 0; \\ C_{2k-1} & \text{if } k > l = 0, \\ \alpha\#\beta & \text{if } kl \neq 0. \end{cases}$$

Let

$$Z_{k,l} = \begin{cases} F_{k,l} & \text{if } (k,l) \in I; \\ F_{k,l}(Z_{k,l-1}, Z_{k-1,l}) & \text{otherwise.} \end{cases}$$

Then the triangle $Z$ generated by $F$ is called the Liu triangle on the monoid $M$ with respect to $C$.

**Theorem (4.2).** Let notations be the same as in (4.1). Let $a$ be an element in $M$. Let

$$C = \{C_k = a\}_{k=0}^{\infty}$$

Then we have

$$Z_{k,l} = \binom{k+l}{k}a = \binom{k+l}{l}a. \quad (\dagger)$$

Proof. Let $Z$ be as defined as in (†). For $kl = 0$, we have

$$\binom{k+l}{k} = \begin{cases} \binom{k}{k} = 1 & \text{if } l=0; \\ \binom{l}{0} = 1 & \text{if } k=0. \end{cases}$$

So $Z_{kl} = a = F_{kl}$ and $Z$ satisfies the initial conditions. Now for $kl \neq 0$, we have

$$\begin{aligned} Z_{k,l} &= \binom{k+l}{l}a \\ &= \left(\binom{k+l-1}{l-1} + \binom{k-1+l}{l}\right)a \\ &= \binom{k+l-1}{l-1}a \,\#\, \binom{k-1+l}{l}a \\ &= F_{k,l}(Z_{k,l-1}, Z_{k-1,l}). \end{aligned}$$

Thus $Z$ satisfies the feedback iteration functions $F$. Therefore $Z$ is the triangle generated from $F$, and the proof is complete.

Note that if $k + l = i$ is fixed, then we obtain the elements of the $i$th row of the triangle, namely,

$$\{Z_{k,l}\}_{k+l=i} = \left\{\binom{i}{l}a\right\}_{l=0}^{i}.$$

**Example (4.3).** When $M$ is the natural number system $N$ and $a = 1$ so that

$$C = \{C_k = 1\}_{k=0}^{\infty},$$

we get the original Liu triangle (Needham and Wang 1959, Peitgen, Jürgens, and Saupe 1992, Temple and Needham 1989).

**Example (4.4).** Consider the sequence

$$\{Z_{k,k} = \binom{2k}{k}\}_{k=0}^{\infty}$$

of all those elements on the bisector of the original Liu triangle. Obviously, this sequence can be constructed from the feedback iteration functions defined below:

$$F_k(\alpha) = \begin{cases} 1 & \text{if } k = 0; \\ \left\lfloor \frac{2(2k-1)\alpha}{k} \right\rfloor & \text{if } k > 0, \end{cases}$$

where $\alpha \in N$, with only one initial condition and each element is constructed from its exact predecessor.

In the rest of this paper, we will construct $n$-dimensional Liu pyramids from given feedback iteration functions and then conversely, find the feedback iteration functions for its lower dimensional subpyramids. Let us consider a special type of triangle on a ring in the next example.

**Example (4.5).** Let $R$ be a ring with traditional addition and multiplication operators. Let $e$ be the multiplication identity. Let $a$ and $b$ be elements in $R$. Let $C$ be the sequence defined as follows:

$$C_k = \begin{cases} a & \text{if } k = 0; \\ b^{k/2} & \text{if } k \text{ is positive and even;} \\ e & \text{if } k \text{ is odd.} \end{cases}$$

Then we obtain a Liu triangle

$$Y = \{Y_{k,l}\}_{k=0,\,l=0}^{\infty,\infty}$$

with respect to $C$ on the ring $R$. In other words, $Y$ is a mapping from $W \times W$ to $R$ so that

$$Y_{k,l} = \begin{cases} C_{2l} & \text{if } k = 0; \quad (1) \\ C_{2k-1} & \text{if } k > l = 0; \quad (2) \\ Y_{k,l-1} + Y_{k-1,l} & \text{if } kl \neq 0. \quad (3) \end{cases}$$

From the above iteration rules, we will find an explicit expression for each entry of the triangle.

**Theorem (4.6).** Let notations be the same as above. Then we have

$$Y_{k,l} = \begin{cases} a & \text{if } k=l=0; \\ b^l & \text{if } l>k=0; \\ e & \text{if } k>l=0; \\ \binom{k+l-1}{l} e + \sum_{j=1}^{l} \binom{k+l-j-1}{l-j} b^j & \text{if } k>l>0. \end{cases}$$

Proof. It suffices to show that $Y$ defined in this theorem satisfies the conditions (1), (2), and (3) in the above section. Plainly, $Y_{0,0} = a = C_0$ and $Y_{k,l} = b^l = C_{2l}$ for $l > k = 0$. This implies $Y_{k,l} = C_{2l}$ for $k = 0$, so (1) is satisfied. For $k > l = 0$, we get $Y_{k,l} = e = C_{2k-1}$, so (2) is satisfied also. To show $Y$ satisfies (3) that

$$Y_{k,l} = Y_{k,l-1} + Y_{k-1,l}$$

for $kl \neq 0$. There are four cases:
Case 1: When $k = l = 1$, we get

$$\begin{aligned} Y_{1,0} + Y_{0,1} &= e + b \\ &= \binom{1}{1} e + \sum_{j=1}^{1} \binom{1+1-j-1}{1-j} b^j \\ &= Y_{1,1}. \end{aligned}$$

Case 2: When $k > 0$ and $l = 1$, we have $Y_{k,1} = Y_{k,0} = e$ and

$$\begin{aligned} Y_{k-1,1} &= \binom{k-1}{1} e + \sum_{j=1}^{1} \binom{k-1+1-j-1}{1-j} b^j \\ &= (k-1)e + b. \end{aligned}$$

These imply

$$\begin{aligned} Y_{k,1} &= \binom{k}{1} e + \sum_{j=1}^{1} \binom{k-j}{1-j} b^j \\ &= ke + b \\ &= e + ((k-1)e + b) \\ &= Y_{k,1-1} + Y_{k-1,1}. \end{aligned}$$

Case 3: When $k = 1$ and $l > 0$ we have

$$\begin{aligned} Y_{k,l-1} + Y_{k-1,l} &= \left(\binom{l-1}{l-1} e + \sum_{j=1}^{l-1} \binom{l-1-j}{l-1-j} b^j\right) + b^l \\ &= e + \sum_{j=1}^{l-1} b^j + b^l \\ &= e + \sum_{j=1}^{l} b^j \\ &= \binom{l}{l} e + \sum_{j=1}^{l} \binom{l-j}{l-j} b^j \\ &= Y_{k,l}. \end{aligned}$$

Case 4: When $k > 1$ and $l > 1$, we obtain

$$\begin{aligned} Y_{k,l-1} + Y_{k-1,l} &= \binom{k+l-2}{l-1}e + \binom{k+l-2}{l}e + \\ &\quad \sum_{j=1}^{l-1}\binom{k+l-2-j}{l-1-j}b^j + \sum_{j=1}^{l}\binom{k+l-2-j}{l-j}b^j \\ &= \binom{k+l-1}{l}e + \\ &\quad \sum_{j=1}^{l-1}\left(\binom{k+l-2-j}{l-1-j} + \binom{k+l-2-j}{l-j}\right)b^j + b^l \\ &= \binom{k+l-1}{l}e + \sum_{j=1}^{l-1}\binom{k+l-1-j}{l-j}b^j + b^l \\ &= \binom{k+l-1}{l}e + \sum_{j=1}^{l}\binom{k+l-1-j}{l-j}b^j \\ &= Y_{k,l}. \end{aligned}$$

Thus $Y$ satisfies the feedback iteration functions in (3) and the proof is completed.

Now consider the sequence of those points $Y_{kl}$ in $Y$ such that $k - l - 1 = 0$. They form a subtriangle of the triangle. We will find its feedback iteration functions. Let us state the next theorem first.

**Theorem (4.7).** Let notations be the same as in (4.6). Then we have

$$Y_{k+1,k} = \begin{cases} e & \text{if } k = 0; \\ \binom{2k+1}{k}e & \text{if } b = e; \\ f_k(Y_{k,k-1}) & \text{if } k > 0 \text{ and } b-e \text{ is invertible,} \end{cases}$$

where

$$f_k(X) = (b-e)^{-1}\left(\binom{2k+1}{k}(b-2e) + b^2X\right).$$

Proof. If $k = 0$, from theorem (4.6), we get $Y_{k+1,k} = Y_{1,0} = e$. Now if $k > 2$, again making use of theorem (4.6), we then have

$$\begin{aligned} Y_{k+1,k} &= \binom{2k}{k}e + \sum_{j=1}^{k}\binom{2k-j}{k-j}b^j \\ &= \binom{2k}{k}e + \sum_{j=1}^{k-1}\binom{2k-j}{k-j}b^j + \binom{k}{0}b^k \\ &= \binom{2k-1}{k}e + \binom{2k-1}{k-1}e + \sum_{j=1}^{k-1}\binom{2k-j-1}{k-j-1}b^j \\ &\quad + \sum_{j=1}^{k-1}\binom{2k-j-1}{k-j}b^j + \binom{k-1}{0}b^k. \end{aligned}$$

This yields, by setting $j+1=h$ and $j-1=i$,

$$\begin{aligned}
bY_{k+1,k} &= \binom{2k-1}{k}b + \binom{2k-1}{k-1}b + \sum_{j=1}^{k-1}\binom{2k-j-1}{k-j-1}b^{j+1} \\
&\quad + b^2\Big(\binom{2k-2}{k-1}e + \sum_{j=2}^{k-1}\binom{2k-j-1}{k-j}b^{j-1} + \binom{k-1}{0}b^{k-1}\Big) \\
&= \binom{2k-1}{k}b + \Big(\binom{2k}{k}e + \binom{2k-1}{k-1}b + \sum_{h=2}^{k}\binom{2k-h}{k-h}b^h - \binom{2k}{k}e\Big) \\
&\quad + b^2\Big(\binom{2k-2}{k-1}e + \sum_{i=1}^{k-2}\binom{2k-2-i}{k-1-i}b^i + \binom{k-1}{0}b^{k-1}\Big) \\
&= \binom{2k-1}{k}b + (Y_{k+1,k} - \binom{2k}{k}e) + b^2Y_{k,k-1}.
\end{aligned}$$

It implies

$$\begin{aligned}
(b-e)\,Y_{k+1,k} &= \binom{2k-1}{k}b - \binom{2k}{k}e + b^2Y_{k,k-1} \\
&= \binom{2k-1}{k}b - 2\binom{2k-1}{k}e + b^2Y_{k,k-1} \\
&= \binom{2k-1}{k}(b-2e) + b^2Y_{k,k-1}.
\end{aligned} \qquad (*)$$

One may check that (*) holds for $1 \le k \le 2$ also. Now if $b = e$, then we have

$$0 = \binom{2k-1}{k}(-e) + e^2Y_{k,k-1}.$$

So

$$Y_{k,k-1} = \binom{2k-1}{k}e = \binom{2k-1}{k-1}e,$$

for $k > 0$. Thus we obtain

$$Y_{k+1,k} = \binom{2k+1}{k}e,$$

for $k \ge 0$.

Again from (*), if $k > 0$ and $b - e$ is invertible, then we obtain

$$Y_{k+1,k} = (b-e)^{-1}\Big(\binom{2k-1}{k}(b-2e) + b^2Y_{k,k-1}\Big).$$

This completes the proof.
From the above theorem, we see that the sequence

$$\{Y_{k+1,k}\}_{k=0}^{\infty}$$

is generated by a set of feedback iteration functions. We state it formally.

**Corollary (4.8).** Let notations be the same as in (4.5). If $b - e$ is invertible, then the sequence

$$\{Y_{k+1,k}\}_{k=0}^{\infty}$$

is generated by the feedback iteration functions defined below:

$$f_k(x) = \begin{cases} e & \text{if } k = 0; \\ (b-e)^{-1}\binom{2k+1}{k}(b-2e) + b^2x & \text{if } k > 0 \end{cases}$$

for $x \in R$.

Next let us consider the special case when $b = 2e$.

**Corollary (4.9).** Let notations be the same as in (4.5). If $b = 2e$, then the sequence

$$\{Y_{k+1,k}\}_{k=0}^{\infty}$$

is generated by the feedback iteration functions defined below:

$$f_k(x) = \begin{cases} e & \text{if } k = 0; \\ 4x & \text{if } k > 0 \end{cases}$$

for $x \in R$.

Proof. Since $b = 2e$, we have $(b - e)^{-1} = e$, the first term in the parentheses vanishes, and the second term becomes

$$(2e)^2 x = 4x.$$

This completes the proof.

By mathematical induction, the proof of the next corollary is straight forward by Theorem (4.7) and Corollary (4.9).

**Corollary (4.10).** Let notations be the same as in (4.5). If $b = 2e$, then we have

$$Y_{k+1,k} = 4^k e$$

for all whole numbers $k$.

Now let us consider a special case below:

**Note (4.11).** In (4.5), if we select the ring to be the integer ring and set $a = 1$ and $b = 2$, then we obtain the triangle shown in Math Horizons (1994: 13). A solution to that problem 6 is given by the specia- case of the above corollary when $e = 1$ in the integer ring. The original problem is rewritten as follows:

**Problem 6.** In the variation on Pascal's Triangle, the 1's on the right were replaced by successive powers (from 0 up) of 2. Show that the numbers in the column on the left of the symmetric axis of the triangle are the successive powers of 4 (also from 0 up).

## Three and Higher Dimensional Liu Pyramids

Before we proceed, let us introduce the Liu coefficient or notation and show some of its important properties.

**Notation (5.1).** Let $x_1,\ldots,x_n$ be whole numbers. Define

$$\langle x_1, \cdots, x_n \rangle = \frac{(x_1 + \cdots + x_n)!}{x_1! \cdots x_n!}$$

This is called the Liu coefficient notation. Note that when $n = 2$, we have

$$\langle x_1, x_2 \rangle = \binom{x_1 + x_2}{x_1} = \binom{x_1 + x_2}{x_2}.$$

**Lemma (5.2).** For every natural number $n$, we have

$$\langle x_1, \cdots, x_n \rangle = \sum_{j=1}^{n} \langle x_1, \cdots, x_j - 1, \cdots, x_n \rangle$$

provided that $x_j > 0$ for all $1 \le j \le n$.

Proof. One may check that the lemma is true for $n = 2$. Assume that the lemma is true for $2 \le n \le m$. Then

$$\begin{aligned}
\langle x_1,\cdots,x_{m+1}\rangle &= \frac{(x_1+\cdots+x_{m+1})!}{x_1!\cdots x_{m+1}!} \\
&= \frac{(x_1+\cdots+x_m)!}{x_1!\cdots x_m!}\,\frac{((x_1+\cdots+x_m)+x_{m+1})!}{(x_1+\cdots+x_m)!\,x_{m+1}!} \\
&= \frac{(x_1+\cdots+x_m)!}{x_1!\cdots x_m!}\left(\frac{(x_1+\cdots+x_{m+1}-1)!}{(x_1+\cdots+x_m-1)!\,x_{m+1}!}\right. \\
&\quad \left.+\frac{(x_1+\cdots+x_{m+1}-1)!}{(x_1+\cdots+x_m)!\,(x_{m+1}-1)!}\right) \\
&= \frac{(x_1+\cdots+x_m)!}{x_1!\cdots x_m!}\,\frac{(x_1+\cdots+x_{m+1}-1)!}{(x_1+\cdots+x_m-1)!\,x_{m+1}!} \\
&\quad +\frac{(x_1+\cdots+x_{m+1}-1)!}{x_1!\cdots x_m!\,(x_{m+1}-1)!} \\
&= \left(\sum_{j=1}^{m}\langle x_1,\cdots,x_j-1,\cdots,x_m\rangle\right) \\
&\quad \frac{(x_1+\cdots+x_{m+1}-1)!}{(x_1+\cdots+x_m-1)!\,x_{m+1}!}+\frac{(x_1+\cdots+x_{m+1}-1)!}{x_1!\cdots x_m!\,(x_{m+1}-1)!} \\
&= \left(\sum_{j=1}^{m}\frac{(x_1+\cdots+x_m-1)!}{x_1!\cdots(x_j-1)!\cdots x_m!}\right)\frac{(x_1+\cdots+x_{m+1}-1)!}{(x_1+\cdots+x_m-1)!\,x_{m+1}!} \\
&\quad +\frac{(x_1+\cdots+x_{m+1}-1)!}{x_1!\cdots x_m!\,(x_{m+1}-1)!} \\
&= \sum_{j=1}^{m+1}\langle x_1,\cdots,x_j-1,\cdots,x_{m+1}\rangle .
\end{aligned}$$

This implies that the lemma is true for $n = m + 1$. Therefore, by mathematical induction, the lemma is proved.

**Theorem (5.3).** Let $(x_1,\ldots,x_n) \neq 0$. Then we have

$$\langle x_1,\cdots,x_n\rangle = \sum_{x_j>0}\langle x_1,\cdots,x_j-1,\cdots,x_n\rangle .$$

Proof. Since Liu notation is independent of $x_j$'s order, without loss of generality, we may assume that $x_j > 0$ for $1 \le j \le h < n$ and $x_j = 0$ for $h < j \le n$. Then, by the above lemma, we have

$$\begin{aligned}
\langle x_1,\cdots,x_n\rangle &= \langle x_1,\cdots,x_h\rangle \\
&= \sum_{j=1}^{h}\langle x_1,\cdots,x_j-1,\cdots,x_h\rangle \\
&= \sum_{j=1}^{h}\langle x_1,\cdots,x_j-1,\cdots,x_n\rangle \\
&= \sum_{x_j>0}\langle x_1,\cdots,x_j-1,\cdots,x_n\rangle .
\end{aligned}$$

Now, given a monoid, we are ready to define a special type of n-dimensional pyramid on it:

**Definitions and Notations (5.4).** Let $(M,\#)$ be a monoid. Let

$$I = \{(x_1,\cdots,x_n) \mid \sum_{j=1} x_j^2 = 0 \text{ for some } 1 \le i \le n\}$$

be a subset of $W^n$. $I$ is called the set of edges of the $n$-dimensional pyramid. Let

$$C = \{C_{x_1,\cdots,x_n}\}_{(x_1,\cdots,x_n)\in I}$$

be a mapping from $I$ to $M$. Let

$$F_{x_1,\cdots,x_n}(\alpha_1,\cdots,\alpha_n) = \begin{cases} C_{x_1,\cdots,x_n} & \text{if } (x_1,\cdots,x_n) \in I; \\ \#_{i=1}^{n}\, sign(x_j)\,\alpha_j & \text{otherwise,} \end{cases}$$

where $(a_1,...,a_n) \in M^n$. Let

$$Z_{x_1,\cdots,x_n} = \begin{cases} F_{x_1,\cdots,x_n} & \text{if } (x_1,\cdots,x_n) \in I; \\ F_{x_1,\cdots,x_n}(Z_{\max(x_1-1,0),\cdots,x_n},\cdots,Z_{x_1,\cdots,\max(x_j-1,0),\cdots,x_n},\cdots, \\ \qquad Z_{x_1,\cdots,\max(x_n-1,0)}) & \text{otherwise.} \end{cases}$$

We call $Z$ the $n$-dimensional Liu pyramid with respect to $C$. In the next theorem, we will show an explicit expression for each entry of the special pyramid when all the initial conditions have the same value.

**Theorem (5.5).** Let notations be the same as in (5.4). Let $a$ be in $M$. Let

$$C_{x_1,\cdots,x_n} = a$$

for all $(x_1,...,x_n)$ in $I$. Let $Z$ be the pyramid with respect to $C$. Then, for all $(x_1,...,x_n)$ in $W^n$, we have

$$Z_{x_1,\cdots,x_n} = \langle x_1,\cdots,x_n\rangle a$$

Proof. Let $Z$ be defined as in the theorem. It suffices to show that it satisfies the initial conditions and feedback iteration functions in (5.4). For $(x_1,...,x_n) \in I$, we get

$$\begin{aligned} Z_{x_1,\cdots,x_n} &= \langle x_1,\cdots,x_n\rangle a \\ &= a \\ &= C_{x_1,\cdots,x_n} \\ &= F_{x_1,\cdots,x_n}. \end{aligned}$$

Thus, the initial conditions are satisfied. For $(x_1,...,x_n) \notin I$, by (5.3), we have

$$\begin{aligned} & F_{x_1,\cdots,x_n}(Z_{\max(x_1-1,0),\cdots,x_n},\cdots, \\ & \qquad Z_{x_1,\cdots,\max(x_j-1,0),\cdots,x_n},\cdots, \\ & \qquad Z_{x_1,\cdots,\max(x_n-1,0)}) \\ &= \#_{j=1}^{n} sign(x_j)\, Z_{x_1,\cdots,\max(x_j-1,0),\cdots,x_n} \\ &= \#_{x_j>0} Z_{x_1,\cdots,\max(x_j-1,0),\cdots,x_n} \\ &= \#_{x_j>0} \langle x_1,\cdots,x_j-1,\cdots,x_n\rangle a \\ &= \Big(\sum_{x_j>0} \langle x_1,\cdots,x_j-1,\cdots,x_n\rangle\Big) a \\ &= \langle x_1,\cdots,x_n\rangle a \\ &= Z_{x_1,\cdots,x_n}. \end{aligned}$$

Thus, the feedback iteration functions are satisfied also. This completes the proof.

For the case when $n = 3$, let us consider two of its special subpyramids, namely,

$$S = \{S_k = Z_{k,k,k}\}_{k=0}^{\infty}$$

and

$$T = \{T_{k,l} = Z_{k,l,1}\}_{k=0,l=0}^{\infty,\infty}.$$

We want to find their feedback iteration functions.

**Corollary (5.6).** Let $S$ and $T$ be the same as in the discussion after (5.5). We then have

(1) $S$ is the sequence on $M$ generated by

$$F_k(\alpha) = \begin{cases} a & \text{if } k = 0; \\ \dfrac{(3k)!}{(k!)^3} a & \text{if } k > 0 \end{cases}$$

so that $S_k = F_k$. Note that all $F_k$ are constant mappings from $M$ to itself.

(2) $T$ is a triangle generated by

$$F_{k,l}(\alpha,\beta) = \begin{cases} (k+1)a & \text{if } l = 0; \\ (l+1)a & \text{if } k = 0; \\ \alpha\#\beta\#\binom{k+l}{l} a & \text{if } kl \neq 0 \end{cases}$$

so that

$$T_{k,l} = \begin{cases} F_{k,l} & \text{if } kl = 0; \\ F_{k,l}(T_{k,l-1}, T_{k-1,l}) & \text{otherwise.} \end{cases}$$

Proof. This corollary is a direct consequence of the definitions of $S_k$ and

$T_{kl}$ after (5.5) and the following identities:

$$Z_{k,k,k} = \frac{(3k)!}{(k!)^3}a$$

and

$$Z_{k,l,1} = \begin{cases} Z_{k,0,1} & \text{if } l = 0; \\ Z_{0,l,1} & \text{if } k = 0; \\ Z_{k,l-1,1} \# Z_{k-1,l,1} \# Z_{k,l,0} & \text{if } kl \neq 0, \end{cases}$$

where

$$Z_{k,0,1} = (k+1)a,$$

$$Z_{0,l,1} = (l+1)a, \text{ and}$$

$$Z_{k,l,0} = \binom{k+l}{k}a$$

To close this section, we give an alternative definition for the Liu notation by a single initial condition on the vertex of the pyramid and a simple iteration rule.

**Note (5.7).** When $M$ and $a$ are respectively replaced by the integer ring and 1, we find that Liu coefficients form the Liu pyramid with initial value 1 on its edges. Note also that the Liu notation pyramid can also be defined directly as follows:

$$Z_{x_1,\cdots,x_n} = \begin{cases} 1 & \text{if } (x_1,\cdots,x_n) = 0; \\ \sum_{x_j>0} Z_{x_1,\cdots,x_j-1,\cdots,x_n} & \text{otherwise.} \end{cases}$$


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# Gravity Override of Immiscible Fluids in Porous Media

## Abstract

*When one fluid is displaced by another in a permeable medium, the front between the two fluids changes its shape. The change in shape of the front depends on miscibility of the two fluids, the density difference, and the time of contact. Inside a petroleum reservoir, when oil is pushed with a fluid, the front's changed shape is one of the important factors in determining the efficiency of the production system. Therefore, it is important to study the changing shape of the front, in order to extract oil in an efficient manner. Using Darcy's law and the convection-diffusion equation, a detailed mathematical study of the motion of the front and the fluid particles is presented for miscible fluids. The model is then restricted to immiscible fluids and numerical results are presented. This paper describes how the front between two fluids changes its shape because of a difference in density.*

Key Words: fluid flow, porous media, immiscible fluid, miscible fluid.

## Introduction

The phenomena of the simultaneous flow of two fluids through a porous medium occurs in many important problems of petroleum recovery, reservoir engineering and groundwater hydrology. Consequently, many problems have arisen and been solved in past years. Problems in hydrology and geology related to the flow of two fluids concern the more or less natural contact of two fluids inside the earth. However, in petroleum reservoir engineering the contact of the fluids is an artificial situation created in the oil field inside the reservoir. Examples are pushing the oil (with miscible or immiscible fluids) toward the production well to get more output, the under ground motion of a spilled contaminant that is moving towards a river or a lake, and seawater intrusion into a coastal freshwater aquifer.

The problem discussed here comes from an oil field where a fluid is injected through an injection well to increase the pressure inside the reservoir and to push the oil toward the production wells. When the injection fluid is injected at a very high pressure the pressure is distributed in the flow domain and the front between the two fluids (oil and injection fluid) moves toward the production wells. The motion and shape of the front between two fluids depends on the contrast of the fluids such as high or low density difference, high or low viscosity difference, and high or low miscibility of the fluids. Initially the front between the two fluids can be assumed to be sharp and vertical. After awhile, because of miscibility, the front is not sharp anymore as shown in Figure 1. Using Darcy's law and the convection- diffusion equation, an extensive mathematical study of the motion of the front between two fluids is possible. A mathematical model has been developed that studies the change in the shape of the front, under gravitational force only, inside a porous medium. It has been assumed that the fluid particles near the front are in motion only due to density differences of the two

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fluids. The density difference between the two fluids causes a pressure gradient which makes the front move.

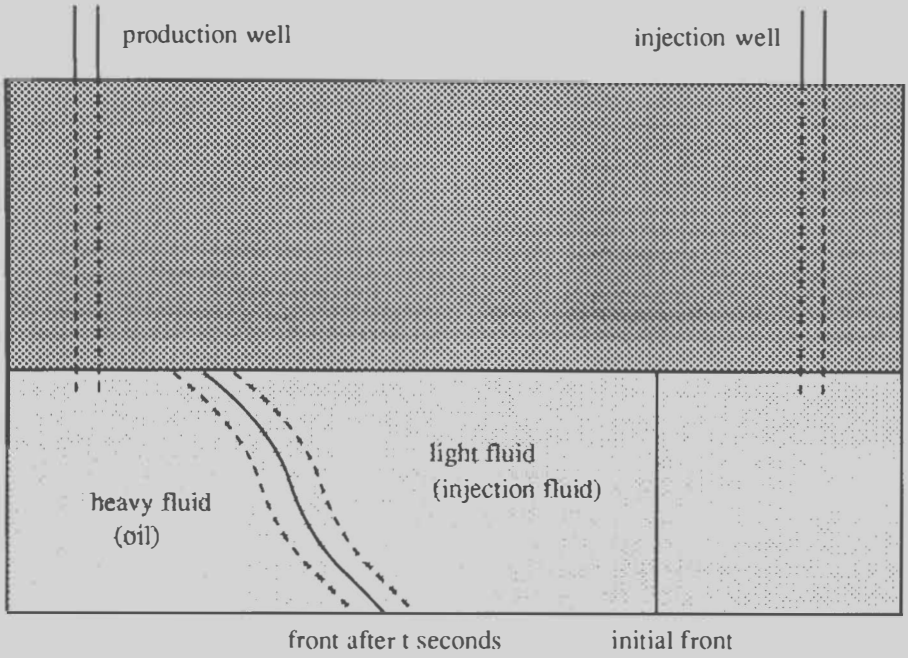



**Figure 1.** *Motion of the front inside the reservoir*

## Diffusion and Flow

If a liquid is in contact with another substance (solid or gas) there is free interfacial energy present between the two. This means that a certain amount of work has to be performed in order to separate a liquid from, say, a solid. The interfacial energy comes from the inward attraction of the molecules in the interior of a substance toward those at the surface. Since a surface possessing free energy contracts (if it can do so), the free interfacial energy manifests itself as *interfacial tension*, (Collins 1976). Thus the interfacial tension $\sigma_{ik}$ for a pair of substances $i$ and $k$ is defined as the amount of work that must be performed to separate a unit area of substance $i$ and substance $k$. For air and water, at 20°C, $\sigma_{ik} = 72.5 erg/cm^2$. The interfacial tension $\sigma_i$ between a substance $i$ and vacuum (or vapor of the same substance) is called *surface tension*.

If the interfacial tension between two fluids is nonzero, the fluids do not mix. This is referred to as immiscible. If the interfacial tension between two fluids is zero then a distinct fluid interface does not exit and the fluids are miscible. If two fluids are miscible then molecules of one fluid can diffuse into the other fluid. This is a spontaneous process. Consider two fluids brought into contact at a plane. Within either fluid the molecules have a random motion which is dependent upon the absolute temperature. This motion is isotropic, *i.e.* in any homogeneous region there are equal numbers of

molecules moving in all directions with the same distribution of velocity. At the plane of separation there are molecules of *kind 1* on the left and molecules of *kind 2* on the right. Due to random motion some molecules of *kind 1* cross the plane to the right and some of *kind 2* cross to the left. This process expands in both directions until a homogeneous mixture of two kinds of molecules exists. This process is termed *molecular diffsion* (Rafai 1956).

## Convection-Diffusion Equation

Assume a linear fluid element between A and B. If C is the average concentration of the fluid at a certain instant, then

$$\text{Total mass} = \int_A^B C dx. \qquad (1)$$

Since mass is conserved, the rate of change of mass is equal to the change in mass per unit time due to flow plus the change in mass per unit time due to diffusion. That is

$$\frac{\partial}{\partial t}\int_A^B C dx = (vC(A) - vC(B) + (DC_x(B) - DC_x(A)$$

where D is the diffusion coefficient. But

$$(vC(A) - vC(B)) = -\int_A^B (vC)_x dx$$

and

$$(DC_x(B) - DC_x(A)) = \int_A^B (DC_x)_x dx.$$

This gives

$$\int_A^B C_t dx + \int_A^B (vC)_x dx - \int_A^B (DC_x)_x dx = 0$$

and so

$$\int_A^B (C_t + (vC)_x - (DC_x)_x) dx = 0.$$

If the material can be regarded as having continuous properties then

$$C_t + (vC)_x - (DC_x)_x = 0.$$

In two dimensions this becomes

$$C_t = -\nabla \cdot (\vec{v}C) + \nabla \cdot (D\nabla C). \qquad (2)$$

## Darcy's Equation

In 1856 Henry Darcy described in an appendix of his book *"La Fountaina Publiques de la Ville de Dijon"* a series of experiments on the downward flow of water through sand filters, whereby it was established that the rate of flow depends on the pressure difference between the two end points and the length and the cross-sectional area of the sand pack (Hubbert 1969). The liquid used in Darcy's original experiment was water. Later, the experiment was repeated using different liquids and a generalized relation between the flow rate, density and viscosity of the liquid, and porosity, permeability, length, and cross-sectional area of the sand pack was established.

**Definition 0.1 Porosity** *The porosity of a porous material is the fraction of the bulk volume of the material occupied by the voids. The symbol usually employed for this parameter is $\phi$. Thus*

$$\phi = \frac{V_p}{V_B} = \frac{\textit{Volume of the pores}}{\textit{Bulk volume}}.$$

*The porosity $\phi$ is a dimensionless quantity.*

Two kinds of porosity can be defined, namely absolute or total porosity, and effective porosity. Absolute porosity is the fractional void space with respect to bulk volume regardless of pore connections. Effective porosity is that fraction of the bulk volume constituted by interconnecting pores. Many naturally occurring rocks, such as lava and other igneous rocks, have a high total porosity but essentially no effective porosity. The porosity can range from zero to more than 0.5. In most sedimentary rocks, however, the porosity is predominantly interconnected and seldom exceeds 0.3.

**Definition 0.2 Permeability** *This is the property of the porous material which characterizes the ease with which a fluid may be made to flow through the material by an applied pressure gradient. Permeability is the fluid conductivity of the porous material.*

The permeability of the medium measures the facility with which fluids flow through the medium. For the present only a quantitative definition is necessary. Of two media through which the same fluid is made to flow under identical conditions, that the medium through which the flow is more rapid has the greater permeability. A medium may be said to be isotropic with respect to permeability if it is equally permeable in all directions.

Inside the porous medium, where $\vec{v}$ is the fluid velocity and $\phi$ is the porosity of the medium, Darcy's velocity $\vec{u}$ is defined by

$$\vec{u} = \frac{\vec{v}}{\phi}. \tag{3}$$

If a liquid with density $\rho$ and viscosity $\mu$ is flowing through a porous medium which has permeability, $k$, then Darcy's velocity is given by (Muskat 1946 and Bear 1979)

$$\vec{u} = -\frac{k}{\mu}\left(\nabla P + \rho\vec{G}\right) \tag{4}$$

and thus

$$\nabla P + \frac{\mu}{k}\vec{u} + \rho\vec{G} = 0 \tag{5}$$

where $P$ is the pressure and $\vec{G} = (0, g)$ is the gravitational acceleration.

Darcy's experiment and the derivation of these equations is discussed in detail in Collins (1976).

## Model Development

### Another form of Darcy's Equation

From (5) one can take the divergence and, assuming that $k$ is constant, arrive at

$$\nabla^2 P + \frac{\nabla\mu\cdot\vec{u}}{k} + \frac{\mu}{k}\nabla\cdot\vec{u} + \nabla\rho\cdot\vec{G} + \rho\nabla\cdot\vec{G} = 0 \tag{6}$$

Since the fluid is assumed to be incompressible, the divergence of its velocity is zero. This fact eliminates the third term of (6). Also since $\vec{G}$ is a constant vector, $\rho\nabla\cdot\vec{G} = 0$. This eliminates the fifth term of (6). Hence (6) reduces to

$$\nabla^2 P + \frac{1}{k}\nabla\mu\cdot\vec{u} + \nabla\rho\cdot\vec{G} = 0$$

But using (4) gives

$$\nabla^2 P - \frac{\nabla\mu}{\mu}\cdot(\nabla P + \rho\vec{G}) + (\nabla\rho\cdot\vec{G}) = 0. \tag{7}$$

Since $\frac{\nabla\mu}{\mu} = \nabla(\ln\mu)$, (7) becomes

$$\nabla^2 P - \nabla(\ln\mu)\cdot\nabla P - \rho\nabla(\ln\mu)\cdot\vec{G} + \nabla\rho\cdot\vec{G} = 0.$$

Since $\rho$ and $\mu$ are both functions of the concentration, $C$, this equation can be written as

$$\nabla^2 P - (\ln\mu)'\nabla C\cdot(\nabla P + \rho\vec{G}) + (\rho)'(\nabla C\cdot\vec{G}) = 0, \tag{8}$$

where $\mu' = \frac{\partial\mu}{\partial C}$ and $\rho' = \frac{\partial\rho}{\partial C}$.

If two fluids with densities $\rho_1$ and $\rho_2$, viscosities $\mu_1$ and $\mu_2$, and concentrations $C_1$ and $C_2$ respectively, are diffusing into each other, then empirical results (Peaceman 1955) show that (*i*) the density $\rho$ of the mixture is a linear function of $C$ and (*ii*) if $\mu$ is the viscosity of the mixture then $\ln(\mu)$ is a linear function of $C$, where $C$ is the concentration of fluid one. Thus

$$\rho = (\rho_1 - \rho_2)C + \rho_1, \tag{9}$$

$$\ln(\mu) = (\ln(\mu_1) - \ln(\mu_2))C + \ln(\mu_1)$$

and hence

$$\ln(\mu) = \ln(M)C + \ln(\mu_1), \tag{10}$$

where $M = \frac{\mu_1}{\mu_2}$. Hence (8) reduces to

$$\nabla^2 P - \ln M(\nabla C\cdot\nabla P) - (\rho\ln M - (\rho_1 - \rho_2))\left(\frac{\partial C}{\partial y}g\right) = 0. \tag{11}$$

## Diffusion Equation and Velocity of the Sharp Front

From (2)

$$\frac{\partial C}{\partial t} = -(\nabla \cdot \vec{v})C - \vec{v} \cdot \nabla C + \nabla D \cdot \nabla C + D\nabla^2 C.$$

If we assume that the fluid is incompressible and that the diffusion coefficient is constant, then this equation reduces to

$$\frac{\partial C}{\partial t} = -\vec{v} \cdot \nabla C + D\nabla^2 C. \tag{12}$$

If at a certain instant of time concentration and velocity are known then this equation can be solved numerically.

In the particular case where there is no mixing between the two fluids, then $D = 0$. The fluids are thus immiscible. Since $C$ is a function of position and time,

$$\frac{dC}{dt} = \frac{\partial C}{\partial t} + \nabla C \cdot \frac{d\vec{x}}{dt}, \tag{13}$$

where $d\vec{x} = (dx, dy)$. Following a particle on a particular iso-concentration line, $\frac{dC}{dt} = 0$. Hence (13) gives

$$\frac{\partial C}{\partial t} = -\nabla C \cdot \frac{d\vec{x}}{dt} = -\nabla C \cdot \vec{V}, \tag{14}$$

where $\vec{V}$ is the velocity of the front. From (12) and using the fact that $D = 0$,

$$\vec{V} \cdot \nabla C = v \cdot \nabla C$$

and so

$$\vec{V} \cdot \hat{n} = \vec{v} \cdot \hat{n}.$$

Here $n = \frac{\nabla C}{\|\nabla C\|}$ is the unit vector in the direction of $\nabla C$ which is also the direction of the velocity of the front. This implies that the speed, $V$, of the front is

$$V = \vec{v} \cdot \hat{n}. \tag{15}$$

This is the same as the normal component of the velocity of the fluid particle on the front. Thus if the velocity of the fluid particles on the front is known then the speed of the front can be determined. By (3) and (4)

$$\vec{v} = -\frac{k}{\mu\phi}\left(\nabla P + \rho\vec{G}\right),$$

which gives

$$v_x = -\frac{k}{\mu\phi}\frac{\partial P}{\partial x} \tag{16}$$

and

$$v_y = -\frac{k}{\mu\phi}\left(\frac{\partial P}{\partial y} + \rho g\right), \tag{17}$$

where $v_x$ and $v_y$ are the horizontal and vertical components of $v$, respectively.

At a certain instant of time if the velocity components $v_x$ and $v_y$ are known and the inclination of the front from horizontal is $\alpha$ then the velocity of the front can be determined by the formula

$$V = v_x \sin\alpha + v_y \cos\alpha. \tag{18}$$

## Initial Conditions

Consider a rectangular box of length $l$ and height $h$ (Fig. 2). Initially it is assumed that the front is vertical and in the middle of the box; the heavy fluid is in the left-hand side of the box and the light fluid is in the right-hand side. Initially we have

$$P(x,y) = \begin{cases} \rho_1 g(h-y) & x < l/2 \\ \rho_2 g(h-y) & x \geq l/2, \end{cases} \tag{19}$$

$$C(x,y) = \begin{cases} 1 & x < l/2 \\ 0 & x \geq l/2, \end{cases} \tag{20}$$

and

$$\rho(x,y) = \begin{cases} \rho_1 & x < l/2 \\ \rho_2 & x \geq l/2, \end{cases} \tag{21}$$

$$\mu(x,y) = \begin{cases} \mu_1 & x < l/2 \\ \mu_2 & x \geq l/2. \end{cases} \tag{22}$$

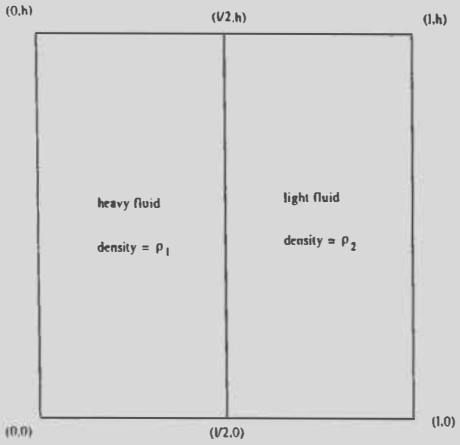



**Figure 2.** *The flow domain at $t = 0$.*

## Boundary Conditions

There is no flow through the boundaries. Hence $v_x$ and $v_y$ must be zero. Then (16) and (17) give

$$\frac{\partial P}{\partial x}(0, y) = \frac{\partial P}{\partial x}(l, y) = 0, \tag{23}$$

and

$$\frac{\partial P}{\partial y}(x, 0) = \frac{\partial P}{\partial y}(x, h) = -\rho g. \tag{24}$$

# Results

## Algorithm

1. (11), (16), and (17) are discretized using a finite difference method on a rectangular domain.

2. Using the initial values of $P$, $\rho$, $C$, and $\mu$, (11) is solved using the Successive Over Relaxation (SOR) method. SOR method approximates the solution of a system of partial differential equations. An introduction of SOR method can be found in (Peaceman, 1955).

3. Using the new pressure from step (2), $Vx$ and $Vy$ are calculated from (16) and (17), respectively.

4. The new position of a point $(x, y)$ on the front after time $\Delta t$ is $(x+v_x\Delta t, y+v_y\Delta t)$.

5. Step (4) gives the new front after time $\Delta t$. We assume that the change in the shape of the front affects the density at the neighboring points since the fluids are carried along by it. A new front after a certain time $\Delta t$ is shown in Figure 3. Initially the density at $(x, y+\Delta y)$ is $\rho_1$ and at $(x + \Delta x, y+\Delta y)$ is $\rho_2$. After time $\Delta t$ the density at the point $(x, y+\Delta y)$ is interpolated by using the formula

$$\rho(x, y + \Delta y) = \frac{\rho_1 A_1 + \rho_2 A_2}{A_1 + A_2} \tag{25}$$

where $A_1$ = area *ABDE*, and $A_2$ = area *BCD*.

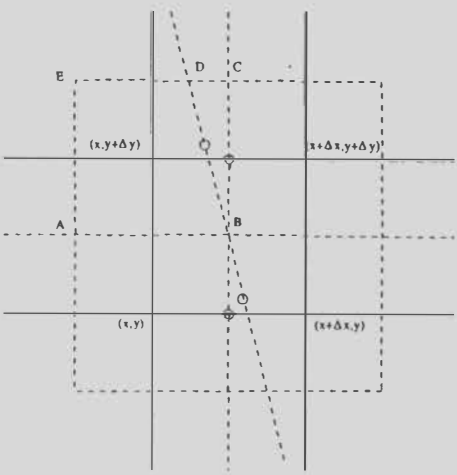



**Figure 3.** *Initial front and the front after time $t$.*

If the density at a certain grid point in the domain is $\rho$, then the average density of the fluid around the grid point in a rectangular box with length $\Delta x$ and height $\Delta y$ is $\rho$. Initially the front is vertical and the average density of the fluid in the box ABCE is $\rho_1$. But after a certain time the front divides the box ABCE into two parts, the region ABDE and the region BCD, where region BCD

contains a fluid of density $\rho_2$. This affects the average density of the fluid inside the box if it is approximated using (25). It is clear that when the moving front passes completely through box ABCE (Fig. 3), the whole box is filled with the fluid of density $\rho_2$ so the average density of fluid in the box is $\rho_2$. Also (25) shows that as soon as the front passes the box ABCE, the area $A_1$ in the equation becomes zero, that is, the average density of the fluid in the box is $\rho_2$.

6. Equation (9) gives the new concentration at the grid points.

7. Using the new $P$, $\rho$, and $C$, perform steps (2)-(6) for the required number of time steps.

## Discussion

Consider a rectangular flow domain. In the vicinity of the bottom of the front, the pressure difference is higher than at any other horizontal level in the box. So the bottom of the front moves faster than any other height toward the light fluid. In a box filled with uniform sand (Fig. 4), the left side of the sand is saturated with a fluid of density $\rho_1$ and the right side is saturated with a fluid of density $\rho_2$. The front is initially vertical and in the middle of the box. Thus the pressure difference is $(\rho_1 - \rho_2)gh$. Because $g$, $\rho_1$ and $\rho_2$ are fixed, the pressure difference depends on the depth of the points only. Since the bottom of the box is the level of maximum depth, the heavy fluid moves toward the light fluid faster than any other level because velocity is proportional to pressure difference between two points. When the heavy fluid moves toward the light fluid its upper level descends and to fill the gap, the light fluid of the upper level moves toward the heavy fluid. In the bottom half of the box, the fluid particles of the heavy fluid move toward the light fluid with a velocity proportional to the depth of the point. This makes the light fluid move toward the heavy fluid in the upper half of the box. Thus, we get the moving front between the two fluids as a consequence of a general circulatory motion of the fluid. Figure 5 shows how the light fluid overrides the heavy fluid under gravitational effects.

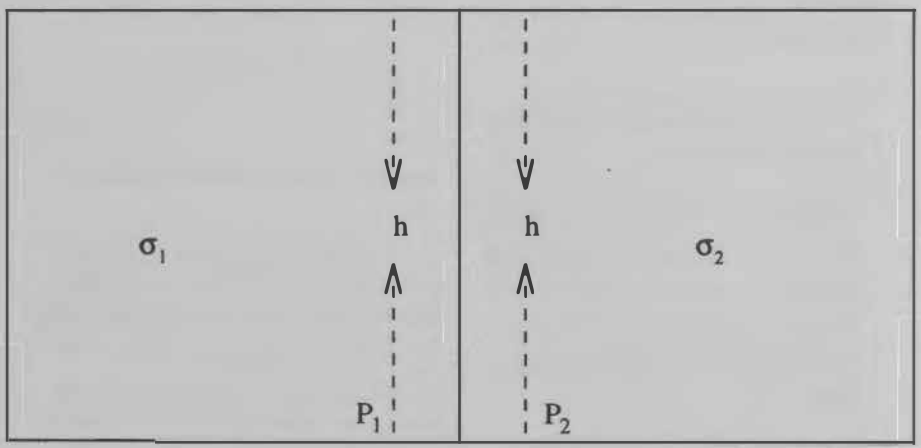
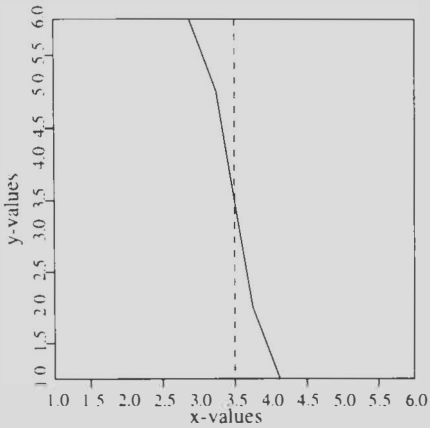
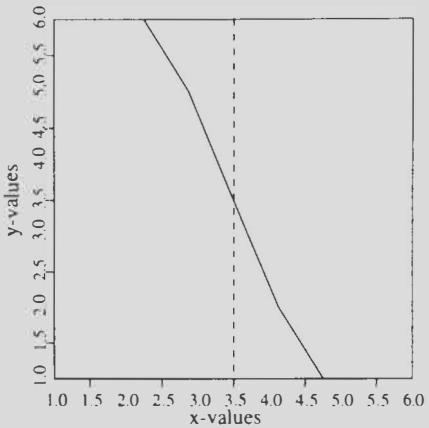


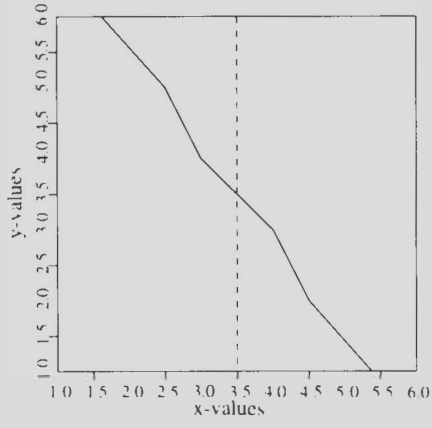

**Figure 4:** *The flow domain.*



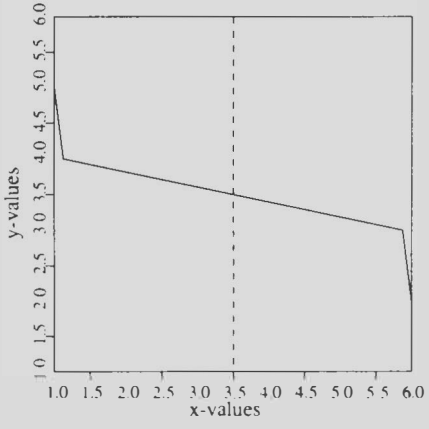

Position of the front after 1000 seconds




Position of the front after 2000 seconds




Position of the front after 4000 seconds




Position of the front after 200000 seconds

**Figure 5.** *The sharp front at different times.*

Equation (11) is solved numerically for the pressure distribution inside the domain with the initial values of $\rho_1 = 1.2$ gm/cm$^3$, $\rho_2 = .8$ gm/cm$^3$, $\mu_1 = \mu_2 =$ 1 centi poise, $k = 1.0$ Darcy $\left(\frac{1(cm^3/s)\ 1(centi\ poise)}{1(cm^2)\ 1(atm/cm)}\right)$ and $\phi = 0.3$.

The time step is 10 seconds. After every time step a new front is produced with a changed shape. The position of the front after 1000 seconds, 2000 seconds, 4000 seconds, and 20000 seconds is shown in Figure 5. All the graphs show the changing position of the front from its initial vertical position to a new horizontal state. Here, miscibility is considered to be zero and the sharp front between the fluids has been tracked from its initial state to its steady state. The approximate motion of the front is consistent with the analytic description of the override of the light fluid over the heavy fluid described previously.

## Conclusion

The mathematical model derived in this paper simulates the simultaneous motion of two fluids in porous media. The numerical results are consistent with the analytic description of the physical phenomena discussed in the introduction. Also the qualitative behavior of the solution is verified by an experiment done by the Petroleum Recovery Research Center at New Mexico Tech. An extension of this work would be to include the thermal effects on the flow and to consider multiphase flow instead of a single phase flow as considered in this paper. A variation of this model may be used to describe the under ground motion of a spilled contaminant that is moving towards a lake or a river.

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Ahmad B. Rezvani
Barbara A. Miner

# Micellar Influence on the Decarboxylation of the 2-Cyano-2-Phenylacetate Ion

## Abstract

*Decarboxylation of the 2-cyano-2-phenylacetate ion in water is catalyzed by a number of cationic surfactants. The longer the surfactant's alkyl chain and the more hydrophobic its charged head, the greater is the surfactant's catalytic ability. Sodium lauryl sulfate, an anionic surfactant, does not catalyze the decarboxylation.*

**Key words:** 2-cyano-2-phenylacetate, decarboxylation, kinetics, catalysis, surfactants, magnetic float.

## Introduction

A surfactant ion is amphiphilic, i.e., consists of a hydrophilic (water-loving) part and a hydrophobic (water-hating) part. As might be expected, this diversity is responsible for some rather unique properties. Aggregation of surfactant ions in water to form micelles is one of them. For the purpose of illustration, we focus our attention on the decyltrimethylammonium surfactant ion, $CH_3(CH_2)_9N(CH_3)_3^+$. The charged $-N(CH_3)_3^+$ head is hydrophilic and the $CH_3(CH_2)_9-$ tail is hydrophobic. The interior of a micelle formed when a decyltrimethylammonium salt is dissolved in water consists primarily of decyl chains and the aggregate's surface is comprised mainly of positively charged trimethylammonium groups and negatively charged counterions. This arrangement minimizes contact between the decyl chains and water while it maximizes interaction between the charged ends and the solvent. Small spherical micelles may have aggregation numbers well below fifty (Debye 1949) and large rod-shaped micelles may have aggregation numbers in excess of 5,000 (Debye and Anacker 1951).

Surfactants have many uses (Anacker 1970). Serving as a catalyst for a chemical reaction is one of them (Fendler and Fendler 1975). An example of special interest to us is that provided by Buntin, Kamego and Minch (1972). They reported that the decarboxylation of the 2-cyano-2-phenylacetate ion is catalyzed ca. 660-fold at 25.0° C by micelles of hexadecyltrimethylammonium bromide and postulated that an electrostatic interaction between the micelle surface and the substrate stabilizes the transition complex. If this be the case, structural changes in the polar heads of the surfactant ions comprising the micellar surface could influence the reaction rate. We decided to investigate this possibility.

Buntin, Kamego and Minch (1972) followed the decarboxylation reaction spectrophotometrically (235 nm) and observed that not only was the change in absorbance small during the course of the reaction but that absorbance by the surfactant catalyst interfered. Initially

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we tried to use the spectrophotometric method, but the instrumentation available to us was not suitable for the purpose. We then turned to another procedure.

The density of a liquid medium in which a chemical reaction is taking place usually changes with time. Often the change can be monitored with a float containing a small magnet sealed in its tip (Lamb and Lee 1913, Cartan and Anacker 1960). After the reaction mixture, float, and glass cell container reach the temperature of the thermostat in which they have been placed, the float is forced to the bottom of the cell by a magnetic field created by a direct electrical current passed through a solenoid located below the cell. As long as the magnetic force downward on the float is greater than the upward buoyancy force, the float will remain submerged and in contact with the cell's bottom. When the two forces are in balance, the density of the liquid medium can be calculated from the solenoid current (Cartan and Anacker 1960). In practice this "equilibrium" solenoid current is obtained by slowly reducing the current until the float breaks away from the bottom of the cell and noting the reading of an ammeter in the circuit at this time.

For a 1st order chemical reaction, which the reaction under investigation is considered to be (Thomson 1970), we may write

$$dC/dt = - kC,$$

where C is the concentration of the substrate, t is the time, and k is the rate constant. A slight rearrangement gives

$$d\ln C/dt = - k. \qquad (1)$$

We assume that for dilute solutions we can write

$$C = C_0(i - i_\infty)/(i_0 - i_\infty)$$

where $C_0$ is the initial concentration of reactant, $i$ is the equilibrium solenoid current at time t, $i_0$ is the initial equilibrium solenoid current, and $i_\infty$ is the equilibrium current when the reaction is complete. Taking the natural logarithm of each side, we get

$$\ln C = \ln [C_0/(i_0 - i_\infty)] + \ln (i - i_\infty).$$

Hence,

$$d\ln C/dt = d\ln (i - i_\infty)/dt. \qquad (2)$$

We combine equations (1) and (2) and obtain

$$d\ln (i - i_\infty)/dt = - k.$$

The indicated procedure is to plot ln ($i$ - $i_\infty$) vs. t and assign the negative of the slope of the resulting straight line to k.

## Experimental

Ethylphenylcyanoacetate (Aldrich) was converted to 2-cyano-2-phenylacetic acid (2C2P) by the method of Hessler (1904). Sodium lauryl sulfate (NaLS), decyldimethylammonium bromide (DDMAB), decyltrimethylammonium bromide (DTMAB), and dodecyltrimethylammonium bromide (DoTMAB) were taken from batches prepared for earlier studies (Anacker, Rush, and Johnson 1964; Geer, Eylar, and Anacker 1971; Underwood and Anacker 1984; Gerry, Jacobs, and Anacker 1977). The decylmethylammonium bromide (DMAB) and the hexadecyltrimethylammonium bromide (HTMAB) were prepared from mixtures of the appropriate amines and alkyl bromides in the manner described by Geer, Eylar, and Anacker (1971).

Prior to the start of a run, 0.0075 mole of surfactant and 0.23 gram of TRIS buffer, tris (hydroxymethyl) aminomethane, were mixed with 100 ml of distilled water in a beaker and placed in an oven set at 35°C. Then 1.000 gram of 2C2P (0.00620 mole) was stirred into the mixture of TRIS and surfactant. After all of the 2C2P had dissolved, the resulting solution was poured into the float cell in a constant temperature bath set at 35°C. The magnetic float, cell, cell holder and measurement procedures used were essentially those described by Cartan and Anacker (1960). The $i_\infty$ adopted in a run involving a cationic surfactant was that which led to the

highest correlation in a least-squares procedure for obtaining the best linear plot of ln ($i - i_\infty$) vs. t and its slope - k. In the run in which NaLS was present, the $i_\infty$ used was the observed equilibrium current about three weeks after the start of the reaction and when the reaction was apparently over. It did not seem appropriate to use the procedure employed in the other runs since it would have involved a very long time extrapolation.

## Results and Discussion

Figures 1, 2 and 3 are least-squares plots corresponding respectively to the run for which the highest correlation (for line of regression of ln ($i - i_\infty$) *on* t) was obtained, to the run for which the lowest correlation was obtained, and to the run for which the rate constant was the smallest. The relatively large scattering of points in Figure 2 may be due to the adherence of some $CO_2$ bubbles to the float. In all runs the float was pulled through the liquid surface to remove gas bubbles before each current reading, but not all may have been dislodged in this particular run.

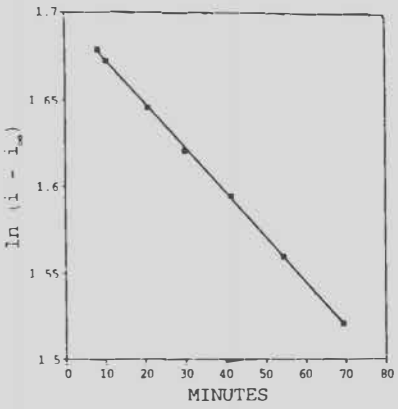


**Figure 1.** *Decarboxylation of 2 cyano 2-phenylacetate at 35°C in 0.075 M decyldimethylammonium bromide. Plotted is natural logarithm of difference between solenoid current at time t and calculated solenoid current when reaction is completed versus time.*

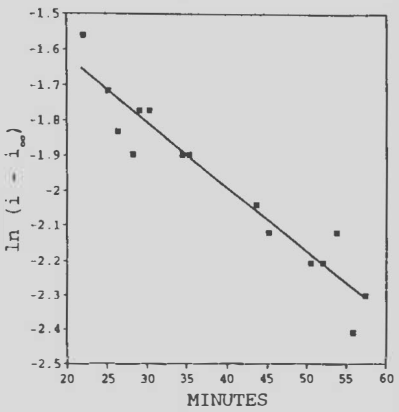


**Figure 2.** *Decarboxylation of 2-cyano-2-phenylacetate at 35°C in 0.075 M dodecyltrimethylammonium bromide. Plotted is natural logarithm of difference between solenoid current at time t and calculated solenoid current when reaction is completed versus time.*

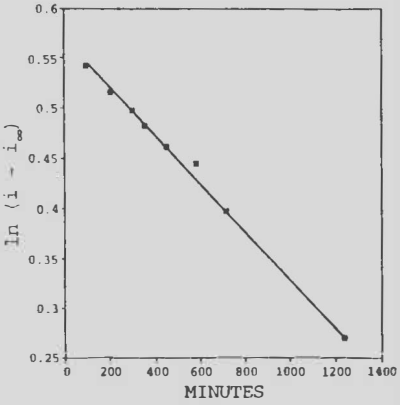


**Figure 3.** *Decarboxylation of 2-cyano-2-phenylacetate at 35°C in 0.075 M sodium lauryl sulfate. Plotted is natural logarithm of difference between solenoid current at time t and observed solenoid current when reaction is completed versus time.*

Experimental rate constants for all the runs are given in Table 1. The trends exhibited by the rate constants associated with the cationic surfactants imply that the longer the alkyl chain and the more methyl groups attached to the nitrogen of the polar head, the more

effective the surfactant is as a catalyst. This is in keeping with the observation of Dunlap and Cordes (1968) that when hydrophobic interactions between the substrate and micelle are at least partially responsible for adsorption of the organic substrate into the micellar phase, "increasing hydrophobic character of the surfactant causes increased catalysis." Thomson (1970) provided helpful insights. He represented the decarboxylation of 2C2P by

$$RCO_2^- \xrightarrow[\text{slow}]{} R^- + CO_2 \xrightarrow[\text{fast}]{H_2O} RH + OH^-$$

where R stands for $C_6H_5C(CN)H$. From observed changes in enthalpy and entropy of activation accompanying the change of solvent from water to mixtures of water with ethanol and with dioxane, he reasoned that if it is assumed that the transition state is close to the intermediate ion $RCO_2^-$ in structure, it follows that the negative charge in the transition state is considerably delocalized. Bunton, Kamego, and Minch (1972) concluded from their kinetic study of the same reaction that electrostatic interactions between the cationic micelle and carboxylate ion $RCO_2^-$ assist the incorporation of the latter into the micelle. This stabilization of the initial state would by itself result in rate reduction. However, the transition state, with its delocalized charge, interacts more strongly with the micelle. The net effect is a rate increase, as we have observed.

The ineffectiveness of NaLS as a catalyst for the decarboxylation of $RCO_2^-$ undoubtedly arises from the fact that micelles of this surfactant have a negative charge. Bunton, Kamego, and Minch (1972) also found that NaLS had no effect on the rate. They felt that this was the case because "$RCO_2^-$ should not be incorporated into an anionic micelle." This is not an accurate statement. We found that one can dissolve 1.000 gram of 2C2P in 100 ml of water at 35°C if 0.0075 mole of NaLS is present, but not in pure water. It is likely that the absence in anionic micelles of the electrostatic stabilization of the transition state provided by cationic micelles is responsible for the lack of catalytic activity.

**Table 1.** *Rate Constants for Decarboxylation of 2C2P*[1]

| Surfactant | k, $min^{-1}$ | Correlation[2] |
|---|---|---|
| DMAB | 0.0022 | 0.9995 |
| DDMAB | 0.0026 | 0.9998 |
| DTMAB | 0.0096 | 0.9959 |
| DoTMAB | 0.019 | 0.9547 |
| HTMAB | 0.028 | 0.9936 |
| NaLS | 0.00024[3] | 0.9972 |

[1] At 35°C. Surfactant concentration = 0.075 M.

[2] Linear correlation for line of regression of ln $(i - i_\infty)$ on t.

[3] Bunton, Kamego, and Minch (1972) calculated by extrapolation that the rate constant in the absence of surfactant to be $3.9 \times 10^{-6}$ $sec^{-1}$ at 33.2° C, i.e., $2.3 \times 10^{-4}$ $min^{-1}$. NaLS, indeed, is no catalyst.

## Acknowledgements

The authors extend special thanks to Montana State University for a Research Creativity Grant in support of this research, to Norman Williams for construction of the magnetic float cell holder and solenoid compartment, and to Lee David for assistance with circuit wiring.

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# Abstracts

## Biological Sciences - Terrestrial

### Response of Bitterbrush and Scouler's Willow to a Shelterwood Harvest and Prescribed Burn in Western Montana [TWS]

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In western Montana, fire suppression and selective logging in ponderosa pine (*Pinus ponderosa*) stands have resulted in conditions more conducive for shade-tolerant Douglas-fir (*Pseudotsugs menziesii*). This increase in tree density has changed the multi-resource values of these stands and altered ecosystem functions. To recreate park-like stands of ponderosa pine, shelterwood cutting and understory prescribed burning have been used as surrogates for pre-settlement ecological processes in the Lick Creek drainage of the Bitterroot Mountains, Montana. This paper, specifically, describes the response of the dominant browse species, antelope bitterbrush (*Purshia tridentata*) and Scouler's willow (*Salix scouleriana*), following a fall shelterwood cut and spring prescribed burn. On a 50 ha site, the survival, vigor and browsing intensity of 1,856 bitterbrush and 871 willow were monitored for 2 years following a fall shelterwood cut and 2 spring burn treatments. Mortality related to mechanical damage associated with the shelterwood cut was 35 percent for bitterbrush and 13 percent for willow. Mortality related to fire damage was 72 percent for bitterbrush and 19 percent for willow. Vigor was highest for bitterbrush in the logged-only treatment, whereas willow was most vigorous in the logged and burned treatments. Preferential use by wild ungulates was observed on willow in the burn units and on bitterbrush in the shelterwood harvest units.

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### Sustaining Elk on the Rocky Mountain Front: The Importance of Private Lands [TWS]

Thomas Baumeister
Boone and Crockett Wildlife Conservation Program, University of Montana, Missoula, MT

Theodore Roosevelt Memorial Ranch plays an important role in the distribution of elk on the Rocky Mountain Front, Montana. The ranch is

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

[MAS] *Montana Academy of Sciences, Helena, MT, April 1995*
[TWS] *Montana Chapter of the Wildlife Society, Billings, MT, March 1995*
[AFS] *Montana Chapter of the American Fisheries Society, Chico Hot Springs, MT, February 1995*

managed as a working cattle operation. The difference in seasonal distribution of cattle and elk allows both ungulate species to use the ranch with a minimum of competition for forage. Both the historic creation of state-managed winter ranges, current land use practices on private lands, and a conservative hunting regime have helped establish a healthy elk herd of about 500 animals north of the Teton River. Without extensive use of private lands, current elk numbers could not be maintained because public lands lack suitable winter habitats. The value of private lands as elk habitat is primarily a function of the type of land use. Livestock grazing managed below the full capability of the land to support a cattle operation throughout the year provide the most valuable elk habitat in this region. This form of ranching maintains healthy and productive grasslands that provide quality forage for both livestock and elk. Heavy use by both domestic and wild ungulates, however, has the potential to cause local overuse that subsequently may result in a reduction in quality grasslands. Sportsmen's dollars have traditionally been spent to help purchase lands on the Rocky Mountain Front to preserve habitat for elk. On these lands, modern management practices include the use of cattle to maintain quality forage production for elk. This management strategy could also be applied to existing ranching operations and may accomplish similar results without the initial cost of land purchase. Such a conservation strategy, however, requires close cooperation between private landowners and the state wildlife management agency. Some form of compensation may be necessary to provide the incentive to initiate cooperation with some private landowners. Compensation could include an expansion of the existing landowner preference program for hunting permits or tax reductions for good stewardship programs of natural resources, among others.

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## Breeding Bird Community Effects of Big Game Habitat Enhancement in Lodgepole and Ponderosa Pine Forests[1ws]

Daniel Casey
Wildlife Division, Montana Fish, Wildlife and Parks, Kalispell, MT

Point counts and cursory habitat surveys are being used to describe bird communities in forest stands being treated to increase forage production for big game. Our primary objectives are to describe and compare the presence, frequency and relative abundance of breeding species to habitat features in treated and untreated stands in order that we might better plan future efforts to meet a broader range of wildlife needs. Small (<8 ha) timber sale units in seral lodgepole pine/western larch stands along Hungry Horse Reservoir (Flathead NF) are being harvested and burned to produce shrubfields for elk forage production. Paired treatment/control points are being surveyed with 4 replicate counts per year. These units are primarily seed-tree or shelterwood cuts with retention of larger Douglas-fir, larch, and snags. We have collected 2 years of data, primarily pre- and immediately post-treatment. Along Lake Koocanusa (Kootenai NF), we are sampling in >100 larger (10-150 ha) treatment units of various (pre- and post-treatment) ages. These are

primarily in ponderosa pine/ Douglas-fir stands treated through combinations of overstory and understory removal and prescribed fire. Study design will allow comparison of the trade-offs between 5- and 10-min point counts, and 1-4 replications. This monitoring work is part of our wildlife mitigation package for the habitat losses at these two hydroelectric facilities. We hope to add a nesting/ production component to this project within the next 2 years.

## Natural and Experimental Prevalence of *Fasciola hepatica* in Lymnaeid Intermediate Hosts [MAS]

Kristi L. Dimke, Matthew C. Rognlie, Robert S. Potts and Stuart E. Knapp
Veterinary Molecular Biology, Montana State University, Bozeman, MT

*Fasciola hepatica*, the common bile duct fluke of cattle and sheep, is an economically important parasite in Montana, resulting in the condemnation of livers in 17% of cattle at slaughter. Transmission of the disease is dependent upon the presence of snails of the genus *Lymnaea*, which serve as intermediate hosts for the parasite. There are several species of lymnaeids that are found in Montana, but none have been found naturally infected with *F. hepatica*. This is probably due to the low incidence of infection in snails and the difficulty in identifying early developmental stages of the parasite in the snail using conventional methods. Recently we have developed an assay that uses RT-PCR to detect a fasciolid specific, small ribosomal subunit sequence from total snail RNA preparations, and have used this assay to test field collected snails for infection. Our results support the hypothesis that the natural prevalence of infection is low in the snail host, and we suspect that this is due to some form of resistance in snail populations. To test this, several species of lymnaeids were exposed to *F. hepatica* miracidia and tested at 6 hours and 5 days post exposure. Almost 100 percent of snails tested positive at 6 hours post exposure; however, in all but the most permissive snail, few infections were detectable at 5 days post exposure.

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## "...But Some Are More Equal Than Others:" Managing Multiple "Featured" Species Under Ecosystem Management [TWS]

Pat Dolan and Mike Hillis
USDA Forest Service, Lolo National Forest, Missoula, MT

For much of its early history, wildlife management focused on single species management. Habitat goals were determined based on our understanding of the needs of a few species, primarily game. In the last 2 decades, two changes have lead to a shift away from that approach. (1) Starting in the 1970s the number of featured species increased. Following

the passage of the Endangered Species Act, many rare or declining species were designated in some way. Other concepts emerged that led to designation of "indicator species", "keystone species," etc. On the Lolo NF there are 23 featured species (endangered, threatened, sensitive, indicator, and game species), all of which must be addressed in every project. (2) In the 1980s, many agencies adopted an "ecosystem management" approach, a two-phased approach including (a) "the coarse filter," based on the role and consequences of natural processes and (b) the "fine filter," based on the special needs of featured species. Consequences of these changes include (1) potential for conflict between plans developed separately for different featured species, (2) potential for the "coarse filter" outcome to be overwhelmed by all the identified single-species needs, (3) practical problems of integrating the "coarse filter" and many individual species in analyzing projects. In this paper, we present a process to integrate the "coarse" and "fine filter" approaches, identify and resolve conflicts, and develop a habitat-based approach for each species.

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## Lichenometric Evidence of Change in Stream Channel Dimensions [MAS]

Richard B. Keigley
National Biological Survey, Greater Yellowstone Field Station
Yellowstone National Park, WY

This study examined the possibility that the lichen *Xanthoria elegans* has recently colonized a lower zone on a segment of Soda Butte Creek in Yellowstone National Park. At two sites on the Lamar River, thallus cover diminished monotonically to the lower limit of distribution (rates: 1.1 and 1.4 % /cm respectively); thalli were submerged by up to 1.5 m of water during flood. The monotonic decline in cover percent suggests equilibration to an environmental gradient. Along a segment of Soda Butte Creek, a zone of monotonic decline (3.1 % /cm) terminated above peak stage height. Below the monotonic decline a few small thalli were evenly distributed in a zone 0.6 m wide. The upper monotonic zone was interpreted to be a relic distribution. The lower zone appears to be colonized recently enough that equilibration to new conditions has not occurred. Lichen distribution on the Soda Butte segment was interpreted to be caused by a drop in stage height due to a change in channel dimensions. Early this century, browsing by elk (*Cervus elaphus*) eliminated tall willow from the adjacent floodplain, possibly leading to an increase in erosion rate.

## An assessment of Relative Bird Abundance in two Riparian Areas with Differing Grazing Histories on the Charles M. Russell National Wildlife Refuge [TWS]

Craig J. Knowles, P. R. Knowles and M. A. Maj
FaunaWest Wildlife Consultants, Boulder, MT
and W. Haglan
USDI Fish and Wildlife Service
Charles M. Russell National Wildlife Refuge, Lewistown, MT

We conducted surveys for breeding birds in riparian zones of two perennial streams on the Charles M Russell National Wildlife Refuge in north-central Montana during June 1994. One drainage, Siparyann Creek, had a history of intensive livestock use while the other drainage, Rock Creek, had a history of lesser use including no grazing and spring-only grazing in recent years. Few trees or shrubs were present along Siparyann Creek while plains cottonwood (*Populus deltoides*) and willow (*Salix spp.*) were common along Rock Creek. Thirty bird species were observed along 15 transects in Siparyann Creek, and an average of 12.2 individual birds were recorded per transect. Thirty-two bird species were observed along 20 transects in Rock Creek averaging 20.2 individual birds per transect. Bird species associated with grasslands dominated in Siparyann Creek, while bird species associated with forested riparian habitats dominated in Rock Creek.

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## Tracking Elk Hunters with GPS [TWS]

L. Jack Lyon
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and Milo G. Burcham
University of Montana, Missoula, MT

As a part of a study of elk hunting techniques and hunter behavior, we used battery powered GPS units to record hunter locations at 15 second intervals during 29 hunting expeditions in 1993. GPS units were carried in a back pack with the antenna protruding on a short cable. At the end of the hunting day, data were downloaded to a PC and converted to UTM coordinates. Subsequent analysis within a GIS system 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 hunting technique. Hunter locations were overlaid on other GIS layers to determine time spent in different vegetation types, and topographic situations selected for hunting. In this paper we discuss logistics and limitations and present some preliminary results. Although our sample size is very limited at this time, we expect to detect differences in hunting technique between bow hunters and rifle hunters, evaluate the influence of various vegetation types and topography on hunters, and eventually develop mathematical models to predict the influence of hunter density on elk vulnerability.

## The U. S. Fish and Wildlife Service Ecosystem Approach for the Upper Missouri/Yellowstone River and Columbia River Basin Ecosystems [TWS]

Stephen Martin
USDI Fish and Wildlife Service
Benton Lake National Wildlife Refuge, Great Falls, MT

The U. S. Fish and Wildlife Service (USWS) has adopted an Ecosystem Approach to Fish and Wildlife Conservation. The Ecosystem Approach is defined as "Protecting or restoring the function, structure, and species composition of an ecosystem, recognizing that all components are interrelated." In simple terms it's an attitude - a way of thinking about the "whole" environment within a geographical area that ultimately determines how the USFWS plans and acts, in conjunction with partners, in managing biological systems and resources. An ecosystem approach will enable the USFWS to more effectively address its mission, "To conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people". The USFWS will continue to emphasize its legal mandated responsibilities (e.g. migratory birds, anadromous fish, endangered species, wetlands and the National Wildlife Refuge System). The USFWS identified 52 ecosystems across the United States. This delineation is based on U.S. Geological Survey watersheds. Two of these ecosystems occur in Montana, the Upper Missouri and Yellowstone River Ecosystem and the upper Columbia Basin Ecosystem. Ecosystem teams have been formed to develop, refine and implement the ecosystem approach. Team members include representatives from all USFWS programs to promote cross program collaboration. The Montana ecosystems teams have identified six priority issues including; 1) Biological Monitoring, 2) Outreach, 3) Habitat Restoration and Enhancement, 4) Law Enforcement, 5) Candidate T&E Species, and 6) Native Aquatic Species. Partnerships are crucial in the ecosystem approach. The USFWS recognizes it is only one of many players in any ecosystem project. We need assistance from the States and other partners to more effectively accomplish our mission. In turn, we hope to offer support to other organizations with complementary objectives. Our ability to strengthen and/or develop partnerships will be the true measure of success. We invite your comments, discussion, and involvement.

## Northern Region Landbird Monitoring Program [TWS]

Christine Paige
USDA, Forest Service, Missoula, MT
and Richard L. Hutto
Division of Biological Sciences, University of Montana, Missoula, MT

Since 1990, the Forest Service Northern Region has been developing a program to monitor birds across Forest System lands, and 1994 was the first

season of full-scale implementation. Over 6,000 sampling points were visited on 13 forests in order to examine distributions and landscape-scale habitat relationships of diurnal landbirds. Ten-minute point counts were spaced at 300 m intervals on transects along forest roads and trails. Ocular vegetation plots were conducted at each point to describe cover type and general habitat structure. Landscape relationships will be examined with the use of Landsat satellite imagery of vegetation cover in cooperation with the Montana Spatial Analysis Lab at the University of Montana.

## Studies on the Phenotypic Variability of the Fungus *Beauveria bassiana* Cultures During Pilot Scale Production [MAS]

Joanna I. Rosinska and Stefan T. Jaronski
Mycotech Corporation, Butte, MT

For the past 10 years Mycotech Corporation has been developing fungi for commercialization as insect control agents. Fungal candidates are chosen on the basis of virulence , safety for humans and non-target organisms, and satisfactory production characteristics. It is important that a fungal culture maintain its phenotypic characters, particularly those characters affecting production efficiency and efficacy. Genetic profile (RFLP or RAPD-PCR pattern) of the parent and subcultures is only one criterion for selection. Phenotypical measurements (eg. spore production, stability under different storage regimes and virulence for the target insect) also must be evaluated during commercial scale-up of a fungal product. The experiment described in this paper is part of an evaluation of phenotypic differences arising from mutation and selection during subculturing and pilot scale production of an isolate of *Beauveria bassiana.* Five slant cultures of the fungus *B. bassiana* Mycotech Strain BB726 produced by subculture from the same parent culture were evaluated for sporulation efficiency during parallel benchscale production, conidial stability at 32° C , and virulence for a target insect, the grasshopper, *Melanoplus sanguinipes.*

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## Conservation of Prairie Ecosystems in North America [TWS]

Fred B. Samson
USDA Forest Service, Region 1, Missoula, MT

This presentation reviews the status and trends of North American prairie, their endemic biota, and sums current, major conservation efforts. The largest vegetative province in North America is the native prairie, and grasses as an integral component of prairies inhabit the continent (and worldwide) in greater abundance than any other comparable group of plants. Estimates suggest that European settlement declines in native prairie range as high as 99 percent, and the potential for species loss, both plant and animal, is high. More subtle impacts in the loss of prairie, for example, loss of the highly

developed ecotypic differentiation, often go undetected. Endemism is high in prairie given the long evolutionary history of grasslands. Grassland bird species have shown more consistent and steeper, geographically widespread declines than any other grouping in North America; 55 grassland species in the United States are listed as threatened or endangered and one-third of the species considered endangered by the Committee on the Endangered Wildlife in Canada are found on grasslands. Developing ecosystem assessments and conservation strategies are difficult, given approximately 98 percent of lands historically native prairie are in private ownership. Nevertheless, the first broadscale ecosystem management effort--The Great Plains Initiative--continues with more recent initiatives by the USDA Forest Service, National Biological Survey, and Environmental Protection Agency. Over a half century has passed since Weaver (1954, North American Prairie) noted that the disappearance of a major unit of vegetation--the North American Prairie is an event worthy of recognition if not action.

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## Indicators of Plant and Grasshopper Community Composition in Montana and Colorado [MAS]

Kerri Farnsworth Skinner and William P. Kemp
USDA-ARS Rangeland Insect Laboratory, Montana State University, Bozeman, MT

Grasshopper communities in the Great Plains display broad species heterogeneity. Descriptive data on grasshopper communities are needed for grasshopper control efforts to be tailored to local differences in species composition. The project objectives were to examine differences in the plant and grasshopper communities of Montana and Colorado, and to identify factors which influence grasshopper community composition in the two states. Plant and grasshopper species were sampled at 80 sites in Montana and 90 sites in Colorado in 1992. Species proportions and percentages were analyzed using detrended correspondence analysis (DCA). Percent bare ground, litter, total cover, proportions of grasses and forbs, and plant height were not useful in distinguishing among plant communities in either state. Individual plant species DCA did detect differences among plant communities. Plant and grasshopper community compositions differed significantly between the two states, with *Buchloe dactyloides* and *Bouteloua curtipendula* distinguishing Colorado sites. Spearman rank correlations found grasshopper DCA results for Montana were correlated with percent bare ground, mode plant height, and plant species which increase with grazing. Such factors are thus important in determining grasshopper community composition, though they are not useful in distinguishing among plant communities. The value of collecting these data depends on the resolution and variables of interest.

## Daily Activity Patterns of Western Toads on the Targhee National Forest, Idaho [TWS]

Stephen R. Sullivan
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Paul E. Bartelt and Charles R. Peterson
Department of Biological Sciences, Idaho State University, Pocatello, ID

Populations of many amphibian species appear to be declining in locations all over the world, including the Pacific Northwest. For example, many populations of the western toad *(Buto boreas)* have undergone decline or local extinction throughout much of their range. Answers to questions about amphibian decline and plans to conserve species such as *Buto boreas* require knowledge of the natural history and normal behavior of healthy animals, preferably in their natural environments. With the use of radio transmitters (1.8 g, externally mounted, we conducted a focal-animal study on the daily activity pattern and movements of individual free ranging *Buto boreas*. This study was conducted during July and August of 1994 and 1995 on the Targhee National Forest, Idaho. We observed four adult male toads each year. Observation periods were three hours and occurred throughout the 24 hour day. Dependent variables included activity index (number of active minutes per total minutes), distance moved (cm per total minutes), and number of feeding strikes (strikes per total minutes). Independent variables included hour of day, air temperature, and relative humidity. Considerable individual variance existed between toads. Surface activity rate peaked between 2100 and 2400 hours. Surface activity occurred over a broad range of temperatures (-2° C to 27° C) and occurred over a broad range of relative humidity (60%-100%). Distance moved increased during the night as toads moved from a daily retreat site to water or warm substrate. Most movements took place between 5°C and 16°C with low distance movement above 16°C. Movements increased as relative humidity increased above 75 percent. Feeding strike rate peaked during mid-day and occurred over a broad range of temperatures and relative humidities.

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## Preliminary Analysis of Forest Structure Used by Flammulated Owls in a Managed Montana Landscape [TWS]

Vita Wright
Division of Biological Sciences, University of Montana, Missoula, MT

During 13 May-16 July, 1994, 593 points were surveyed for flammulated owls (*Otus flammeolus)* along 299 km (180 mi) of transect on the Bitterroot National Forest, Montana. Transects were located primarily in ponderosa pine (*Pinus ponderosa*)/Douglas-fir (*Pseudotsuga douglasi*) forest on the west side of the Bitterroot River between Lolo and Sula, Montana. Approximately 50

flammulated owls were detected along 11 transects between Darby and Sula. In an attempt to explain the distribution of flammulated owls along occupied transects, I compared forest structure data collected in 11.3 m fixed-radius circular plots centered on owl singing locations and unoccupied random plots. Flammulated owls were positively associated with the number of snags >15 in dbh, ponderosa pine trees >15 in dbh, canopy height, live basal area, and percent cover of dry forest indicator species (*Antennaria racemosa, Balsamorhize sagittata, Festuca idahoensis*). Conversely, they were negatively associated with number of Douglas-fir trees <9 in dbh, trees other than ponderosa pine or Douglas-fir, and percent cover of moist forest indicator species (*Galium triflorum, Linnaea borealis, Thilictrum occidentale*, and *Vaccinium spp.*) These variables were collectively represented by cover type, with owls using mature and old ponderosa pine/Douglas-fir forest types rather than young or moist forest types. In future analyses, I will use a Geographic Information System to determine whether broad-scale habitat variables, such as the percent of the landscape covered by each forest type, explain which transects contained flammulated owls. Results of this study are expected to provide a greater understanding of flammulated owl habitat use and provide managers with information needed to manage for this species at a variety of spatial scales.

## Humanities and Social Sciences

### The Concept of Ethnicity: What Weight is Ethnicity? [MAS]

Daniel Bonadurer
University of Montana, Missoula, MT

Where one belongs, where one can retreat, where one can find familiarity; this is one's ethnicity. The concept of ethnicity can be considered to be the an extrapolation of the family or the most basic unit of biological and social reproduction. Although identity is the central concept, it is ethnicity that often supplants this notion because it is often assigned from outside the group or from within as a response to pressures from without. With borders being questioned everyday, ethnic affiliation, with its many levels of application, becomes hyperstragetized, hyperinflated, and superimposed.

## Montana Metamorphosis - Thundering Transformation of Montana's Economy [MAS]

John M. Crowley
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Montana is undergoing a thundering economic transformation that began about 25 years ago with the country-living craze. It is still going on, but is largely unnoticed. The major driving forces of the transformation are the coal boom, the rise of remote-area enterprises, and -- most importantly -- what the author has named the "leisure boom." Dramatic changes accompanying this transformation include a general decline of traditional extractive industries, a tremendous increase in nonlabor income and self-employment, the hiring of labor to do household tasks formerly done by family members, and money spent here by would-be immigrants. To these must be added several national economic trends, which are affecting Montana as they are the rest of the nation, and some dramatic changes brought about by government. At the same time, there are structural changes in the web of cities, communications, and hinterlands. The transformation is having some adverse side effects and tends to be concentrated in a number of small areas and along certain routeways. The author proposes a wiser direction than that currently being taken by the powers that be.

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## A Futuring Approach to Alternative Development for Fish, Wildlife and Parks' Wildlife Environmental Impact Statement [TWS]

Gary L. Dusek and Scott A. McCollough
Wildlife Division, Montana Fish, Wildlife and Parks, Bozeman, MT

In 1991, Montana Fish, Wildlife and Parks (MFWP) initiated a review of its Wildlife Program. This review includes preparation of an environmental impact statement (EIS) covering all of MFWP's wildlife-related actions. This EIS is expected to provide guidance for future environmental reviews and program compliance with the Montana Environmental Policy Act. Fish, Wildlife and Parks identified 13 issues relevant to managing the state's wildlife and associated recreation. The process of developing alternatives to address these issues has taken several turns since mid 1993. The initial proposed action, intended to "manage wildlife with a focus on ecological systems...", failed to adequately address many of the issues. That process was replaced by one in which alternatives were represented along a continuum of management emphasis such as game species vs. all wildlife, public trust vs. privatization, etc. Montana Fish, Wildlife and Parks is now using scenario planning to develop alternatives that address technological, social, and economic forces that affect MFWP's decisions and actions. Some of these forces are predetermined while others are shrouded with uncertainty. These "predetermined elements" and "critical uncertainties" are the building blocks for scenarios that provide insight into what may shape a probable future.

## Comparative Analysis of Fluorescent Dye Stains for Latent Print Processing [MAS]

Amy Eaton
University of Montana, Missoula, MT

One common process for stabilizing latent prints is cyanoacrylate (Super Glue) fuming. The cyanoacrylate polymer formed via this process is an excellent base for absorbing fluorescent dyes, which may yield enhanced visualization under an alternative light source. In this study I tested the ability of four fluorescent dyes to enhance the visualization of latent prints on various types of surfaces. I tested Rhodamine, Ardrox, MBD, and RAM dyes, on four different surface types: black plastic from the base of soda containers, plastic grocery bags, clear glass plates, and treated semifinished wood panels. Two types of latent prints were tested for each combination of dye and surface: prints made with natural skin oils and prints made in my blood. Each of the dyes was effective on at least some print/surface combinations, but no single dye was effective on all such combinations. Further research is needed to completely characterize the utility of each dye.

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## Uses for Plaster Casting in Historic Preservation [MAS]

Julie Eklund
University of Montana, Missoula, MT

This paper presents a procedure for plaster casting of architectural features. I discuss my tests of various molding and casting materials, and present my recommendations for which are best. I mention some precautions regarding building and historic preservation codes. Much of the content of this research stems from the casting of an acanthus leaf design relief that was attached to a wall at the University of Montana, Missoula, and the preparation for casting a column capital from the Daly Mansion. This procedure can be especially useful for historic restoration projects because exact replicas can be produced, often from the same materials of which the original was made.

## Russian American Differential Adjustment Within the Family [MAS]

Scott M. Fitzpatrick
University of Montana, Missoula, MT

In contrast to many other ethnic groups that have maintained a relatively constant rate of immigration throughout the twentieth century, Russian-Americans are unique in that they have not experienced a continuous immigration to the United states. For Russian immigrants, this has created a

number of unique problems. The lack of central Russian-American communities, deficiency in the English language, and other disparate social problems all have contributed to a general inability to adjust rapidly to American society. The Bicultural Model attempts to examine and explain the conflicts that arise between family members and the importance of the individual variables that can promote or discourage effective adaptation, as well as the differential rates at which it occurs.

## The Hmong: Through Conflict and Transition [MAS]

James Anthony Flanagan
University of Montana, Missoula, MT

The Hmong have an extended history of resettlement, conflict, and change. Through these transitions, the Hmong have defined themselves ethnically and distinctly from other ethnic groups. The greatest challenge to Hmong ethnicity, however, has been a result of their emigration to the United States. In America they are confronted with a culture that is extremely different from their own and difficult to integrate into traditional cultural practices and values. This presentation provides a brief history of the Hmong and discusses their ethnic transitions, concentrating on their movement to America and how it has affected the elder men in their American communities.

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## Is American Ethnicity Revolting? [MAS]

Aaron Goodfellow
University of Montana, Missoula, MT

The work of Dick Hebdige demonstrates how style in subcultures is a response to changes in the socio-economic arrangements of society. Hebdige reads the text of subcultural style as an expression of identity opposed to the hegemonic culture of bourgeois capitalism. Punk style represents a running commentary on life within the cultural boundaries of society. Rereading the work of Hebdige, in light of recent anthropological work, allows the political question of identity to be explored, providing insight into the term ethnicity. By viewing style as an expression of ethnicity, anthropology can comment on the dialectic between culture and capitalism.

## Native Americans and "The" Ethnic Experience [MAS]

Scott Heron
University of Montana, Missoula, MT

By separating the last two centuries of Native American conflict into four distinct types, this paper examines the common origins, processes and outcomes of each. The commonalities, or "laws of conflict", can help anthropologists understand how and why groups that come into contact react as they do. By using historical examples, I will show how conflict itself changes not only the groups' practices, but their ethnic identity as well. This model is applicable to all conflict situations and may help us to further understand them; possibly, even predict them.

## Archaic Peoples Among the Rocky Mountains [MAS]

Russell L. Holzheimer
Department of Anthropology, University of Montana, Missoula, MT

Archaic peoples among the Rocky Mountains can be examined by looking for those things that they made and did. This report focuses on some aspects of a project aimed at documenting past human existence. We'll probably never know with certainty whether certain meanings or interpretations are true, but one can develop a model and test how reasonable an interpretation might have been. The Archaic Period dates to 6000-1000 B.C. One can present a model for the life-style of Archaic peoples during this time span based on the analysis of cultural features, burial sites, faunal and floral remains, tools, and other forms of data available in the archaeological record. It is also possible to suggest a local, regional, and areal environmental reconstruction based upon ecological data recovered. By showing the possible technological derivations of traditions that develop, a hypothesis for cultural transition during the North American Archaic Period can be made. This report establishes a general foundation for human occupation over thousands of years and characterizes the conditions for life in the Archaic Period.

## Tibetan Refugees: Politics, Religion, and Ethnic Identity [MAS]

Timothy B. Hughes
University of Montana, Missoula, MT

The considerable number of people that have fled from Tibet since the Chinese invasion in 1950 make up one of the worlds larger refugee communities. The struggle of the Tibetan people to maintain their ethnic identity in the variety of socio-political environments, represented by the many

different countries to which they have immigrated, provides a unique opportunity to examine the concepts of ethnicity and identity. The articulation of these concepts in relation to the political and religious aspects of the group, and its history, provide an informative approach to the problem of defining the concept of ethnicity.

## The Effect of Sleep Deprivation On Mental, Physiological, and Physical Function [MAS]

Jodi Kranpitz and Chad Dunn
Carroll College, Helena, MT

Many people believe sleep rest restores the wear and tear that occurs during the day. Until recently, this hypothesis has been supported by little research. The objective of this experiment is to determine the effect of sleep deprivation on mental physical, and physiological performances. Three female and two male students from Carroll College were selected to participate in the experiment. Subjects were evaluated by completing a series of 3 mental and 3 physical tests before and after sleep deprivation for a period of 24 hours. It was found that mental ability increased after sleep deprivation; Student's T-test probabilities ranged between .058 and .10. Physical ability decreased after sleep deprivation; probabilities ranged between .04 and .1494.

## Opium Dens Under the Big Sky [MAS]

Kevin J. Lyons
University of Montana, Missoula, MT

The 19th century opium dens of North America were places where Sino- and Euro-American acculturation occurred. The perceived threat of the seduction of "innocent" Euro-American daughters at the hands of "evil" China Men set the stage for contemporary drug wars. Through an examination of the historic record, the relative importance of the opium den in the Western United States illustrates that an open market for drugs results in lower rates of addiction than explicit state proscription.

## The Effect of Admixture on Race Categorization in Forensic Anthropology [MAS]

Darcy Olson
University of Montana, Missoula, MT

Forensic anthropologists are often asked to estimate race from skeletal remains. This is one of the most difficult tasks they face, and it is made even more difficult by the pervasive tendency to confuse biological race with ethnicity. Race may be estimated by visual examination of the skull or by discriminant functions analysis, wherein measurements of the skull or other bones are used in a computer-generated formula giving a score that may be used to classify individuals to one group or another. Most individuals of all races are, in reality, of mixed ancestry. Societal rules tend to classify mixed individuals with whatever non-white race predominates in their ancestry. The effect of such admixture on discriminant functions analysis has been little studied. Using measurements of "pure" Native Americans (Sioux), "pure" Whites, and mixed Sioux/White individuals recorded in databases collected by Franz Boas in the 1800s. I found that individuals who are less than 7/8 "pure" score randomly on discriminant functions for race.

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## A Mindworks Exhibition as a Model for Informal Education on a University Campus [MAS]

Coleen Rarlsen, Shannon Rirkwood, and M Gershon Bulgatz
Montana State University-Billings, Billings, MT

Formal education is the dominant aspect of learning on a university campus and emphasizes the abstract and artificial. Life relates thoughts and feelings to behavior in a natural setting and can be called informal. The university competes with life. This problem has been recognized and one alternative model is an interactive exhibit based on non-linear processes. How prevalent and viable is such a model? A survey concerning these and other questions were sent to psychology departments in the United States. Forty-one out of 148 were returned. One hundred percent had no knowledge of an interactive exhibit on a university campus. The respondents felt that an interactive exhibit could be used best for class projects and community service. Connections with other departments on campus could be done thoroughly showing that psychology is embedded in other fields, similar methods are invoked in different disciplines, informal contact can occur, cooperative exchanges can take place and it can connect to the community. The interactive exhibit is not prevalent but is useful and seems adaptable to a variety of needs. The interactive exhibit is an informal place that generates enthusiasm and creativity.

## Flaked Stone Artifacts from 24GN13, a Historic/Prehistoric Site in the Northern Rocky Mountains [MAS]

Brenda Reed
University of Montana, Missoula, MT

Site 24GN13 lies within the Northern Rocky Mountain physiographic province. Historic and prehistoric artifacts are present within the site's boundaries, as is 24GN167, the Hogback Homestead cabin. The prehistoric artifacts include flaked stone tools, blanks, preforms, and lithic debitage. Projectile point types suggest repeated use of the site from the Late Paleoindian through Late Prehistoric or historic periods. Projectile points are potentially assignable to types associated with the Columbia Plateau, Great Basin, or Great Plains culture areas. A Northern Rocky Mountain sequence may also be represented. The variety of artifacts at 24GN13 suggest that the site was a campsite at which the occupants pursued a variety of activities. The material may reflect both women's and men's activities. Obsidian is present. Most of the sourced samples came from Timber Butte or Bear gulch, both in Idaho. Comparisons of the relative percentages of material types at 24GN13 with those at nearby sites demonstrate statistically significant inter-site differences that might be archaeologically meaningful. The possibility that thermally altered (heat-treated?) materials were flaked at the site deserves further investigation.

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## Watchable Wildlife Program in Ecosystem Management [TWS]

Deborah Richie
The Nature Conservancy, Missoula, MT

Wildlife viewers continue to represent the fastest growing group of wildlife recreationists. From 1980 to 1990, participation in wildlife viewing away from home increased by 76 percent in the Mountain West. Watchable wildlife as a program to address the recreation, conservation, and educational aspects of wildlife viewing continues to gain momentum as well. Montana published one of the first wildlife viewing guidebooks in 1990, with sites marked by binocular logo road signs. To date, there are 18 state guidebooks, with 10 more on the way and a revised Montana edition planned for Spring, 1995. Each marked viewing area represents a "teachable moment" for concepts key to the understanding of ecosystem management. Watchable wildlife is a significant tool to convey ecosystem management principles in a lively, interpretive way at influential moments (i.e. while watching a bald eagle feasting on kokanee). The selection of wildlife viewing areas and choice of interpretive messages are especially critical. Charismatic megafauna sites (bighorns, elk, deer) attract viewers and can be a focal point for exploring the strands of an ecosystem. Enigmatic minifauna sites (frogs, bats, butterflies) offer infinite possibilities from the amazing role of

pollinators to the effects of global climate change. Finally, whole community sites, such as tallgrass prairie or cottonwood river bottom, can yield interpretation of interlocking landscapes. Watchable wildlife also goes beyond "sites" to holistic programs. The Lolo National Forest's program carries biodiversity themes to people of all ages via school talks, naturalist walks, wayside exhibits, nature trails, canoe trails and songbird educational trunks. The trick to making ecosystem management "real" is to take the esoteric and make it simple and connected to a wildlife viewing experience in a natural environment. Sound science and creative interpretation can be powerful partners.

## The Efficacy of Hypnosis on Pain Reduction [MAS]

Natalie Roe
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The use of hypnosis to reduce the intensity of pain has been well-documented in both research and applied settings. This experiment was performed to determine the effect of hypnotic induction on the perception of pain and to establish whether or not the researcher could learn to effectively hypnotize subjects. Nineteen college students volunteered to be hypnotized, or to participate as a control subject. In the experimental situation, subjects were exposed to hypnotic techniques and then pricked with an acupuncture needle. The control subjects were exposed to a reading on hypnosis and then pricked with an acupuncture needle. All subjects indicated their perception of pain on a pain perception rating scale. Data were classified into pain vs no pain categories. Chi-square analysis ($df=3$, $X^2=9.6$) indicated that hypnotized subjects experienced pain less frequently ($p<.05$) than non-hypnotized subjects.

## Contracting for Recovery of Endangered Species [TWS]

Greg Schildwachter
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In the debate over reauthorization of the Endangered Species Act, few professionals have considered additional or alternative strategies to a federal program for preventing extinction. The federal Endangered Species Program is the dominant approach, but it could be supplemented with any strategy that successfully organizes and uses the necessary labor, habitat, and information. An additional strategy may be to enable people to organize the effort privately, through contracts among citizens, private recovery firms, and landowners (i.e, people who control labor, habitat, and information necessary for recovering endangered species). The feasibility of this approach is affected largely by the cost of establishing and executing

contracts (i.e., the transaction cost); therefore, I used Contracting / Transaction-cost economic analysis to study contracts for conservation. Conservation agents included: U.S. Department of Agriculture (Conservation Reserve Program), Delta Waterfowl Foundation, Colorado Division of Wildlife (Ranching for Wildlife), The Nature Conservancy, Defenders of Wildlife, and U.S. Fish and Wildlife Service (Red Wolf Recovery Program). Transaction costs in these contracts are affected most by the definition of the product or service purchased from landowners: more specific definitions are more costly to measure. For example, purchasing the service of determining only the presence of a species is less expensive than purchasing the service of maintaining a certain level of population viability. In some situations, the extra cost of measuring population viability may be covered willingly. Additional factors influencing the terms of contracts include: the number of landowners involved, the type of contract (i.e., handshake agreement, easement, or fee-title purchase), and the state of technology in wildlife science. Franchising may be an acceptable way of authorizing private firms to handle endangered species. Firms offering to purchase a public management franchise would need to: (1) demonstrate competency; (2) agree to follow certain performance guidelines; and, (3) purchase from the government the legal authority to handle endangered species.

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## How Children Score on Discriminant Functions Designed for Adults [MAS]

Randall R. Skelton
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Forensic anthropologists attempt to determine the identity of individuals from skeletal remains brought to them by law enforcement agents. One aspect of personal identity is sex, which may be estimated by visual and metric methods. The standard metric technique for estimating sex is discriminant functions analysis. Existing discriminant functions for sex are designed to be used with adults. The question of how well they work with children has not been adequately explored. I constructed a discriminant function for sex using 7,428 adults from the Boas Anthropometric Data Set, and used the function to estimate sex for 6,102 children from this data set. The accuracy was about 50% for people 12 and under, about 90% for people 19 and older, and increased in a nearly linear fashion between ages 12 and 19. The function scores small people as female. I tried three methods for compensating for the effect of size, without success.

## Haitians: Ethnic Maintenance Through Ethnic Baggage [MAS]

Matthew A. Tornow
University of Montana, Missoula, MT

Despite the fact that many culturally unique peoples living in the United States have been subject to coercive assimilation, many have succeeded in preserving their ethnic identities. Haitians in the United States provide an excellent example of how ethnicity can be preserved through the expression and utilization of multiple ethnic identities. The examination of the Haitian population, and the different ways in which Haitian ethnicity is expressed by members of the group, provides insight into the phenomenon of ethnic preservation through the use of multiple ethnic affiliation.

## Ethnogenesis and the Metis [MAS]

Joseph Trottier
University of Montana, Missoula, MT

During the sixteen hundreds, the Algonquian tribes that inhabited the Great Lakes Basin developed an alliance with the French that offset the Iroquois-English pact. Relationships between French men and Native women produced a culture we now label "Metis". Through various modes of transportation, the Metis people adapted to the prairie-plains region of North America. Geographic mobility, crucial to the fur trade, was essential to the ethnogenesis and maintenance of the Metis identity. Centered along the Red River area of present day Manitoba, North Dakota, and Minnesota, the Metis culture is a synthesis which has developed into a singularly unique identity and way of life.

## The Basque: Ethnic Preservation Through Language [MAS]

Christopher C. Wahlfeld
University of Montana, Missoula, MT

The concept of ethnicity has played a very important role throughout the world in the last three decades, and will continue to do so well into the twenty-first century. But without an understanding of how, and why, groups maintain their individual ethnic identities, the concept remains ill defined and, consequently, poorly understood. The Basque community of the American West illustrates two important aspects of an understanding of the concept of ethnicity: language and comfort. Not only are these aspects of ethnicity important to the maintenance of the group, but they are also ethnic markers which are essential to the group's preservation.

## Mothering Strategies in *Pan troglodytes* and *Homo sapiens* [MAS]

Jennifer Yoneji
University of Montana, Missoula, MT

This study applies information gained from primatological studies to the development of mothering strategies for human mothers. Because the nature of the mother-child relationship is critical in the development of a child's self-esteem, which, in turn, impacts the nature of society as a whole, it is essential that women have access to as many sources of guidance and support as possible in their roles as mothers. The choice of *Pan troglodytes* as a model for human behavior is substantiated by the high degree of correlation between the psycho-physiological attributes of chimpanzees and *Homo sapiens*. Comparison of the behavior of two chimpanzee mothers from the Gombe National Park in Tanzania with the behavior of twenty-five human mothers, as reflected in a mothering survey, reveals that principles of effective mothering can be derived from chimpanzee behavior. The principles modeled by successful chimpanzee mothers are patience, love, firm discipline, and active involvement with the child.

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## Retaining Skeletal Information through the Use of Plaster Casting Before Repatriation [MAS]

Wendy Young
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Herein I explore the possibility of applying plaster casting techniques to problems involved with repatriation of skeletal remains. I propose that plaster casting can be used to help retain information that may be lost during the repatriation process. I focus on what the Native American Graves Protection and Repatriation act is, who it effects, and the controversy surrounding it. I discuss the importance of retaining information inherent in skeletal material, how plaster casts can help in retaining a record of this information and what some members of the Native American community think about the casting of human remains.

# Molecular Biology

## Site-specific scission of *E. coli* Ribosomal RNA by Aminophenantroline Linked to the 3' end of Transfer RNA [MAS]

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In order to study the interaction between the 3'- end of tRNA and rRNA, aminophenanthroline was linked to the adenine nucleotide at the 3' end of E.coli transfer $RNA^{Phe}$. This was done via a phosphoramidate linkage. The "modified" tRNA was then bound to 70S ribosomes under conditions described by Moazed and Noller (Cell, vol 47, 985-994,1986). Under reducing conditions and in the presence of $Cu^{2+}$ the phenanthroline caused site-specific cleavage(s) of the 23S RNA. The positions of these sites were determined using primer extension analyses. The cleavages were found to be within a 10 Å "sweep" of the modified nucleotide. The data presented indicate that chemical nucleases, such as phenanthroline can be used to study biomolecular interactions and determine rRNA neighborhoods of ligands bound to the ribosome.

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## Gamma/Delta T Cells Defined By A New Lineage Specific Monoclonal Antibody (mAb) [MAS]

Ward Jones, Mark Jutila, and Bruce Walcheck
Veterinary Molecular Biology, Montana State University, Bozeman, MT

In the mid-1980s a new T cell subset was described based upon a unique T cell receptor (TCR). The new TCR, termed gamma/delta, is expressed on an unusual population of T cells. In humans, gamma/delta T cells comprise 2-5 percent of circulating lymphocytes. However, in bovine, gamma/delta T cells can comprise up to 80 percent of the lymphocyte population. Gamma/delta T cell function is not fully understood. They appear to be one of the more ancient immune cell types and possess some myeloid-like characteristics. These T cells are found in non-lymphatic tissues such as the intestinal mucosa and skin. Due to their unusual location, it is thought that gamma/delta T cells may play a role in the "first line of defense". We demonstrated, by FACS analysis and polyacrylamide gel electrophoresis, a lineage specific 220kD epitope on gamma/delta T cells that is distinct from other known cell surface markers. Upon mitogen stimulation, this marker regulates differently than other known cell surface markers on gamma/delta T cells. Finally, *in vivo* and *in vitro* data suggest that virtually all circulating gamma/delta T cells express the 220kD antigen while tissue gamma/delta T cells appear to down regulate the expression of this marker.

## Recombinant Vaccines to Prevent Gonorrhea: Maltose Binding Protein/Gonococcal Antigenic Peptide Protein [MAS]

Douglas C. Marchion
University of Montana, Missoula, MT

Gonorrhea, with up to a million new cases each year, is one of the most reported communicable diseases in the United States. Of particular concern is an increasing incidence of gonorrhea infection among inner city youths. Vaccine trials using major outer membrane components of *Neisseria gonorrhoeae* have proven ineffective due to the immunogenic dominance of variable sequences in comparison to the weak immunogenicity of conserved sequences. We propose to use conserved immunorecessive sequences in a recombinant vaccine. To test that an immunorecessive invariant peptide will elicit protective antibodies, a fusion protein was constructed using the pMAL-CR1 Vector System, which fuses maltose binding protein of *Escherichia coli* with a conserved surface exposed antigenic peptide of the multiple transferable resistance 44,000 dalton protein (MtrC) of *Neisseria gonorrhoeae.* This system, which efficiently produces fusion proteins that can be purified in a single step, provides the opportunity to generate antibodies to specific, conserved, immunorecessive outer membrane peptides. Antibodies to these peptides will be used in assays to determine their ability to bind native protein and to kill gonococci. Ultimately, peptides identified in these studies will be used for immunoprophylaxis against *Neisseria gonorrhoeae.*

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## Partial biochemical and functional characterization of gamma delta T cell receptor antibiotics [MAS]

E. Wilson, M. Jutila, G. Perry, G. Watts, and B. Walcheck
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The functional role of gamma delta T cells in infectious disease is enigmatic. Gamma delta T cells have been shown to be important in experimental listeriosis, leishmaniasis and malaria; gamma delta T cells have also been shown to be toxic for cells infected with herpes simplex virus and tumor cells. In new born ruminants, gamma delta cells comprise up to 70 percent of total of lymphocytes, indicating that these cells are vital to the ruminant immune system; although actual function of the gamma delta T cell in new born ruminants remains unclear. We have generated antibodies with specificity for the bovine gamma delta T cell receptor (TCR), both pan TCR and subset TCR. Specificity of these antibodies was determined by flow cytometric and biochemical analysis, the ability of these antibodies to simulate T cell proliferation was determined, as well as immuno-histologic staining to determine the tissue specificity of various TCR subsets. These antibodies may serve as useful probes for analyzing the functional importance of gamma delta T cells in newborn ruminants.

## Studies of Lysosomal Membrane Protein Functions Using Transgenic Mice [MAS]

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and J. D. Coffin
McLaughlin Research Institute for Biomedical Sciences, Great Falls, MT

Transgenic mice have been employed to study the function of a number of proteins by either expressing a protein in excess of normal (gain of function) or eliminating expression (loss of function). The functions of the lysosomal membrane glycoprotein lgp-B are not known, although this protein is both abundant and highly conserved in mammals. We have generated mice transgenic for the hamster lgp-B cDNA and are examining the mice for expression of this hamster protein. In addition, mice without a functional lgp-B gene (knockouts) are being developed for loss of function studies.

## Introduction of Dam DNA methyltransferase into *Drosophila* for *in vivo* chromatin mapping [MAS]

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Montana State University - Billings, Billings, MT

We have introduced the *Escherichia coli* dam gene for DNA methytransferase into *Drosophila* to determine if patterns of methylation can be used to map chromosomal structure *in vivo* in *Drosophila*. This approach has been successful in yeast. The dam methylase gene was cloned into a pUAST vector, which is designed to direct GAL4 dependent transcription of inserted genes in transgenic flies, and introduced into *Drosophila* by P-element mediated transformation. We obtained ten individual lines containing insertions of the dam methylase construct. The extent of methylation was checked directly by cleaving *Drosophila* genomic DNA with enzymes which have differential sensitivity to methylation. The extent of methylation was estimated in EtBr stained gels by comparison to digests of *in vitro* methylated *Drosophila* genomic DNA and of genomic DNA from flies which do not contain a methylase construct. The methylase is active *in vivo* in four out of five lines tested so far. We have examined the extent of methylation at three housekeeping genes, one at a euchromatic locus (Prat), and two at heterochromatic loci *(light and rolled)* on Southern Blots. The *Prat* locus shows high levels of methylation in all active methylase lines. The heterochromatic loci also show high levels of methlylation in lines with high methylase activity. However, in lines which have low methylase activity, there appears to be selective decrease in methylation at heterochromatic loci. These results suggest that the dam methylase system may be a powerful *in vivo* tool to map chromosomal structure.

# Neurosciences

## Role of Central Amygdaloid Nucleus In the Hypothalamic-Pituitary-Adrenal Activation Associated with the Onset of Diabetes Mellitus [MAS]

Bret F. Bessac and Craig A. Johnston
Department of Pharmaceutical Sciences, University of Montana, Missoula, MT

The central amygdala nucleus (ACe) has been indicated to be involved in the secretion of adrenocorticotropic hormone (ACTH) and glucocorticoid negative feedback of ACTH, in awakening and various acute stressors. The chronic stress of untreated diabetes mellitus (DM) altered ACTH and glucocorticoid secretion. Therefore, streptozotocin induced DM in rats was used as a model to examine the ACe involvement with ACTH secretion during chronic hyperglycemic stress. Bilateral lesions of the ACe decreased ACTH concentration in plasma of diabetic rats (LD) compared to ACe lesioned non-diabetic (LC), control (C) and nonlesioned diabetic (D). An intravenous injection of 0.5 microgram corticotrophin-releasing hormone caused an equivalent increase of ACTH in all the groups with the LD rats ACTH remaining lower than the other rats; LC, C, & D. The lower level of ACTH in lesioned diabetics might implicate the ACe in overriding glucocorticoid negative feedback in chronically stressed rats.

## Postnatal Binge-like Alcohol Exposure Can Cause Thinner Myelin in Rat CNS [MAS]

D.E. Phillips, S.K. Krueger; and L.A. Schubloom
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We have previously demonstrated that postnatal alcohol exposures in the rat (third trimester human equivalency) delay the acquisition of myelin and cause thinner myelin. The present study provided a "binge-like" exposure to alcohol during that same time frame to determine if such an exposure, limited in time but of a high concentration, would produce similar effects and if so, to determine if any temporal windows of vulnerability could be correlated with known developmental events associated with myelination. Rat pups were artificially reared from postnatal days (P) 4-11. Control animals were provided a gastrostomy-fed artificial diet in 12 daily feedings, given over 20 minutes every 2 hours. Experimental animals were provided the same diet except dietary ethanol (15%v/v) was included in two successive feedings on P9 and P10. Blood alcohol concentrations following such an exposure averaged 392 mg/dl. Optic nerve tissues from animals at P15 & P20 were prepared for light and electron microscopic study. Brain weight was decreased by

approximately 10 percent at P15 and approximately 5 percent at P20. The following effects were present in optic nerve of alcohol-exposed animals compared to control animals at P15: the cross-sectional area of the nerve was reduced by approximately 15 percent; the myelin was thinner at larger axon diameters, based on regression line analysis; and, the overall ratio of myelin thickness to axon diameter was reduced. The number of myelinated axons per unit area, axon diameters, and the number of glial cell nuclei per cross section were unaffected by the alcohol exposure. There was a subtle trend toward the same effects at P20 but the differences were generally not statistically significant. Thus, even a relatively limited "binge-like" ethanol exposure on P9 and P10 in the rat can cause effects on myelin acquisition and maturation in optic nerve similar to, but more subtle, than those from a more chronic third trimester equivalency exposure.

## Ultrastructural Analysis of b-Amyloid, Islet Amyloid and Prion Protein Induced Cell Death in Cultured Neurons [MAS]

John A. Watt
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and Carl W. Cotman
IRU Brain Aging, University of California, Irvine, CA

Previous investigations have demonstrated aggregated, but not soluble, synthetic b-amyloid (Ab) may induce cell death in cultured neurons via programmed cell death, or apoptosis. Aggregated Ab is characterized by a secondary b-pleated sheet structure which may contribute to its toxicity. In order to further explore the role of b-pleated sheet 2° structure in neuronal toxicity, we undertook a comparative ultrastructural morphological analysis of three peptide aggregates that share the b-pleated sheet configuration, Ab (23-35), prion protein and islet amyloid. Scanning electron microscopic analysis of Ab (25-35) treated cultures revealed limited somal blebbing as early as 4 hrs following treatment and continued to increase in occurrence throughout the 24 hr experimental period. Blebbing occurred globally on an affected cell and did not appear restricted to sites of visible amyloid contact. Ultimately, continued blebbing resulted in somal fragmentation into multiple apoptotic bodies. Transmission electron microscopic analysis of all three peptide treatment groups revealed distinct chromatin condensation and nuclear fragmentation, prominent cytoplasmic vacuole formation, dispersal of polyribosome rosettes and the disappearance of the golgi complex, smooth endoplasmic reticulum and microtubules with increased cytoplasmic electron density. Reduced numbers of mitochondria and cisternae of rough endoplasmic reticulum remained intact throughout the process of cell death. These structural alterations are consistent with earlier morphological descriptions of apoptosis suggesting that all three peptides share a common mechanism of programmed cell death in which the b-pleated sheet configuration may play an important role.

# Pharmacology and Toxicology

## Pesticide Control: The Method of Michel with an Emphasis on Quality Control[MAS]

A. Abentroth
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The use of pesticides, especially organophosphate pesticides, causes different adverse effects in human applicators. Most of the symptoms are due to inhibition of the enzyme cholinesterase. There are several methods that are used to determine these drops in cholinesterase levels. The Montana Department of Health and Environmental Sciences uses a modification of the Method of Michel that measures change in pH of human plasma samples to determine cholinesterase levels. During the 1994 field application season, two new quality control sessions were added to ensure more accurate results and these proved to be helpful. However, this study suggests additional changes including the involvement of more applicators. The program, if run correctly, could protect the health of many Montana pesticide applicators.

## Effects of Trimethyltin on C6 Gliomax[MAS]

V. Hardy and C. Eyer
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Trimethyltin (TMT) is a potent neurotoxin. Symptoms manifest in 48 hours. The rat C6 glioma cell line was used as a glial cell model of TMT toxicity. Three indices: morphological change, cytotoxicity, and generation of reactive oxygen species (ROS) were investigated. Morphological changes were observed over a 72 hr period with 2.5 mM and 5 mM TMT showing changes at 48 hrs and 24 hrs respectively. These changes involved cell swelling, loss of processes, and loss of adhesion to culture flasks. Concentrations of 5mM and higher of TMT showed time and concentration dependent increases in cytotoxicity up to 72 hrs. A concentration of 5 mM TMT increased the intracellular levels of ROS by 24 hours, but 2.5 mM TMT did not produce any increase in ROS after 72 hours. A cytotoxic concentration of TMT (5 mM and higher) produced morphological changes and increased ROS at times prior to detectable cytotoxicity. Trimethyltin also produced morphological changes at times and concentrations that did not increase ROS and were not cytotoxic.

## Relating Autogenic Biofeedback-Assisted Relaxation and Migraine Treatment[MAS]

Emily Nevin
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This study attempts to establish autogenic biofeedback training as a possible non-pharmaceutical treatment for migraine. The approach is to show that both autogenic training and prescribed medications share a common effect upon the autonomic nervous system. Since the abnormal biphasic event of vasoconstriction followed by vasodilation is recognized as the precursor of a migraine episode, both treatments should alter the activity of the vascular system. Hand temperature is directly related to peripheral blood flow, and given that peripheral circulation is controlled entirely by the autonomic nervous system, a change in hand temperature can be used as a convenient indicator of the state of the system. It is therefore proposed that if hand temperature is decreased in both forms of treatment, both treatments share a common effect on the autonomic system. The work is designed to be completed in two phases: 1) In conjunction with normal medication procedure at a medical clinic, hand temperature changes are monitored by a registered nurse; and 2) volunteer female high school students will be monitored for hand temperature while participating in Autogenic Biofeedback Training. The training involves listening to a formatted relaxation and imagery tape which utilizes abdominal breathing, autogenic phrases and general relaxation techniques.

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## Serotonergic Receptor Binding of the Natural Product Parthenolide [MAS]

John T. Weber, Ethan B. Russo, and Keith K Parker
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Serotonin (5-HT) receptors are thought to play roles in the pathology of migraine headache. Of the multiple 5-HT receptor subtypes known, 5-HT1 and 5-HT2 receptors are targets for the acute and prophylactic treatment of migraine, respectively. In this preliminary study, 5-HTla and 5-HT2 receptors were utilized as targets for parthenolide, a major component of European Feverfew. Feverfew has been successfully used as a folk remedy for migraine, and has been shown to be a clinically relevant treatment in controlled studies. The 5-HTla receptors from rabbit brain were labeled with the specific agonist, [$^3$H]-8-OH-DPAT. While known 5-HTla agents such as spiroxatrine and buspirone displace this agonist in a concentration-dependent fashion, parthenolide is without activity. Rabbit and rat brain 5HT2 receptors were labeled with the antagonist, [$^3$H]-ketanserin. Methysergide and mesulergine displace this binding in a fashion consistent with published potencies. Parthenolide also displaces ketanserin binding in a concentration-dependent fashion, but weakly ($IC_{50}$ of about 0.1 mM). A crude,

highly polar extract of Feverfew was shown to be capable of displacing ketanserin, suggesting that some component other than the non-polar parthenolide may be the active agent. Identification of the p rmacologi al sites of action for Feverfew awaits further investigation.

## 5-HT1A Receptors: A Comparison of Ligand Binding in Rabbit, Rat, and Human [MAS]

John T. Weber, Sue Wilson, and Keith K Parker
Department of Pharmaceutical Sciences, University of Montana, Missoula, MT

Serotonin (5-HT) exerts its actions through a group of receptors in the central nervous system. These receptors have been characterized pharmacologically and are classified into seven subtypes. One of the first subtypes identified, 5-HT1, is represented by five divisions (5HT1a,b,d,e,f). 5HT1a has been analyzed in several mammalian species including rabbit, rat, and human; it has never been fully characterized in rabbit. The current study compares the characteristics of the 5HT1a receptor in rabbit brain to those in rat and human. A selective agonist, 8-OH-DPAT, is at 5HT1a and is used in the characterization of this receptor. [$^3$H]-8-OH-DPAT binding was analyzed in rabbit and rat brain and in Chinese hamster ovary (CHO) cells transfected with clonal cDNA for the human 5-HT1a receptor (gift from John Raymond, Duke). Specific, saturable binding was observed with Kd values of 1. 1, 0.8, and 0.6nM for the rabbit, rat, and human receptor, respectively. To further investigate the receptor, displacement studies were conducted in which drugs with known activity (i.e. buspirone, propranolol) competed for binding with [$^3$H]-8OHDPAT. Ki values for each of the competing drugs were similar across the three species. These results suggest that the 5-HT1a receptor in the rabbit brain shows comparable characteristics to that in rat and human.

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