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T he 2004-2005 staff presents the fourth edition of The University of Texas at Austin Undergraduate Research Journal (URJ). This year's edition was the result of hard work and diligence, both by the authors themselves and the editorial staff. The URJ is in constant development, both structurally and creatively. This year was a breakthrough for us in terms of the way we promote the URJ and how we function as an organization on campus. I hope that this year proves to be the foundation that will be built upon in future years, leading the URJ to success.

I would like to thank Dr. Sarah Simmons, Ms. Annie Elderbroom, and Dr. Jonathan Koehler for their endless guidance and support over the year. Through countless meetings and conversations, they provided expert advice and emotional support. The editorial staff is extremely grateful for the opportunity to work with such passionate individuals.

This year of publication proved to be extremely different from previous years, and we can see the result in the published articles of this URJ. These selected authors were involved in tough competition to be published, and they deserve to be recognized for their outstanding research and creative thought. The chosen articles will show our readers how diverse the University of Texas campus is and what the undergraduate student body is capable of. I know that there is still much research out there that has not been tapped by our publication, and readers should expect great things from the Journal in upcoming years. I hope that as you read the URJ, you will obtain a greater appreciation and understanding of the work being performed by undergraduates on this campus.

The URJ is always looking for quality research articles to publish and more talent for our editorial staff. Please visit our website at *http://www.utexas. edu/student/urj* for more information.

Sincerely,

Jessica L Miller

Jessica Miller, Editor in Chief
URJ Editorial Staff

Contents

The Effect of Religiosity and Music on Sexual Anxiety in College Students

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Abstract

This study examines the effects of musical ambiance and religiosity on overall sexual anxiety among college students by using a slightly modified version of the Sexual Anxiety Inventory.[9] Results indicate that a significant difference in overall sexual anxiety exists between religiously practicing and nonpracticing individuals, thus making religiosity a powerful predictor of sexual anxiety in multiple scenarios. On the other hand, different musical ambiances did not appear to impact students' sexual anxiety significantly, implying that music alone may not be strong enough to fundamentally influence an individual's sexual mood. Unlike previous research, this study looks at a variety of sexual scenarios to determine an overall measure of sexual anxiety as opposed to simply

looking at attitudinal differences towards pre-marital sex. This provides a comprehensive insight into the sexual tendencies and behaviors of college-aged individuals. The information gained is a necessary prerequisite for the creation of prevention strategies to minimize negative effects (STD transmission, unplanned pregnancies, etc.) from otherwise potentially risky sexual behaviors (oral sex, group sex, etc.).

Introduction

Factors possibly affecting sexual anxiety among young adults and adolescents have been a topic of great interest for social psychologists seeking to understand and prevent alarming STD rates, teenage pregnancy rates, and sexually irresponsible behavior (e.g., reduced condom use, promiscuity, etc.). Two such factors studied have been the media and religiosity. A good amount of research has been conducted to determine whether religiosity influences sexual anxiety and attitudes in adolescents and adults with results indicating it is a strong predictor within those groups.[16] However, research seeking to evaluate whether religiosity is also a factor impacting sexual anxiety in emerging adults (e.g., college-aged individuals) is lacking. Additionally, the few extant studies focusing on the effects of media on sexual beliefs and behaviors have mainly examined sexually explicit music videos and television. Consequently, there is a deficient base of empirical research regarding the effects of music on sexual beliefs and behaviors.[11, 21, 4] In an age where IPODs are becoming more prevalent and MTV is airing less music videos, music alone merits attention as a possible factor influencing sexual anxiety.

This study attempts to assess the effects of music and religiosity on college-aged individuals' sexual anxiety. College students comprise a noteworthy sub-population to study because many are beginning to live on their own without the supervision of their parents and are surrounded by increasingly liberal environments. This increases their freedom to experiment with a myriad of sexual activities, and consequently, this age group appears to be the most accepting of frequent casual-hookups.[13] College-students, therefore, deserve special attention to

determine the strongest factors influencing their drop in sexual anxiety as a group.

Researchers focusing on the media analyze its effect via three theories: the Agenda Setting/Framing Theory[12], Cultivation Theory[5], and Cognitive Social Learning Theory.[23] As summarized by Brown (2002), "[The media] keeps sexual behavior on public and personal agenda, [it reinforces] a relatively consistent set of sexual and relationship norms, and [it] rarely [includes] sexually responsible models."

The Agenda Setting/Framing Theory proposes that the media influences people's beliefs about what is important in the world and how to think about certain events, people, and topics.[12] Iyengar (1991) explains that, "The result often reinforces stereotypes and helps define what is considered appropriate and inappropriate behavior in the culture." On the other hand, Cultivation Theory proposes that the media's powerful role as a societal storyteller helps spread the patterns of relationships that maintain and keep social order running. The theory helps explain how individuals with diverse backgrounds end up with shared sets of perceptions and expectations about societal norms.[5] Lastly, Cognitive Social Learning Theory suggests that people imitate models of behavior that have been rewarded or gone unpunished. It contends that people exposed to media depicting individuals enjoying sexual behaviors and rarely dealing with negative consequences will imitate these kinds of behaviors.[3] This theory could help explain why some individuals are reluctant to use condoms or engage in other safe-sex practices.

Although earlier studies focus on the effect of music videos on decreased sexual anxiety and increased sexual behaviors,[4, 6, 21] one should note that the study we present only explores music as a possible contributor to sexual anxiety. Therefore, the findings of the music video studies may not be entirely indicative of what we should expect with music because music videos have an added visual component. However, the underlying logic driving research based on music alone is derived from Rosenfeld's (1985) study confirming that the mood-altering effects of music make individuals more susceptible to attitudinal and behavioral changes.

Further support appears in Ballard and Coates' (1995) study which showed that lyrical content has an increased impact on people's beliefs and attitudes when the music sets a particular mood.

In addition to research on the media, a vast number of psychologists have focused on religiosity as a possible factor contributing to sexual anxiety and behaviors in adolescents and adults.[13, 14, 16, 20, 24] Degree of religiosity was the most accurate predictor of sexual attitudes and behaviors in high school students, even when controlling for age, parental education, availability of romantic partners, and race.[14, 20] Additionally, although some believed that traditional adherence to anti-premarital sex laws was eroding with time, there is growing support that religion still hinders sexual activity and attitudes amongst unwed, religious adults.[10, 13, 16]

The most commonly used theories to support religiosity's affects on sexual anxiety and behaviors are Reference Group theory,[13] Berger's Religious Plausibility Structures Theory,[16] Social Control theory,[20] and Sexual Socialization Theory.[18] Reference group theory proposes that an individual will follow their religion's teachings regarding sexual attitudes and behaviors.[13] On other hand, Berger's religious plausibility structures theory maintains that religion has an impact on an individual only if they are integrated into their religious community's social network. These religious groups, called plausibility structures, are what confirm and reinforce our religious beliefs about sexual attitudes and behaviors.[16] Similarly, social control theory proposes that religious institutions influence their followers' sexual behaviors by indirectly rewarding or punishing sexual activity before marriage.[20] However, Reiss's (1989) sexual socialization theory explains that a double standard of sexual socialization exists in many cultures in which females are more severely punished for engaging in recreational sex. Consequently, some women are now engaging in sexual behaviors to rebel against the unequal gender relations in sexual beliefs and attitudes.[16]

There is a need to understand what motivates individuals to engage in sexual behavior if we are to create effective prevention programs to reduce negative outcomes of such sexual behaviors. This study's goal is to examine the effects of both musical environment and religiosity on college aged students' sexual anxiety, and in so doing, it will add important information to the previous base of knowledge regarding media and religiosity. It will also help determine whether the various theories supporting this study's hypothesis hold true in a college population. For the purpose of the study, musical environment was defined by exposure to spiritual music or romantic music, religiosity was determined by whether the individual was a practicing member of their religion or not, and sexual anxiety was measured using the 25-item Sexual Anxiety Inventory.[9] Within a group of college-aged individuals, the following was hypothesized: practicing members of a religion would exhibit more sexual uptightness than nonpracticing individuals; people exposed to spiritual music would have more sexual anxiety than those listening to romantic music; and religiously practicing subjects exposed to spiritual music would have the most sexual anxiety.

Method

Participants

Thirty-two undergraduate students participated in the study. Age ranged from 18 to 27 years. The sample included 23 Anglo Americans, 2 Asians, 4 Hispanics, and 3 African Americans. Five (15.63%) participants claimed to either have no religious affiliation or reported that they were atheists. Twenty-seven (84.38%) participants did report a religious affiliation, and of those, 15 (56.25%) claimed they were practicing members of their religion, and 12 (43.75%) said they were non-practicing members of their religion. All participants were treated in a manner consistent with the "Ethical Principles of Psychologists and Code of Conduct."[1]

Materials

A modified version of the 25-question Sexual Anxiety Inventory was used to determine the participants' degree of sexual anxiety in various situations.[9] We chose this as our measure because, of all the existing scales, it provided the most comprehensive view of sexually-oriented topics. By providing five answer choices for each question, we were able to use a five-point Likert scale

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ranging from 0 to 4 to calculate the participants' responses for each item. A score of zero would indicate absolutely no sexual anxiety while a score of 4 would indicate extreme sexual anxiety in the situation. Questions dealt with a variety of sexually-oriented topics including flirting, dirty jokes, groping, sexual dreams, pornography, masturbation, casual sex, extramarital sex, oral sex, premarital sex, and group sex.

Additionally, a compact disc with two tracks was used for the two musical environment conditions (spiritual vs. romantic). Track 1, the Benedictine Monks of Santo Domingo's "Ave Mundi Spes Maria", was chosen because of chanting's presence in multiple religions—thus making it relevant to most religious subgroups. Track 2, Marvin Gaye's "Let's Get It On", was chosen because of its appearance on multiple articles praising its romantic quality.[15, 22]

Procedure

Undergraduate students volunteered to complete a 10 minute questionnaire. Prior to experimentation, it was decided to expose half of the participants to Track 1 and the other half to Track 2, regardless of the participants' gender or religiosity status. After signing the consent forms, participants listened to their respective tracks for a while to get the "feel" of the song. Then, they filled out the 25-item questionnaire with the music playing in the background. Participants were thanked and provided with a short debriefing detailing the study's purpose and specific variables being examined. At the end of the study, the total score for each participant was recorded as well as the mean scores for the two music groups and the mean scores for the two religiosity groups.

Results/Discussion

The researchers conducted a two-way Analysis of Variance with an alpha level of .05 set for all tests (See Table 1). Although participants who listened to romantic music while filling out the questionnaire had a lower mean sexual anxiety score than those who listened to spiritual music ($\overline{X}_{romantic}$ = 45.00; $\overline{X}_{spiritual}$ = 51.08;), the difference was not statistically significant. On the other hand, participants practicing their religion had a significantly higher mean sexual anxiety score than participants not practicing their religion ($\overline{X}_{practicing}$ = 50.94; $\overline{X}_{not\_practicing}$ = 37.87). Thus, it appears that sexual anxiety is greater for individuals who practice their religion than for those who don't, while musical environment has no significant effect (Table 1).

Although the present study found no evidence to support an effect of music on sexual anxiety, the significant difference between religiously practicing and non-practicing college students was consistent with our expectations. One should be cautious, however, to infer that religiosity caused the observed difference as this study is purely correlational in nature. Our results cannot conclude whether religiosity causes sexual anxiety, whether sexual anxiety causes religiosity, or whether another variable not examined caused both studied variables to appear in the observed trend. Because our study was unable to find that music alone affected the sexual anxiety levels of college students, the results were unable to lend support to the Agenda Setting/Framing theory,[12] Cultivation Theory,[5] or Cognitive Social Learning Theory.[3, 23] However, our findings may be inconsistent with other studies supported by these theories because our study focused solely on listening

Table 1 | *Mean Score on the Sexual Anxiety Inventory for Each Variable*

Religiosity Status	*M*	*SD*	*n*
Practicing	50.94	21.37	18
Not Practicing	37.87	10.52	14
Musical Environment	*M*	*SD*	*n*
Romantic	45.00	19.67	16
Spirtual	51.08	19.58	16

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to a song without the added stimulus of dancing[7] or a video.[4, 6, 21] In essence, our study focused on one sensory input—audio—while the other studies included multisensory inputs which seemed to have an augmented impact on sexual anxiety. Additionally, the music video studies assessed sexual anxiety by measuring attitudes towards premarital sex. However, because our study aimed to measure overall sexual anxiety, our questionnaire included a number of sexually-oriented topics (e.g., group sex, masturbation, flirting, etc.). Therefore, our inability to replicate those studies may be a direct result of our different operational definition of sexual anxiety as well as differences in research design. It is important to note that our design was an important addition to the existing research because it singled out music's influence on sexual anxiety devoid of other stimuli.

On the other hand, the study's findings were consistent with the results hypothesized by Reference group theory,[13] Berger's Religious plausibility structures theory,[16] social control theory,[20] and sexual socialization theory.[18] One can infer from the study that practicing individuals had higher sexual anxiety scores because of their religion's traditional teachings against pleasures of the flesh. This would be consistent with Reference group theory. It appears, therefore, that even though college students are surrounded by a predominantly liberal environment, those who adhere to their religious beliefs tend to have higher sexual anxiety in a variety of situations.

Conclusions/Future Research

This study adds an important dimension of sexual anxiety into the existing literature as it has found that religiosity significantly affects a more comprehensive view of sexual anxiety amongst college students. The limiting definition of sexual anxiety as attitudes toward premarital sex excludes important forms of sexuality that can have some of the same negative consequences as coitus. Because other sexual interests are also more prevalent in college-aged groups (group sex, pornography, etc.), the Sexual Anxiety Inventory served the purpose of addressing those sexually-oriented topics as well.

Future research should seek to find which specific aspects of religiosity have more influence on an individual's sexual anxiety: whether it be religious beliefs, practice, community, or different religious behaviors.[13] Additionally, future designs could allow a more precise analysis of the validity of the Agenda Setting/Framing Theory, Cultivation Theory, or Cognitive Social Learning Theory. For instance, by including ethnicity as a subject variable, one could evaluate the claims of Cultivation Theory. Furthermore, questions addressing music's influence on beliefs and perceived risk of sexual behavior could be added to the Sexual Anxiety Inventory[9] to evaluate the Agenda Setting/Framing Theory and the Cognitive Social Learning Theory. In terms of religiosity theories, added questions geared towards defining whether or not participants spent time with their church groups could determine how relevant Berger's Religious Plausibility Structures Theory was to college students. Similarly, questions could be included to determine whether sexual activity was viewed as highly punishable in their churches to evaluate social control theory. Lastly, an analysis should be done to verify whether females were more sexually anxious than males in order to evaluate the claims of sexual socialization theory.[18]

Our overall research serves an important practical purpose for society in trying to understand what influences college students' sexual anxiety during a time in their lives where sexual experimentation has begun. Although the decision to engage in sexual behaviors is a personal value decision, these choices are still molded by a number of social contexts—including the media and religiosity. Future research should attempt to include other factors in their analysis that may have an effect on sexual anxiety such as the following: prior engagement in substance or alcohol abuse, family satisfaction, family background, and socioeconomic status. Furthermore, designs implemented in future research should include portions dedicated to determining the relevance of the various theories supporting the hypothesis that religiosity will affect sexual anxiety significantly.

Although music was not found to have a significant effect on sexual anxiety, future research should try to determine whether we arrived at these results because

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our music variable was isolated from the added visual input that music videos have (which would explain the difference in results with previous studies). [4, 6, 21] Researchers should also begin doing research on middle school students' sexual anxiety levels because now, they too have begun to engage in risky sexual behaviors which we must understand if we are to attempt any sort of prevention intervention. For now, however, college students seeking to understand the different sexual behaviors and attitudes surrounding them may appreciate this study's findings supporting a higher level of sexual anxiety in religiously-practicing college students as opposed to those who are non-practicing and have no religious affiliation. However, those seeking to dismiss their own sexual behaviors because music 'got them in the mood' may have to re-think their excuse.

Acknowledgements

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Simulation of Fluid Flow Around Rigid Bodies

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§ 1.0 Motivation

When two exactly identical objects, i.e. same mass, surface area, shape, and material are released in water or any other viscous fluid, they descend at the same rate. But if the surface areas are different (with identical or different physical shape), we observe that the rates of descent for the objects typically vary. Intuitively, we expect that when the descent is very slow so that the fluid never separates from the surface, the greater the surface area, the greater the resistance felt by the object when descending in fluid. What about objects with the same surface area as illustrated in Fig. 1.00 and 1.01? The rate of descent in this case depends on the shape of the object.

Figure 1.00 | Two objects of same mass and surface area.
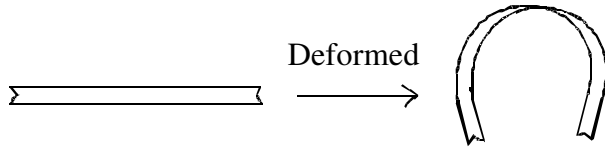
A special case that is of interest to us is long and very thin metallic strips/filaments that are bent into different shapes as illustrated in Fig. 1.01. All six filaments shown in the figure below have the same surface area and mass, and are all formed out of the same material with equal length. However each filament behaves differently when released in a viscous fluid.

Filaments (knots) are named according standard table which can be found in [AD]. There is a unique non-trivial knot that can be constructed with only three crossings, K3_1. Similarly there are two five-crossing knots, K5_1 and K5_2. The rest of the knots (filaments) are named accordingly. For more information consult [OG].

Figure 1.01 | Filaments K3_1, K4_1, K5_1, K6_1, K7_1, and K7_7 (left to right).

The behavior of a filament, or in general, any rigid object in a viscous fluid depends on its shape and can be described as follows (Gonzalez etal 2004). Each filament has a center of mass and either one or three characteristic axes (called hydrodynamic axes) which depend on its shape. Moreover, each end (tip) of each axis has a characteristic label: S (for stable) or U (for unstable).

Figure 1.02 | The 1-axis case.
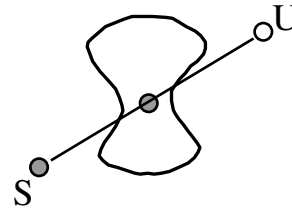
Figure 1.03 | The 3-axis case.
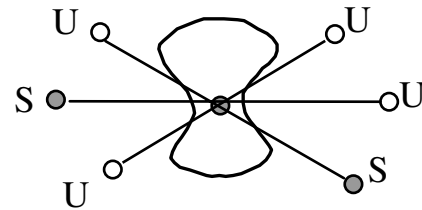
When a filament is released in a fluid it will quickly re-orient itself so that an *S-tip* points downward and so that the corresponding hydrodynamic axis is parallel to gravity. In the case of a filament with two *S-tips*, the one that ends up pointing downward depends on the release conditions (only one *S-tip* of a filament points downward after each release).

Figure 1.04 | Axis alignment upon release.

Charith C. Tangirala
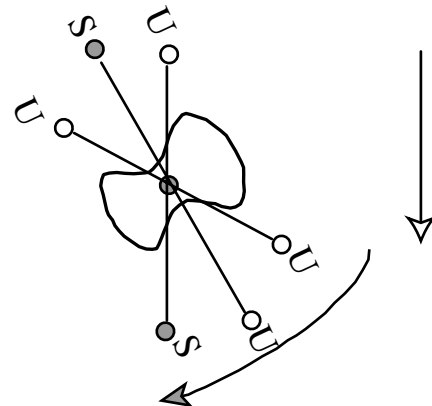
After this initial re-orientation, the *S-tip* remains vertically downward throughout the descent, but the center of mass need not follow a straight path. In general, the center of mass traces out a helical path (Figure 1.05) with velocity $\mathbf{V}_{steady}$ while the filament rotates about the hydrodynamic axis with angular velocity Ω_{steady}. The velocities $\mathbf{V}_{steady}$ and Ω_{steady} depend on the shape, the particular *S-tip* that is pointing down, the magnitude of gravity, and properties of the fluid. It should be noted that these results hold only for generic filaments. In particular, they do not hold for non-generic filaments with symmetrical shapes such as circles or ellipses.

Figure 1.05	Helical path of filament center of mass.

gravity
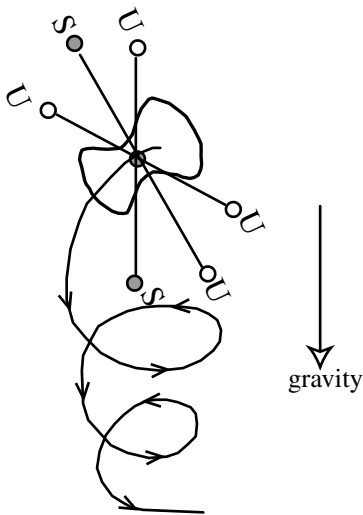
This paper is devoted to the visualization of fluid flow around a steadily descending filament. In particular, given a shape, an axis (S-*tip*), and velocities $\mathbf{V}_{steady}$ and Ω_{steady}, we want to visualize how the fluid flows around and through the filament. This can be visualized in two different ways: "streamlines" and "smoke particles" and examine streamline visualization.

§ 2.0 Streamline Visualization for a Sphere

One way to visualize steady fluid flow is with streamlines. As an example we will first illustrate the mathematical calculations and details involved in visualizing streamlines around a sphere. It should be noted that the streamlines we generate are only an approximation to the actual fluid flow because:

i.   our fluid model is only an approximate model, and
ii. the numerical method (explicit midpoint method) that we use to solve the model (ODEs) gives us only an approximation as every other numerical method does.

Consider a sphere with radius $r > 0$, and center at the point $Z = (z_1, z_2, z_3)$ in a 3-dimensional space. To compute a streamline for a sphere in a viscous fluid, we are required to solve an ODE representing the velocity of a particle at some point $X = (x_1, x_2, x_3)$ in the fluid. Moreover, the derivation of this ODE involves:

i.   determining the $\mathbf{V}_{steady}$ and Ω_{steady} for a sphere settling under the action of gravity, and
ii. computing the fluid velocity.

The solution to the resulting ODE can then be approximated using the explicit midpoint method with given initial conditions.

§ 2.1 Hydrodynamic Properties of a Sphere

The hydrodynamic properties of a sphere (released from rest and settling under the action of gravity) in a viscous fluid can be described as follows:

i.   Every axis in a sphere is a hydrodynamic axis. Because of symmetry, every axis in a sphere is a hydrodynamic axis with every tip being an *S-tip*. No matter what *S-tip* is initially chosen to point downwards, the same tip will remain downwards throughout the entire descent. Thus there is no initial re-orientation.

ii. $V_{steady} = (0, 0, -m.g/6p\,\mu\,r)$ i.e. the center of mass of the sphere descends straight down.

   Here g is the gravitational acceleration constant, m is the mass of the sphere, and μ is the (absolute) viscosity of the fluid. The only forces acting on the sphere during its descent are gravity and the drag force exerted by fluid on the sphere. The direction of the drag force (upward) is opposite to that of gravity (downward). Therefore the direction of $\mathbf{V}_{steady}$

is in the negative z direction (downward). The magnitude of $\mathbf{V}_{steady}$, which is m.g/6pµr, is the speed at which the drag force equals the force due to gravity. For convenience, $\mathbf{V}_{steady}$ is set to (0, 0, -1) because it does not affect our visualization of streamlines.

iii. $_{steady}$ = (0, 0, 0) i.e. no angular velocity.

In general, the angular velocity of a rigid object is the vector which describes how the object rotates in space. The direction of the angular velocity vector represents the instantaneous axis of rotation while its magnitude represents the instantaneous rate of spin about this axis. Because of symmetry, a sphere released from rest in a viscous fluid will never spin throughout its descent. Thus for a sphere we have $_{steady}$ = (0, 0, 0).

| *Figure 2.10* | Sphere and a representative fluid particle. |
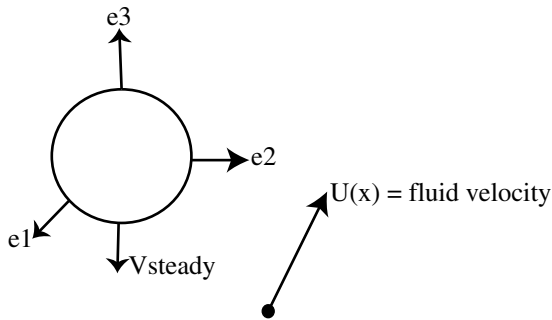
§ 2.2 Equation for Fluid Velocity

For the case of a single sphere, we define the sphere velocity ($\mathbf{V}_{sphere}$) to be the velocity of its center of mass. Thus,

$$\mathbf{V}_{sphere} = \mathbf{V}_{steady.} \qquad (2.20)$$

Our next step is to compute the *steady-state force* on the sphere which is required for the computation of the fluid velocity field.

Computation of steady-state Force

The *steady-state force,* $\mathbf{F}_{sphere}$, for a sphere is the force required to push a sphere at velocity $\mathbf{V}_{sphere}$. According to Stoke's formula [SK] we have:

$$(1/6\pi\mu r)\mathbf{F}_{sphere} = \mathbf{V}_{sphere},$$
$$\mathbf{F}_{sphere} = (6\pi\mu r)\,\mathbf{V}_{sphere}.$$
$$(2.21)$$

From the above equation, $(1/6\pi\mu r)$ is a scalar and therefore the force vector ($\mathbf{F}_{sphere}$) is obtained by multiplying a scalar by the vector $\mathbf{V}_{sphere}$.

Equation of Fluid Velocity Field

The steady fluid velocity field around a moving sphere subject to an external force $\mathbf{F}_{sphere}$ is given by

$$\mathbf{V}_{fluid} = f(X, \mathbf{F}_{sphere,}\, \mathbf{Z}_{sphere}), \qquad (2.23)$$

where $X = (x_1, x_2, x_3)$ is some point in the fluid and $\mathbf{Z}_{sphere} = (z_1, z_2, z_3)$ is the position of the sphere in the fluid (center of the sphere).

The function, f in Eq. 2.23 is given by:

$$\ddot{A}(X\; \mathbf{F}_{sphere},\, \mathbf{Z}_{sphere}) = \left(\frac{C_1}{|XZ|} + \frac{C_2}{|XZ|^3}\right)\mathbf{F}_{sphere} + \left(\frac{C_3}{|XZ|^3} - \frac{C_4}{|XZ|^5}\right)\left(XZ.\mathbf{F}_{sphere}\right)XZ$$

$$(2.24)$$

where $|XZ|$ is the Euclidian norm (L2 norm) of the vector from X to Z, i.e. the distance from the center of the sphere to the point X in fluid defined as:

$$\div((x_1 - z_1)^2 + (x_2 - z_2)^2 + (x_3 - z_3)^2).$$

The constants C_1, C_2, C_3, and C_4 depend on the radius of the sphere and viscosity of the fluid such that,

$$C_1 = C_3 = 1/(8\_\pi),\; C_2 = r^2/(24\_\pi),\; C_4 = r^2/(8\_\pi).$$

Note that in the definition of f, the expression XZ is the vector between the points X and Z i.e. X – Z and $(XZ . \mathbf{F}_{sphere})$ is the dot product of the vectors XZ and $\mathbf{F}_{sphere}$. The vector field in Eq (2.23) is the solution of a certain partial differential equation called Stoke's Equation which describes slow viscous fluid flow. For more information see [WH].

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§ 2.3 Equation of Streamline

We can now cook up an ODE for a streamline with all the ingredients that we obtained above. The equation for a fluid particle moving with the fluid which traces out a path called a "streamline" is:

$$dX/dt = \mathbf{V}_{fluid} - \mathbf{V}_{sphere}. \qquad (2.30)$$

The differential equation above gives us the velocity vector of the fluid particle at point X and time t. So if the ODE were to be solved for a time interval [0, T] where T is a positive real number, then the solution is a series of vectors at each time t, representing the direction of fluid velocity at time *t*. Thus, fitting a curve through these vectors gives a streamline.

Solving an ODE for some time interval is often referred to as solving an *initial value problem (IVP)*. These problems are often referred to as initial value problems because solve the ODE based on the given initial condition. There are many numerical methods to solve initial value problems, such as Euler's Method, Modified Euler Method, Midpoint, Explicit Midpoint, Runge-Kutta, Heun's Method, and so on. The numerical method we used to solve our ODE is the *Explicit Midpoint Method*. For more information on ODEs and IVPs consult [BF].

§ 2.5 Determining Initial Conditions

Initial conditions for our problem include initial time t and initial point of origin for each streamline. Initial condition for t is simply t = 0.0 seconds. An initial condition for each streamline requires some calculations. One possible way is to construct a plane at some point called reference point below the sphere such that

i. the plane is orthogonal to the velocity of the center of mass of sphere $\mathbf{V}_{steady}$

ii. the size of the plane is K*r* (where K is a positive integer greater than 1). The case when K = 2 means that the area of the plane covers the entire sphere (2 times the radius *r*).

In the case of our problem, the normal to the plane is simply $\mathbf{V}_{steady}$. The reference point is thus calculated as

$$(\_r)\, \mathbf{V}_{steady} / \|\mathbf{V}_{steady}\|. \qquad (2.50)$$

Here *r* is the radius of the sphere and _ is any positive integer such that _ > 1 and $\|\mathbf{V}_{steady}\|$ is the Euclidian norm of $\mathbf{V}_{steady}$. The idea here is that greater the value of the greater the distance between the plane and the sphere (Figure 2.50).

Once we have a reference point, our next step is to construct a plane orthogonal to $\mathbf{V}_{steady}$ at that reference point.

Construction of a Plane

Let e_1 be some vector which is not parallel to $\mathbf{V}_{steady}$. Then a basis for the plane, b_1 and b_2, is obtained as follows:

$$b_1 = \mathbf{V}_{steady} \times e_1 \qquad (b_1 \text{ is } \wedge \text{ to } \mathbf{V}_{steady} \text{ and } e_1), \qquad (2.51)$$

$$b_2 = \mathbf{V}_{steady} \times b_1 \qquad (b_2 \text{ is } \wedge \text{ to } \mathbf{V}_{steady} \text{ and } b_1).$$

Figure 2.50 | Construction of a plane for initial conditions.
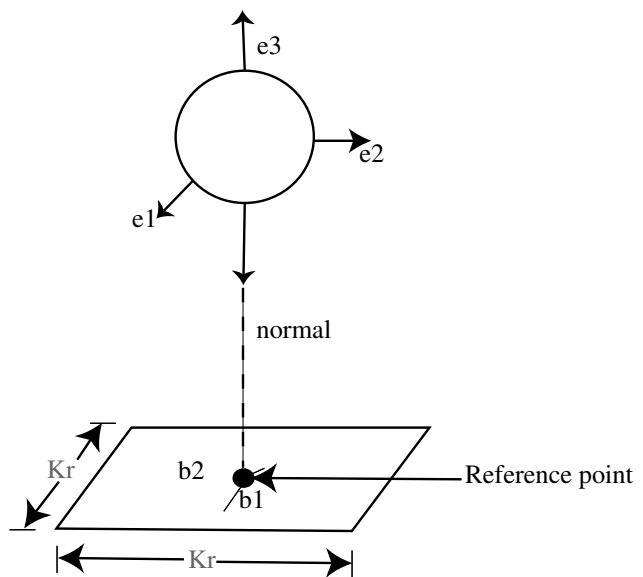
Relating to the Figure 2.50 above, the vectors b_1 and b_2 are normalized to get unit vectors which will give us a uniform grid. To normalize a vector, the vector is divided

by its L2 norm. Therefore normalized b_1 and b_2 are $b_1/\parallel b_1 \parallel$ and $b_2/\parallel b_2 \parallel$ respectively.

Construction of a Grid

Initial conditions for the streamlines are obtained by establishing a grid in the initial condition plane (Figure 2.51). Let N_{grid} be an integer and L the size of the plane. The initial condition points are computed as follows:

Let dx = dy = L / N_{grid} and Ref = reference point.
For each i = 1, 2, ..., N_{grid} ,

(Algorithm 1)

For each j = 1, 2, ..., N_{grid} ,

$X_{i,j}$ = Ref + (i - N_{grid} / 2).dx.b_1 + (j - N_{grid} / 2).dy.b_2 ,

where $X_{i,j}$ is an array of points for each i, j = 1, 2, ..., N_{grid} which we will use as initial conditions for the streamline ODE.

Finally, solving the ODE using the numerical method explained above for each initial condition that we just found will generate the desired streamlines around a sphere. This gives us a good idea of fluid flow around the sphere.

Figure 2.52 (below) shows the desired streamline visualization around sphere at different times that

Figure 2.51 | A streamline at point x(i,j) on the grid.

curve fitted through points attained from solving ODE
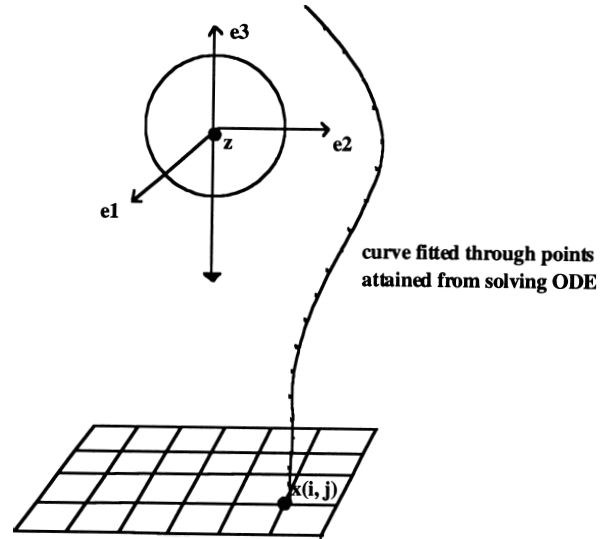
are calculated by the Explicit Midpoint Method. Fig. 2.52 (a), (b), (c), and (d) are the scenarios in the time interval [t_{start}, t_{final}] such that t_{final} > t_{start}. Fig 2.52 (a) depicts the streamlines at some time close to initial time t_{start} and 2.52 (d) depicts the scenario at some time close to t_{final}.

Figure 2.52 | Streamlines around a sphere at different times t.
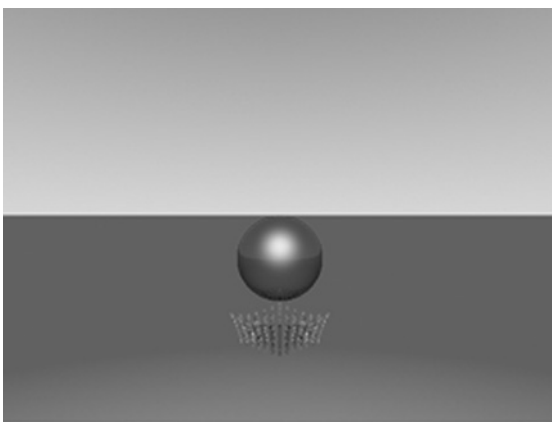
Figure 2.52 (a)

Figure 2.52 (b)

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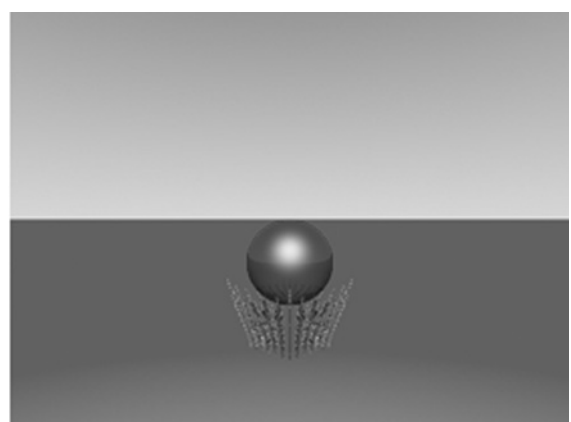
Figure 2.52 | Streamlines around a sphere at different times t.
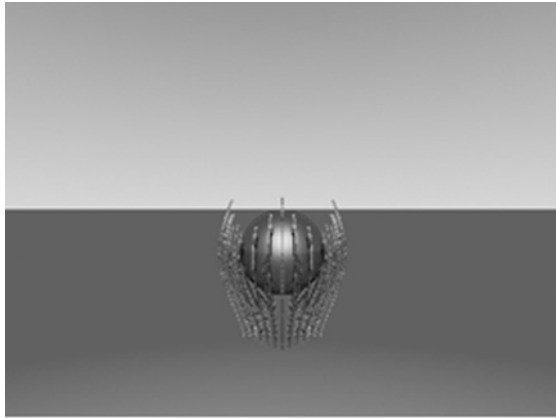
Figure 2.52 (c)
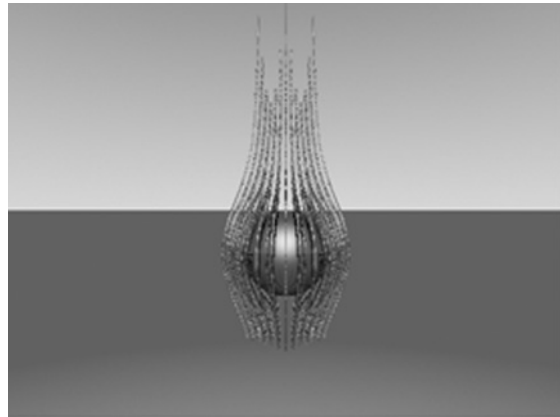
Figure 2.52 (d)

§ 2.6 Remarks from Simulations

The simulation for this model was made possible due the data given by Professor Oscar Gonzalez (Department of Mathematics, University of Texas at Austin). The following pictures in Figure 2.60 shows two different views of the streamlines around the sphere. Notice that in both cases the streamlines closer to the sphere travel shorter distances over the time compared to the ones that are farther away from the sphere. This is because the sphere exerts little force on fluid particles that are very far away from the sphere, i.e. the closer the fluid particles to the sphere, the more they are influenced by the force (calculated in Eq. 2.21) of the sphere. We can see this distinction clearly in Figure 2.60 (b). Streamlines that are to the far left and right are approximately straight.

Figure 2.60 | Streamlines with V_{steady} = (0, 0, -1).
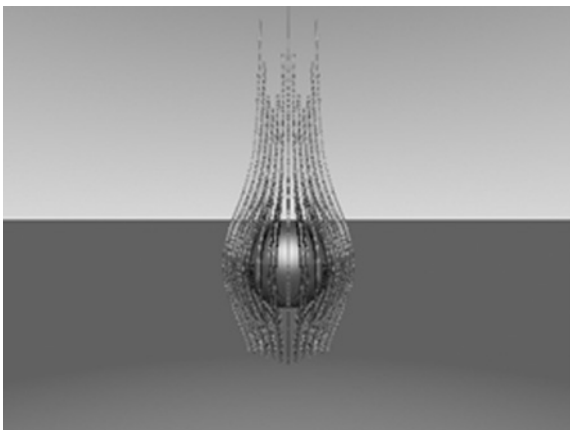
Figure 2.60 (a)
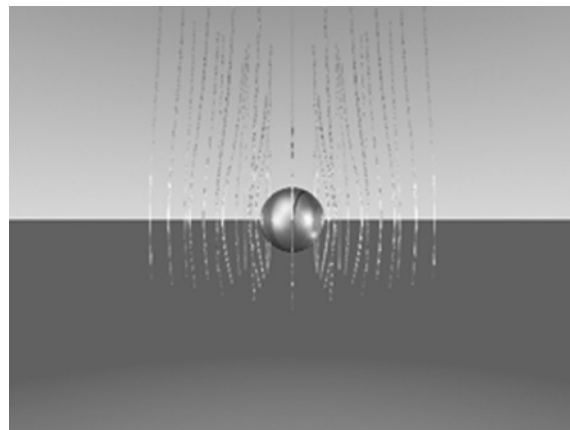
Figure 2.60 (b)

Because of viscosity, fluid particles close to the sphere move more slowly than those far away. Thus the fluid particles closer to the sphere travel a shorter distance in a given time, and hence we observe that the lengths of the streamlines that are close to the sphere are shorter in length compared to those that are farther away. For this model the value of $\mathbf{V}_{steady}$ does not affect the streamlines. So if we chose $\mathbf{V}_{steady}$ to be (n_1, n_2, n_3), for any real numbers n_1, n_2, n_3 the streamlines still follow the same path around the sphere (but in a different direction of course) as shown in Figure 2.61.

Figure 2.61	Streamlines with V_{steady} = (0, -1, -1).
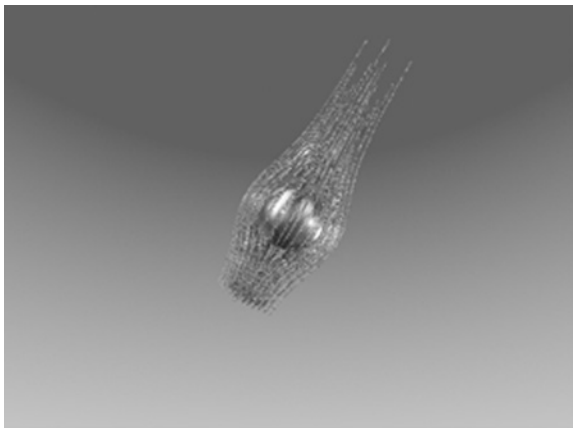
§ 3.0 Streamline Visualization for a Thin Filament

The basic idea for generating streamlines around a thin filament is similar to the case of a single sphere. We assume that the filament is constructed from a concatenation of multiple tiny spheres as shown in Figure 3.00. This assumption leads us to use the Rotne-Prager model for fluid flow around multiple beads [RP]. Any force on one bead impacts the entire system of beads (which is our model for a filament).

The filament shown in Fig.3.00 is K3_1 which is one of the six filaments mentioned earlier in Section 1.0 and the one for which we intend to visualize fluid flow. For a better view of this filament please visit http://www.cs.utexas.edu/users/charitht. Figure 3.00 also shows

the orientations of K3_1 with its three hydro axes (S-U (solid axis), U-U (dashed axis), and S-U (dot-dash axis)). Each of the six filaments differs in their hydrodynamic properties but the concept for calculating streamlines for each filament is exactly the same. However the fluid flow is different for each filament (and for each case of a filament as we will see soon).

Figure 3.00	The K3_1 filament with all three axes.
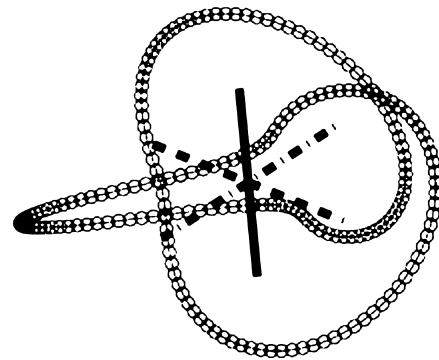
§ 3.1 Hydrodynamic Properties of a Filament

Recall from Section 1.0 that each filament has one or three axes, and has either one or two *S-tips*. The *S-tip* that ends up taking the direction of gravity depends on the release condition, and the velocity of the center of mass, $\mathbf{V}_{steady}$. The angular velocity, $_{steady}$, depends on a particular *S-tip*. Figure 3.10 shows three different views of the filament K31, along first S-U axis (Fig 3.10(a)), along U-U axis (Fig 3.10(b)), and along second S-U axis (Fig 3.10(c)). Recall that the angular velocity $_{steady}$ causes the filament to spin around its center of mass and the path traced out by the filament depends on the release conditions of the filament (the most common path being a helix as in Fig. 1.05)

§ 3.2 Equation for Fluid Velocity

The equations and calculations involving streamline visualization in the case of filament (modeled as a combination of multiple spheres) are synonymous to the case of single sphere except that we have to consider more spheres.

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Figure 3.10 | The three views of K3_1 filament along its 3 hydro axes.
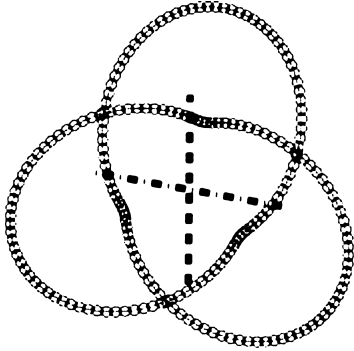
Figure 3.10(a). View along 1st S-U axis.
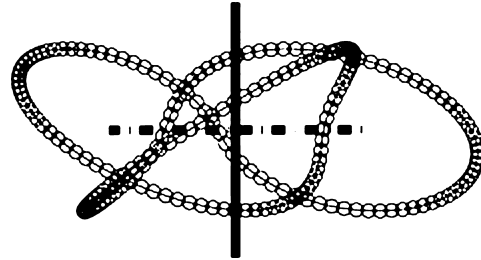
Figure 3.10(b). View along U-U axis.
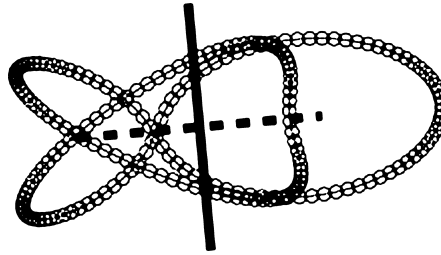
Figure 3.10(c). View along 2nd S-U axis.

Computation of Steady-State Forces

The most complex computation for our model is the derivation of steady-state forces for a system of spheres considering the fact that each sphere in the system has a physical effect on the rest of the spheres in the system. So we need to compute the force vector for each of the tiny spheres. If the filament is constructed with n beads, then we need to compute

$$\mathbf{F}_{spheres} = (F_1^{(k)}, F_2^{(k)}, F_3^{(k)}) \text{ for each } k = 1, 2, \ldots, n. \qquad (3.20)$$

Recall from Eq. (2.21) in section 2.2 that the linear system used for the computation of $\mathbf{F}_{sphere}$ (for a single sphere) is

$$(1/6\pi\mu r)\mathbf{F}_{sphere} = \mathbf{V}_{sphere},$$
$$\mathbf{F}_{sphere} = (6\pi\mu r)\,\mathbf{V}_{sphere}.$$

The above linear system can also be written in the matrix notation as follows:

$$(1/6\pi\mu r) \; I \; \mathbf{F}_{sphere} = \mathbf{V}_{sphere}$$

$$
\begin{bmatrix}
\dfrac{1}{6\pi\mu r} & 0 & 0 \\
0 & \dfrac{1}{6\pi\mu r} & 0 \\
0 & 0 & \dfrac{1}{6\pi\mu r}
\end{bmatrix}
\begin{bmatrix}
F_1 \\
F_2 \\
F_3
\end{bmatrix}
=
\begin{bmatrix}
V_1 \\
V_2 \\
V_3
\end{bmatrix}
$$

$$
\begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} \frac{1}{6\pi\mu r} & 0 & 0 \\ 0 & \frac{1}{6\pi\mu r} & 0 \\ 0 & 0 & \frac{1}{6\pi\mu r} \end{bmatrix}^{-1} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 6\pi\mu r & 0 & 0 \\ 0 & 6\pi\mu r & 0 \\ 0 & 0 & 6\pi\mu r \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}
$$

$$
\begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} 6\pi\mu r\, V_1 \\ 6\pi\mu r\, V_2 \\ 6\pi\mu r\, V_3 \end{bmatrix}
$$

This is a linear system of form Ax = b where A (in the case of a single sphere) is a non-singular 3×3 matrix which we will call R-P matrix (denoted as D_{RP}); x and b are the 3×1 vectors $\mathbf{F}_{spheres}$ and $\mathbf{V}_{spheres}$ respectively. It is not very hard to solve the linear system for $\mathbf{F}_{sphere}$. For general systems of the form Ax = b, MATLAB can be used to solve for x with its internal command \ (i.e. by typing x = A\b). A similar technique can be used to solve for $\mathbf{F}_{spheres}$. The crucial part is to construct the R-P matrix. In fact we want to construct D_{RP} such that,

$$
\begin{bmatrix} \\ \\ \\ D_{RP} \\ \\ \\ \end{bmatrix} \begin{bmatrix} F_{(1)}^{(1)} \\ F_{(2)}^{(1)} \\ F_{(3)}^{(1)} \\ F_{(1)}^{(2)} \\ F_{(2)}^{(2)} \\ F_{(3)}^{(2)} \\ \bullet \\ \bullet \\ \bullet \\ F_{(1)}^{(n)} \\ F_{(2)}^{(n)} \\ F_{(3)}^{(n)} \end{bmatrix} = \begin{bmatrix} V_{(1)}^{(1)} \\ V_{(2)}^{(1)} \\ V_{(3)}^{(1)} \\ V_{(1)}^{(2)} \\ V_{(2)}^{(2)} \\ V_{(3)}^{(2)} \\ \bullet \\ \bullet \\ \bullet \\ V_{(2)}^{(n)} \\ V_{(2)}^{(n)} \\ V_{(3)}^{(n)} \end{bmatrix}
$$

Here n is the total number of spheres used to model our filament, D_{RP} is a nonsingular $3n \times 3n$ matrix (which is constructed using the Rotne-Prager model) and $\mathbf{F}_{sphere}$

and $\mathbf{V}_{sphere}$ are 3n x 1 vectors. So for example, $(F_1^{(n)}, F_2^{(n)}, F_3^{(n)})$ would represent the force vector on the nth sphere. This can also be applied to the case of single sphere, i.e. n = 1 in which case the force vector and the velocity vector are 3 x 1 column vectors and D_{RP} is a 3×3 nonsingular matrix. So we can generalize Eq. 2.21 for any collection of n beads as follows:

$$
\mathbf{F}_{spheres} = D_{RP}^{-1} \mathbf{V}_{spheres}. \tag{3.21}
$$

General Model for Rotne-Prager Matrix

The Rotne-Prager matrix D_{RP}, is constructed with chunks of 3×3 matrices that are all grouped together to form a $3n \times 3n$ matrix. Just as all the diagonal elements of the matrix in the case of a single sphere are $1/6\pi\mu r$, the diagonal elements of D_{RP} in the case of multiple spheres is also $1/6\pi\mu r$. Moreover, if one looks at the D_{RP} as n × n blocks of 3×3 matrices, then all the diagonal 3×3 matrices are $(1/6\pi\mu r)$ I. This leads us to a formulation of the Rotne-Prager matrix.

Consider the matrix described below:

$$
\begin{bmatrix}
D_{11} & D_{12} & D_{13} & \cdot & \cdot & \cdot & \cdot & \cdot & D_{1n} \\
D_{21} & D_{22} & D_{23} & \cdot & \cdot & \cdot & \cdot & \cdot & D_{2n} \\
D_{31} & D_{32} & D_{33} & \cdot & \cdot & \cdot & \cdot & \cdot & D_{3n} \\
\cdot & \cdot & & \cdot & & & & & \cdot \\
\cdot & \cdot & & & \cdot & & & & \\
\cdot & \cdot & & & & \cdot & & & \\
\cdot & \cdot & & & & & \cdot & & \\
\cdot & \cdot & & & & & & \cdot & \\
D_{n1} & D_{n2} & D_{n3} & \cdot & \cdot & \cdot & \cdot & \cdot & D_{nn}
\end{bmatrix}
$$

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D_{11}, D_{22},..., D_{nn} are 3×3 diagonal matrices for spheres 1, 2,...,n respectively. D_{12} describes the matrix relating sphere 1 and sphere 2, D_{13} relates spheres 1 and 3 and so on. Therefore the general formula for constructing D_{RP} is

$$D_{aa} = (1/6\pi\mu r)\, I, \qquad (3.21)$$

$$D_{ab} = \frac{1}{8\pi|z_{ab}|^3}\left[(I\,|z_{ab}|^2 + z_{ab}\otimes z_{ab}) + \frac{2(\mu r)^2}{|z_{ab}|^2}\left(\frac{1}{3}I\,|z_{ab}|^2 - z_{ab}\otimes z_{ab}\right)\right]$$

such that $a \neq b$.

Here $\otimes$ denotes the vector outer product, and Z_{ab} is the vector which points from shpere a to sphere b.

The above part of this subsection is taken from [OG].

Derivation of the Equation for Fluid Velocity
Recall from Eq. 2.23 and 2.24 in Section 2.2 that the equation of fluid velocity for a single sphere was,

$$\mathbf{V}_{fluid} = f(X, \mathbf{F}_{sphere,} \mathbf{Z}_{sphere}),$$

$$f(X, \mathbf{F}_{sphere}, \mathbf{Z}_{sphere}) = \left(\frac{C_1}{|XZ|} + \frac{C_2}{|XZ|^3}\right)\mathbf{F}_{sphere} + \left(\frac{C_3}{|XZ|^3} - \frac{C_4}{|XZ|^5}\right)\left(XZ.\mathbf{F}_{sphere}\right)XZ$$

In the case of a collection of beads, we superimpose the effect from each bead to obtain

$$\mathbf{V}_{fluid} = F(X, \mathbf{F}_{spheres,} \mathbf{Z}_{spheres}) \text{ where} \qquad (3.22)$$

$$F(X, \mathbf{F}_{sphere}, \mathbf{Z}_{sphere}) = \sum_{k=1}^{n} (f(X, \mathbf{F}^{(k)}_{sphere,} \mathbf{Z}^{(k)}_{sphere}).$$

In this case the ODE to calculate the velocity of fluid particles is exactly same as Eq. 2.30, namely

$$dX/dt = \mathbf{V}_{fluid} - \mathbf{V}_{sphere}.$$

§ 3.3 Remarks from Simulations
Similar conclusions can be drawn from the streamline visualization around a filament as can be drawn from

visualizing fluid flow around a sphere. In particular, streamlines closer to the filament are shorter in length as compared to those that are farther away, and streamline flow depends on the steady-state velocities $\mathbf{V}_{steady}$ and ω_{steady}.

Figure 3.30 | Streamline visualization along 1st S-U axis.
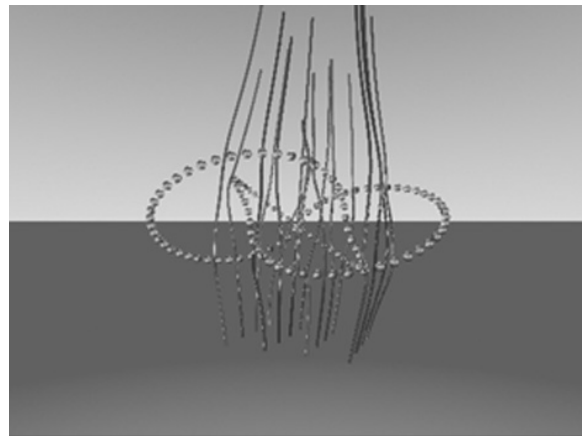
Furthermore, making a detailed observation tells us that ω_{steady} causes some of the streamlines to twist around each other through the course of time. This is because ω_{steady} causes the filament to rotate around its center of mass, which changes the direction of the fluid particles relatively close to it. Figure 3.30 depicts these observations to some extent for both orientations of the stable states. Again, for a more detailed 3-D view, visit http://www.cs.utexas.edu/users/charitht.

§ 5.0 Conclusion
The visualization of fluid flow around filaments (both streamline and smoke-particles) is only an approximation to the actual solution. Real world experiments for fluid flow around a sphere shows similar characteristics to our simulation. However, to my knowledge there have been no physical experiments thus far that depicts actual fluid flow around knotted filaments. While it takes great time, extensive calculations (to estimate the quantity of viscous fluid,

viscosity of the fluid, size of the filament itself, etc) and a good deal of money to perform these experiments, researchers around the globe are currently working on the very same problem to see how these filaments descend in a viscous fluid. This project is an attempt to approximate such visualization.

Acknowledgement

Not a moment has gone by without appreciating the time professor Oscar Gonzalez took to teach, guide, and correct me throughout the course of this research project. I have known Dr. Gonzalez since spring 2004 when I took a class on Numerical Analysis at the University of Texas at Austin. He has been a profound influence on me ever since. The exceptional quality of his lectures, passion for his subject, and the eagerness to motivate his students has registered in me a great deal of respect for him. He loves to teach and share the knowledge that he possesses. He is extremely well organized and what he says is very informative. All of these are virtues every teacher should possess.

I truly admire him for what he is. Through him I learned to think more creatively and mathematically. He is a very helpful person in nature too. At the beginning of this project I was faced with a challenge of learning and quickly adapting to two completely new software packages (MATLAB and PovRay) in a very short period of time with the work load of four other classes. Dr. Gonzalez walked me through critical times of this project showing great interest in helping me understand the complexities that were involved within.

In conclusion, I would like to press on the fact that I am really fortunate to have learned and worked with him. Finally, another great force that kept me going is the everlasting love, support, and guidance from my dad Vijay Tangirala, mom Jaya Tangirala and sister Hershytha Tangirala. My friends have also shown tremendous support and encouragement which also kept me going. I am thankful to every one who has made this project memorable and a good learning opportunity for me.

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End Notes

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BCL11A and its Role in Human Leukemias and Lymphomas

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Abstract

Our current understanding of cancer suggests that it originates in a single cell by an acquired genetic change, resulting in a disturbance of the normal chromosomal balance that is required for normal cell function. We have identified a particular region on chromosome 2 that is recurrently altered by chromosomal translocations and amplifications in divergent types of human cancers, including chronic B-cell lymphocytic leukemia, Hodgkin disease, and follicular lymphoma. We have evidence to suggest that a novel gene in this region, *BCL11A*, can induce cancer when its expression is deregulated by chromosomal translocation or amplification. Using contemporary techniques, it is the goal of my research to identify this gene as being present at the protein level in cancer

cells, and to establish the molecular targets of its activity in cancer.

Introduction

Our DNA is organized and divided into 46 structural units called chromosomes. Chromosomes consist of DNA-protein complexes in which the proteins provide the scaffolding for the DNA, protecting it from degradation and providing the structural framework that allows transcription factors access to the information imbedded in the nucleotides that comprise our genome. These transcription factors may serve to either promote or repress the expression of a particular protein, thereby altering its abundance in the cell. The controlled expression of genes is an extremely delicate system in a cell, and one that is subject to dysregulation and abnormalities. In most cases, any aberrant activity by the cell is recognized and either is corrected, if possible, or the cell undergoes the programmed self-destruct process of apoptosis and is destroyed. However, in cancer cells we observe abnormalities that destroy the integrity of the genome, and instead promote further aberrant activity through the circumvention of apoptosis and the renegade expression of genes.

An abnormality that has been observed in cancer cells is the translocation, in which a sequence of DNA from a chromosome is abnormally transferred and inserted into a different neighborhood of genes on the same chromosome, or another chromosome. Amplifications are also common in which a particular gene or subset of genes are expressed at comparatively higher levels than what is observed in normal cells. In successful translocation events, it is often observed that the translocated gene undergoes amplification because of its new-found proximity to other genes that possess higher expression profiles. In its normal location in the genome, the translocated gene may never be expressed, but if it is placed very near a commonly expressed protein, or if it is able to escape repression by averting the gene silencing mechanisms that keep this gene is check, then a heightened expression profile is often observed. Specific chromosomal translocations have been observed in a litany of human tumors and malignancies, but are curiously absent in the normal cells of the same individual in which a tumor or malignancy is found. This indicates that oncogenesis may have its beginnings in translocation and amplification.

Our lab has identified a region of genes, or locus, on chromosome 2 in which alterations recurrently manifest in the form of translocations and amplifications in several divergent forms of human cancers (1,2). These cancers are of the immune cell variety, including an aggressive B-cell chronic lymphocytic leukemia (CLL), Hodgkin lymphoma (Hodgkin disease) (HL), Diffuse Large B-cell Lymphoma (DLBCL) and follicular lymphoma (FL) (2). Leukemias and lymphomas are cancers that begin in the bone marrow, the anatomical origin for our complement of immune cells and red blood cells. Cancer in the bone marrow deprives an individual of functional immune cells, and places the individual at severe risk of acquiring an infection that their body will not be able to combat. Chemotherapy or full body irradiation to kill all of the cells in the bone marrow, and reconstitution of the bone marrow by a donor are the only known treatments for these cancers, and are not always effective (3).

There is evidence to suggest that a novel gene at this locus in chromosome 2, BCL11A, may lead to cancer when translocated or amplified, resulting in heightened expression (2). The significance of the translocation of BCL11A in these cancers may have gone unnoticed, but the comprehensive sequencing of the human genome enabled us to compare DNA sequence data from this locus in the afflicted to that of normal subjects. In normal cells, this translocation does not exist. However, in cells in which the translocation of BCL11A is presented, it is placed in very close proximity to the REL oncogene, which has been implicated in a wide array of cancers (4). The relationship between these two genes that appear in the same locus in this subset of cancers has not yet been fully identified, but the presence of BCL11A in this locus is especially intriguing since it is possible that REL is not able to promote a malignant phenotype in these cancers without the translocation of BCL11A. In Hodgkin lymphoma, amplification of REL and BCL11A occurs in approximately 50% of all cases, and in as much as 20% of DLBCL's (4).

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In an attempt to characterize the expression profile of BCL11A, Northern blots were performed to try to establish BCL11A RNA expression in cancer. BCL11A RNA was isolated and identified in cells originating from two adolescent patients with a previously uncharacterized aggressive form of B-cell leukemia. Intriguingly, it appears that there may be multiple variants, or isoforms, of BCL11A that may be expressed simultaneously in cancer cells. Given these observations and further discovery of BCL11A isoform RNA in some malignant B-cell lines (Figure 1, *left panel*), in addition to the previous translocation data implicating the translocation of BCL11A in malignancy, it became necessary to verify BCL11A at the protein level. Expression of this protein in cells would further support our hypothesis and line of evidence that BCL11A is involved and perhaps responsible for oncogenesis in cells in which the translocation is present. It was the aim of my research to identify BCL11A protein expression and to characterize as much as possible its function in malignant cells.

Results and Discussion

The aim of this project is medically significant because of the prior evidence that BCL11A was present, at least at the RNA level, in aggressive forms of leukemia and lymphoma (1,2). The objective at hand is to directly observe by quantitative means the physical manifestation of the BCL11A proteins in cells derived from leukemia and lymphoma patients. One of the most direct

| **Figure 1** | *BCL11A protein is expressed at high levels in cancerous cells of the human immune system.* |
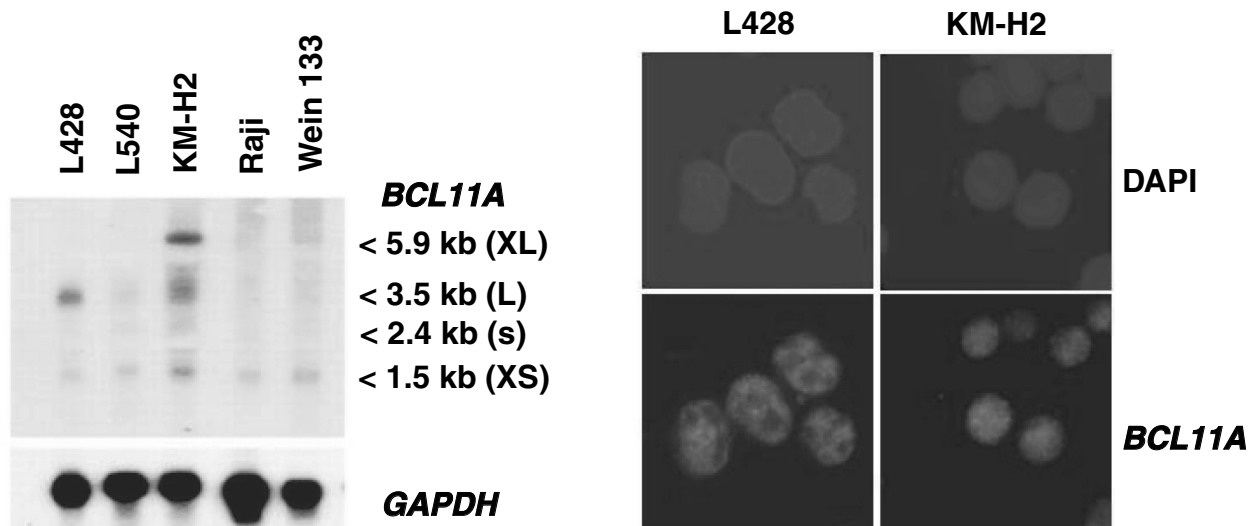
Left Panel: Northern blot showing BCL11A RNA expression in malignant, immortalized human B-cell lines. These include the Burkitt's lymphoma cell lines Raji and Wien 133, and the Hodgkin lymphoma cell lines L428, L540, and KM-H2. *Right Panel:* Immunochemistry using a newly developed monoclonal antibody that recognizes BCL11A documents a high level of endogenous BCL11A protein expression in the human B-cell cancer lines L428 and KM-H2. The size and presence of the nucleus is confirmed by the DAPI stain, which binds DNA and fluoresces blue. BCL11A expression localizes exclusively to the nucleus and appears red via specific binding of the fluorescent-conjugated secondary antibody. The non-B-cell lines COS-7 and NIH-3T3 were negative for BCL11A expression and showed no appreciable signal above background (data not shown).

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and specific methods to observe the physical presence of a protein in a cell is to visually capture it by way of immunochemistry. A primary antibody specific for the BCL11A protein is inserted into a malignant cell and is followed by a secondary antibody conjugated to a fluorescent protein. The secondary antibody is specific for the primary antibody and will emit light from its fluorescent conjugate if excited with the appropriate wavelength of ultraviolet (UV) light. If the primary antibody is able to find its target, BCL11A, it will bind to it and not be rinsed away by a wash step to clear away any excess primary antibody that did not bind its target. Once the secondary antibody is introduced, it will bind its target, the primary antibody that is bound to BCL11A. Again, the cell is rinsed to clear any unbound secondary antibody. The rinsing is necessary to prevent any false positive results. The objective is to only be able to observe antibodies that were able to locate their target in the cell and form the correct target-primary antibody-secondary antibody complex. When the cell is exposed to the appropriate wavelength of light, any bound secondary antibody will become excited and emit light to directly show the presence and location in the cell of the target protein. As displayed here (Figure 1, *right panel*), the presence of BCL11A protein in these malignant B-cell lines was observed. Although much data has been accumulated regarding the expression of BCL11A RNA in human cancers, my data is the first evidence of BCL11A protein expression.

There are four distinct groupings in the left panel of Figure 1 that are labeled XL, L, S, and XS. These groupings are collections of identical RNA fragments that were collected from the respective cell lines, and are representative of the different isoforms of BCL11A RNA that have been found to exist. The nomenclature for the isoforms is a direct representation of the size of the splice product; that is, the XL form is the longest RNA transcript and creates the largest protein product, while XS is the shortest transcript and creates the smallest protein. These different isoforms are generated through alternative splicing events at the RNA level because of an unknown selectivity to either include or exclude certain functional regions of the protein. The

comprehensive function of any or all of these isoforms has not yet been elucidated, but we have definitively identified the cellular localization for all of the isoforms.

At this time, our lab has only been able to procure antibodies specific for the XL and L isoforms, and have been able to observe the endogenous localization of only these isoforms in cancer lines. However, proteins of interest can be artificially deposited by a process known as transfection, in which DNA that codes for a protein is artificially inserted into a cell that will adopt the DNA and synthesize protein from it. This procedure was performed with both S-form and XS-form DNA, which was coupled with the DNA sequence for Green Fluorescent Protein (GFP). The practice is that if the protein for the isoform is expressed, the GFP component will also be expressed as part of the same protein, and the cellular localization will be able to be directly observed under UV excitation. The transfection was successful on both attempts with S and XS, and the cellular localization for both of these isoforms was determined to be exclusively cytoplasmic (Figure 2). As is presented in the right panel of Figure 1, the cellular localization for the XL and L forms is exclusively nuclear.

The significance of the localization of these proteins could be directly related with function. Since the XL and L forms are nuclear, they may have a direct role in the transcriptional regulation of a variety of related and/or unrelated genes, since DNA is only found in the nucleus. The cytoplasmic locale of the S and XS isoforms imply that they may have a role in protein-protein interactions in the cytoplasm, which could have profound affects on protein synthesis, metabolism, and regulation of the cell cycle of replication. However, upon closer examination, the S and XS isoforms were found to contain two unique domains. One was a DNA binding sequence, indicating that they are very likely regulators of transcription, whether through a direct or indirect mechanism. The other domain is a very rare and unique C2HC "Zinc-finger" protein-protein interaction domain that allows proteins that share this domain to form complexes with each other. This domain is shared throughout all of the BCL11A isoforms, but is exceedingly uncommon elsewhere in the genome. The fact that the

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Figure 2	BCL11A isoforms S and XS are localized to the cytoplasm when transfected into COS-7 cells.

GFP-S   GFP-XS

DAPI

GFP
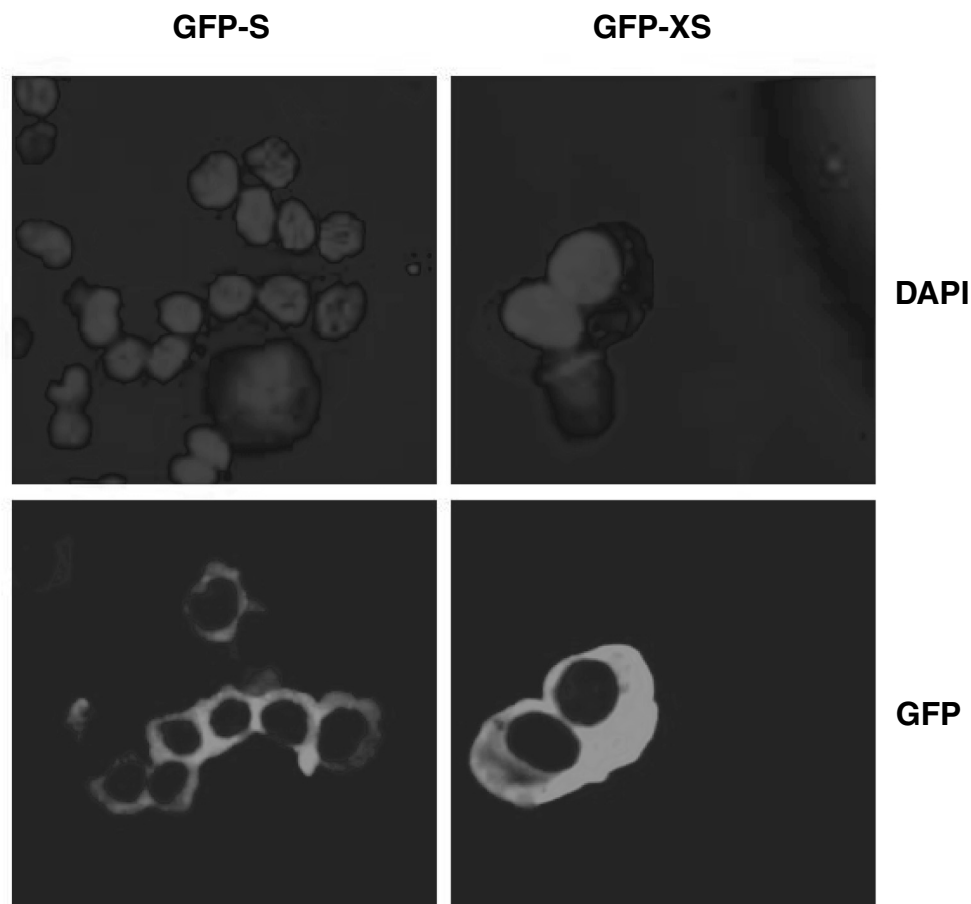
Because there is no antibody specific for the S or XS isoform, artificial expression is the only way to examine their *in vivo* localization. The S and XS isoforms lack Nuclear Localization Signals (NLS), so it is observed that these isoforms exhibit exclusively cytoplasmic localization. DAPI is used to identify the nucleus, and the GFP fusion protein indicates the expression of the isoform to which it is coupled.

S and XS isoforms have DNA binding ability indicates that their true function is probably carried out in the nucleus. This was intriguing because these isoforms lack Nuclear Localization Signals (NLS), which are requisite for a protein to gain entry to the nucleus. The elucidation of the C2HC domain allowed for the speculation that this domain was responsible for the interaction of the different isoforms. This led to the hypothesis that the larger nuclear isoforms (XL and L) were able to recruit S and XS via the C2HC domain and bring them into the nucleus so that their biological function could be carried out.

We have observed data to the effect that when artificially co-expressed in the same cell, the XL and XS isoforms appear in the nucleus together (Figure 3). This has been confirmed by Western Blot, an assay that determines the presence of protein in different cellular compartments (data not shown), and by immunochemistry (Figure 3). This encouraging result has allowed us to now look toward establishing expression profiles

Figure 3 | *When co-expressed in COS-7 cells, XS can be recruited by XL and be re-localized to the nucleus.*

DAPI   **GFP-XS**   **XL**
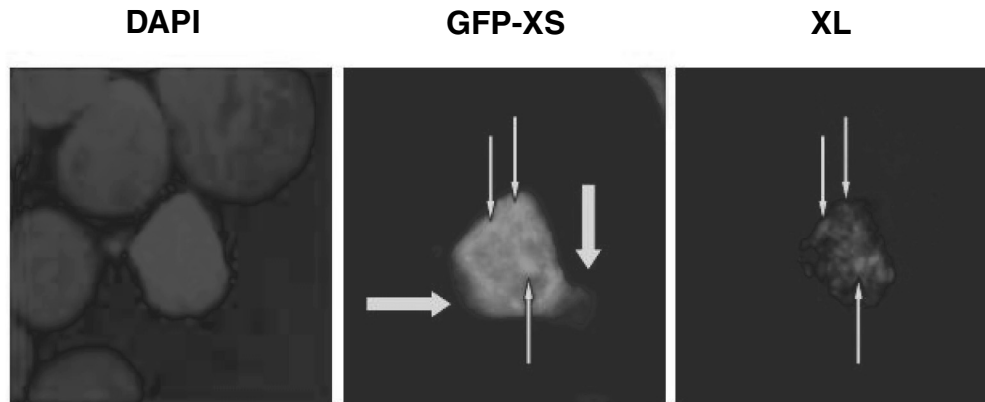
Although an inhabitant of the cytoplasm when expressed by itself, XS can forego an NLS by interacting with XL through the C2HC "Zinc-finger" domain and gain entry to the nucleus. *Middle pane*: The large arrows indicate that some XS remains in the cytoplasm. *Middle and right panes*: Coordinate expression of XS and XL in aggregates is designated by the thin arrows.

in malignant B-cells, where these proteins are expressed endogenously. However, because the XS-specific antibody is still in development, we have yet to acquire any data in B-cell cancer lines.

Better characterization of the functions of these proteins may begin to endow researchers and physicians with tools to combat these types of cancer in patients. The consensus DNA binding sequence of these proteins has yet to be discovered; however, further experiments will give us more information as to what genes it affects the expression profile of, and its interacting partners in the cell. By gaining knowledge as to what proteins and metabolic processes they influence, we may be able to discover the molecular mechanisms that allow the BCL11A family of proteins to convert healthy cells into malignant cells. Because it is often observed in other cancers and is in this case exploited by BCL11A, further elucidation of the processes and mechanisms by which renegade proteins originate and function may open doors to a litany of answers regarding an assortment of cancers and malignancies.

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Army Nurse Corps: Embracing an Evolving Gender Role

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Wading ashore from their transport vessel, the first members of the Army Nurse Corps entered the European Theater on June 10, 1944, just four days after the D-Day invasion of Normandy. Placed on duty only twenty minutes later, Lt. Mary Louise Carpenter remarked: "Of course, we never see the actual immediate destruction of war as it occurs, but we see some of the grimmest results of war."[1] Lt. Carpenter's comment exemplifies the role of the Army combat nurse in World War Two: she did not fight in the war but attended to those who did. Although not a soldier, the combat nurse played a vital role in allied victory. Nurses, like the bandages they used and the letters they transcribed, healed soldiers' physical and psychological wounds. They did this not by challenging traditional gender roles but by working within them,

providing the care of a mother as her patriotic duty. Ironically, while acting within her traditional gender role, the combat nurse discovered hidden talents that would sow the seeds of change and later encourage her to transcend the established role of wife and mother.

The history of United States' military nurses began in 1861 when Dorothea Dix pushed legislation through Congress whereby "untrained civilian nurses also became government contract workers."[2] Although the army only wanted "plain, unattractive women over the age of thirty,"[3] recruitment posters advertising a twelve-dollar a month salary caused many more to apply. Over 3000 women served as Army contract nurses in the Civil War acting more as glorified housekeepers than medical technicians. According to novelist Louisa May Alcott, a nurse's duties included "dusting tables, sewing bandages, keeping my tray tidy, rushing up and down after pillows, bed-linen, sponges, books and directories."[4]

In 1901, through the efforts of Anita Newcomb McGee, a well-known Washington D.C. doctor and assistant surgeon in the army, Congress created the Army Nurse Corps as part of the Army Reorganization Act. Almost forty years later, becoming more certain of the United States' entrance into World War II and recognizing the need for skilled nurses in the military, Congress passed the Bolton Bill. Largely because of this bill, which allotted a combined $4,750,000 for nursing education in 1941 and 1942, the Army Nurse Corps grew from 21,000 active nurses in WWI to almost 60,000 in WWII.[5]

In addition to education, the army required its nurses to be between the ages of twenty-one and forty-five, serve for the duration of the war plus six months, and be unmarried, though as need increased, the army also allowed married women to enlist. Once in the Army Nurse Corps, nurses received varied training. While they were still in the United States, the army schooled some in "bivouacs, marching, obstacle courses, survival courses, and in tropical medicine and chemical warfare;" whereas, others like Louise Connor received no instruction in Army regulations until she was punished for breaking one of the rules.[6] During preparation for Operation Overlord, the army, realizing that its combat nurses needed more training to survive and to work effectively, initiated the first officership education for women. Called a "Commando Course for nurses," the three-week, ten-hours-a-day instruction included "chemical attack defense, military law and courtesy, fire fighting, POWs, booby traps, and many other relevant subjects."[7] For the first time, the military recognized the necessity of training a woman to be a soldier as well as a medical technician.

Life on the Front Lines: Soldiers in Seersucker Dresses

All the training in the world could not have prepared the women of the Army Nurse Corps for the harsh living conditions of the European Theater. In a letter to her parents, June Wandrey wrote of life in France: "I have nothing clean or dry to wear. I've lost sensation in my toes. Walking doesn't help as the ground is so wet and the mud so deep that it goes over the tops of my combat boots and up to my knees."[8] The nurses' living quarters did little to protect them from the elements: the tin huts, freezing and filthy, were nothing short of what one historian described as "a prison-like set up."[9] And, like the soldiers, nurses daily dreaded their C and K rations, which they claimed were barely edible. In fact, Lt. Marjorie Petro remembers when the nurses of the 2nd General Hospital in Lichfield, England were served sandwiches that "proved to be full of worms."[10]

Because the army had no experience outfitting women, a combat nurse's uniform caused her much inconvenience. Problems with sizes and supply often diminished the enthusiasm of newly active nurses. Even if she could acquire a complete uniform in the correct size, a nurse despised her uniform because the olive drab color "made you look like you never took a bath."[11] Having to resort to wearing men's clothing, especially their long underwear and undershirts,[12] made nurses often feel that their male commanding officers lacked concern for them and respect for what they did. By designing the nurse's uniform to be feminine not functional, the men of the army revealed their preference that nurses dress for their gender instead of for their work. Later, the army introduced additional uniforms such as a seersucker dress,

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but a nurse's most valued piece of clothing remained her helmet. As the January 1945 issue of *The Army Nurse* illustrated: "It's a hat, a bucket, washtub, bathtub, and chair, and in a pinch serves as a shovel for digging an emergency foxhole."[13] The virtues of a nurse's helmet mirrored those of its wearer: practical, resourceful, and resilient.

The duties of a nurse both embraced and defied her traditional gender role as a wife and mother. Above all nurses acted as caregivers to soldiers, who, after being wounded, often behaved like boys instead of men. A nurse's unofficial duties ranged from writing letters home for a soldier to smiling at him when circumstances turned grim. Though deprived herself, a nurse like June Wandrey gave all she had to her patients: "I took (the box of 24 Hershey bars) to work, broke it into tiny pieces, and offered each patient some...They were so excited and pleased, they'd just grab my hand and hold it."[14] Playing an important part in their psychological recovery, nurses acting as mothers or sisters made soldiers feel loved and treated them as people instead of cogs in the machine of war. One soldier told Capt. Jean Trucky that she was "the first one to tuck him in since he left the States."[15] By working through her gender role instead of against it, a nurse discovered her true strength in a time of crisis. June Wandrey wrote to her mother that the hardest job was "trying to smile when all you wanted to do was wash your face and curl up on the ground and get a bit of sleep-while the men kept shouting 'Air raid. Damn. Get those lights out.'"[16]

As well as providing care and compassion, nurses acted as skilled medical technicians. Because there was so much need, combat nurses broke down gender boundaries by executing medical procedures previously reserved for male doctors. Between December 1944 and February 1945, army hospitals admitted 78,000 patients, forcing nurses to work up to twenty-four and thirty-six hours straight, perform blood transfusions, and administer intravenous medications. According to historian Diane Fessler author of *No Time For Fear: Voices of American Military Nurses in World War II*, "Objections to nurses being close to front lines, or performing duties that had only been done by doctors, were put aside as need overtook old-fashioned

standards."[17] Because most schools failed to train them in such procedures, combat nurses had to "learn a lot of things right on the spot."[18] Doing so, a nurse discovered that her ability and intelligence was equal to that of a man. June Wandrey knew that her skills could not only to save an individual life but also help win the war: "Blood is like gold, we can't afford to waste it."[19]

As part of mobile field hospitals, expert nurses followed the movements of the troops so that soldiers could be patched-up and sent back to the front. Doing this, combat nurses put their own lives in danger. During the Battle of the Bulge, from December 16 to December 26, 1944, hospitals had to move several times to avoid enemy encounters: a handful of nurses from the 67th stayed behind with over 200 soldiers too weak to be moved only to be evacuated just before the Germans would have captured them.[20] Lorraine Krause wrote to her family of the Battle of the Bulge: "We may be winning alright, but even so it is costing a price. . . Remember when the news sounds good we are the busiest."[21] Because of the efforts of combat nurses, the hospitals of the European front had the lowest mortality rate of all theaters of operations at 3.2 percent, or 12, 353 deaths out of 393,987 wounded admitted.[22]

To achieve such success, combat nurses integrated two traditional gender roles, the care and nurturance of a stereotypical woman with the strength and intelligence often associated with a man. June Wandrey said of herself, "Survivor is my middle name."[23] Before she left the States, she never would have held a shower in higher regard than a promotion. Like June, the members of the Army Nurse Corps quickly learned that comfort came second to care and that self followed service as well. She performed blood transfusions with the skill of a doctor while smiling with the compassion of a woman. Although acting within her gender role, through her experiences at the front, a combat nurse began to see herself as the equal of a man.

Resisting Evolving Gender Roles: Soldiers and American Society

Many soldiers developed respect for nurses after serving with them and sharing all the exhaustion, pain,

and death the front had to offer. Lt. Mary Ferrell remembers when one of her badly wounded patients looked up at her during a plasma transfusion and said, "You are here in hell with us!"[24] Like Ferrell, fellow nurse Helen McKee felt that because of their role as caregivers, nurses were closer to the "boys" and shared in their pain even more than their male superior officers.[25] To show their gratitude, hundreds of soldiers signed a letter to the military newspaper *Stars and Stripes* lauding the nurses' efforts and thanking them for volunteering. In it, 1st Lt. Chester S. Wright, Jr. wrote: "(Nurses) are really just women, like your sister, but they have proved beyond doubt that they have the 'guts' of the best soldier. All the praise, honor, and respect we can shower on the ANC cannot begin to compare to the glory each of them earns each day as an American soldier."[26] Twice using the word "soldier" to describe nurses, Wright as well as the hundreds of others clearly viewed nurses as their equals. She was not just a nurturing woman, but a warrior as well. The praise of Gen. MacArthur in the January 1945 issue of *The Army Nurse* echoes this duality: "Through the mud and mire, through murk of campaign and battle, wherever the fight leads, she patiently, gallantly seeks the wounded and distressed."[27]

Unfortunately, some soldiers still clung to conceptions of conventional gender roles, which dictated men to be more important and more intelligent than women, and degraded the very nurses who fought to save their lives. One patient shouted at June Wandrey, "You are nothing but a bedpan commando like all army nurses!" Although she had too much self-respect to believe him, Wandrey could forget her critic: "His words are burned into my brain."[28] Some soldiers felt threatened by nurses who were educated, confident, and entered the army as officers. Major Shirley Payne Sweet remembers the contempt in the voice of male officer, who sneered "Jesus Christ, a major."[29] Others still viewed nurses as dispensable, companions to entertain the married officers and decorations to make the front more pleasant for the GIs.[30] Ironically, June Wandrey recalls feeling the most degraded at a ceremony intended to honor her profession: "The General gave me a corsage and expected a kiss for it. . . he made me feel like a prize yearling in the auction ring."[31]

Despite some degrading experiences where they were treated more as doctor's handmaidens than medical technicians, nurses generally enjoyed better treatment than other servicewomen. In her book, *They Also Served: American Women in World War II*, Olga Gruhzit-Hoyt argues that this was because nursing lay within the woman's sphere-the traditional gender role of nurturing wife and mother.[32] Before the outbreak of World War II, the majority of Americans believed that a married woman's only job should be raising her children to be good citizens. All her education, intelligence, and skill should enable her only to care for her family. Until she was married, however, a young woman could work in a suitable field, such as nursing, which prepared her for the responsibilities of motherhood.[33]

With the bombing of Pearl Harbor and the entrance of the United States into the Second World War, the need for skilled nurses undercut adherence to conventional standards. A society that had said women should not work outside of the home and, moreover, that innately fragile women were not suited for the front sent nurses to the front lines of Africa, Italy, and Europe. The words of one injured paratrooper express the conflicted feelings of many soldiers: "It's too dangerous for a woman (to be close to the front). It's good to see them, though, when you come into a hospital. You get the feeling that everything is going to be all right."[34] Although he still harbors preconceived gender stereotypes, this paratrooper appreciates the work of a nurse and remains grateful for her presence. He and others on the front, it seems, needed a mother's care to comfort their fears and heal their psychological wounds.

Members of the Women's Army Corps (WAC), on the other hand, were not so easily accepted by the military. Originally named the Women's Auxiliary Army Corps and established in 1942, the WAC freed men to fight by placing women in low-level and administrative jobs, such as cooks, typists, and secretaries. Women such as Ohio Representative Edith Nourse Rogers, who wrote the bill that created the WAC, believed that women could play a vital role in the war effort. Lobbying for the creation of the WAC, Rogers stressed that the evolution of war required the participation of women: "total

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war, no limitations of battlefields, nor gender of its participants. . . to win, every resource, every service must be utilized."[35]

Even though members of the WAC worked in areas that were considered monotonous, mindless, and therefore fit for women, men did not want women invading their army. Showing how firmly gender stereotypes were embedded in American society, most males rejected the Women's Army Corps. The assessment of General George S. Patton exemplifies their sentiments that "war is for men."[36] Even supporters of the WAC such as General Dwight D. Eisenhower trivialized its importance: "after an enlistment or two enlistments woman will ordinarily-and thank God-they will get married."[37]

More vicious was the 1943 slander campaign against the Women's Army Corps, in which editorialists and cartoonists accused Wacs of everything from lesbianism to heterosexual promiscuity. One journalist's logic epitomizes old-fashioned thinking: "Wouldn't it be wiser to just leave them out of the armed forces, and encourage them to marry, produce children, and contribute the old, natural way to the war effort?"[38] Historian Leisa Meyer asserts that above all men felt threatened by a woman whose economic independence allowed her to take over the male position as household provider and thus usurp his power.[39] By arguing that women should stay in the home, men betrayed their fears that in the unpredictable post-war economy, women might gain dominance over them.

Although one group was stigmatized and the other was not, Wacs and nurses enlisted for many of the same reasons. In her memoir, *Call of Duty: A Montana Girl in World War II*, Grace Porter Miller remembers why she and other ex-servicewomen joined the Women's Army Corps despite the slander campaign: "For love of our country and our way of life and for the safety of loved ones, all of which were being seriously threatened at that time."[40] Even though Miller and other Wacs were accused of challenging gender roles, their reason for joining seems stereotypically feminine. Seeking to protect children, husbands, and brothers abroad, she sacrificed herself to bring an end to the war and to ensure a safe return for her loved ones.

The disparate treatment of members of the Army Nurse Corps and members of the Women's Army Corps by both the military and the public illustrates the rigid gender stereotypes of the 1940's. Paradoxically, according to conventional gender roles, it was more appropriate for a woman to be on the front lines acting as a combat nurse than it was for a woman to remain in the United States as part of the WAC and work as an office manager. The Army treated Wacs like second-class citizens while it automatically commissioned nurses as officers. Nevertheless, through both derision and praise, Wacs and nurses gained pride in both themselves and their work. Although they did not shatter the concept of the woman's sphere, nurses worked through it in order to expand its boundaries. To the responsibilities of wife and mother, combat nurses could add the titles of medical technician and soldier. Though she might still be subject to the rules and regulations of the army, when she returned to civilian life, a nurse like June Wandrey would never again "take a lot of demeaning abuse from some second-class dim-bulbs who couldn't whip their way out of a wet paper bag."[41] She had become independent—physically, intellectually, and economically.

Evolving Gender Expectations in a Post-War World

When she returned home five months after V-E Day, June Wandrey expected to receive the same recognition as the soldiers she considered her equals. Instead, she and her fellow nurses were forgotten: "we disembarked into a shabby area-no bands, no flags, no welcoming crowds. A few bums shuffled along the Southern Railroad tracks, two scrawny, lonely dogs sniffing after them."[42] While an army nurse had developed respect for herself on the front lines, citizens on the home front heard little of her contributions. Remembering that she was also "ignored" upon her arrival home, Grace Porter Miller contends that "men think that acknowledging that women served in the armed forces overseas during wartime would somehow detract from their own achievements as males."[43] In other words, to praise women publicly for their valiant deeds would be to challenge the gender stereotype of man as hero and women

as damsel in distress. Nurses did serve courageously, though. Over 1600 were decorated for "meritorious service and bravery under fire."[44]

Even though it gave nurses a fraction of attention and adulation given to soldiers, the military offered all veterans the opportunity to attend college with financial support through the G.I. Bill of Rights. Almost 65,000 ex-servicewomen took advantage of the G.I. Bill to complete college or graduate studies.[45] In a January 1946 letter to her parents, June Kintzel wrote: "Another decision I made this past week was what I'm going to major in college. It's meteorology. . . I could work for either the airlines or perhaps the government." After three years at the University of Wisconsin, Kintzel received a B.S. degree in geography and took a position with the Central Intelligence Agency as a cartographic compiler.[46] According to historian Connie L. Reeves the G.I. Bill provided ex-servicewomen the opportunity to obtain a higher education without the stigma of being un-feminine for stepping out of the traditional role of wife and mother.[47] Attending college became an act of patriotic duty instead of one of self serving ambition.

Although after World War II the number of women graduating from college increased, the gap between them and the number of college-educated men also increased. The 65,000 women educated under the G.I. Bill accounted for only 3 percent of the 2,232,000 total veterans who shared in its benefits.[48] Of these women only half became employed in the type of work they wanted. Those who were most successful obtained degrees in conventionally female fields such as teaching, nursing, and secretarial work.[49] Ironically, though the G.I. Bill enabled a woman to earn the same degree as a man without the risk of castigation, society largely prevented her from entering one of the professions allotted to men and required her to take a job that adhered to her traditional gender role of nurturer.

Though all ex-servicewomen had the opportunity to advance their educations through the G.I. Bill, by early 1947, 22 percent of nurses had married and a total of 38 percent had quit their professions.[50] In an August 1944 letter to her family, Ruth Hess explained the feelings of many military nurses who chose to leave their professions

after the war: "machine guns all around-whiz-there goes a bullet-It really doesn't spare you. . . The life of an army nurse in combat-I love it-but just the same I'm anxious to get back home, marry, have a family of six children, and enjoy the respect of the community as a doctor's wife."[51] Hess's commentary demonstrates that even women such as combat nurses, who challenged gender roles by joining soldiers on the front lines, often still believed in these conventions. Hess and others who quit nursing continued the pre-World War II opinion that the only way for a woman to achieve fulfillment in her life was through her husband and children. After a nurse returned home, her duty to her country ended, but her duty to her family had just begun.

In September 1945, Surgeon General Thomas Parran pleaded with young nurses to forgo marriage, at least temporarily, and work to replace both the military and civilian nurses who had quit the profession: "It is imperative that every one of you as young graduates accepts a position which is essential to our nursing service in this national emergency."[52] The exodus of nurses from the workforce combined with soldiers returning from war (which resulted in an increased birth rate, wounded veterans needing rehabilitation, and higher enrollment in government provided health insurance) caused a shortage of nurses that measured 46 percent in 1947. Paradoxically, this same shortage, caused in part by nurses who quit their jobs for marriage, created such a need for nurses that employers began encouraging married ex-nurses to reenter the workforce. Just as war made it acceptable for nurses to work on the front lines, the nurse shortage made it acceptable for women to have a husband, family, and a profession.

Employers began to recruit married nurses with benefits such as part-time scheduling, day care facilities, refresher courses, and increased salary. In a postwar economy where women had lost one million factory, half a million clerical, 300,000 commercial service, and 100,000 sales jobs, the recruitment of women was both rare and appealing. Those women allowed to keep their blue-collar jobs often had their salaries cut and benefits reduced.[53] The end of World War II and the return of the men who had served signaled the end of

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the unique period in which society approved of women taking jobs both outside of the home and in areas where only men had previously worked. Because her profession was encompassed by the women's sphere and because her services were desperately needed, a nurse could work outside of the home without the fear of losing her job to a man or the risk of reprisal for shirking her duties to her family.

Although many women were attracted to nursing for self-fulfillment and for economic reasons, most justified their employment in terms appropriate for her gender role as caregiver: public service. In an article published in a 1955 edition of the *American Journal of Nursing*, Louise Alcott explained, "I am sure there are times when I would not feel justified in leaving my home. . . if I were doing to solely to satisfy my desire to continue my career, but my family feels that I am making a worthwhile contribution."[54] The percent of married nurses in the labor force increased from 42 to 66 between 1949 and 1966[55]—evidence of the relaxation of traditional gender roles that forbid middle-class married women from working Marriage no longer represented an obstacle for women who wished to exercise their intelligence and authority both within and outside of their homes.

Encouraging ex-Army Nurse Corps members to rejoin the workforce, Rep. Frances P. Bolton, author of the Bolton Bill that provided support for nursing education, wrote in the *American Journal of Nursing*, "(nursing) prepares you to meet the shock of the devastation man has wrought in God's world and fits you to take your part, your woman's part of re-creation in the world that we must build upon the ashes of that which has been destroyed."[56] Though most no longer served in the military, nurses who continued to practice or who returned to work after marriage served their country by caring for its civilians. Bolton's commentary exemplifies how the experience of a combat nurse during World War II allowed her both to embrace her traditional female role as caregiver and to seek to expand this role beyond the home and into the larger world.

The attitudes of ex-ANCs Emma Porteus and Signe Scott Cooper illustrate both results of a combat nurse's

experience. Emma Porteus' service increased her capacity to care: "I put my military experience behind to look toward a new normal life in our free country with more understanding and concern for fellow human beings."[57] On the other hand, Signe Scott Cooper's service stymied her submission: "We had carried a lot of responsibility during the war, and we were not going back to the 'physician's handmaiden' role. We had learned to be assertive, to demand recognition for our abilities and skills."[58] Taken together, these women represent female gender roles after World War II: two dimensional. On one hand she embraces her traditional gender role as nurturer, but on the other, she realizes her new role as an equal to man.

Conclusion

Although the Army sought to affirm conventional gender expectations through its policies regarding the recruitment, clothing, and training of nurses, and although many soldiers preferred to view them as typically feminine nurturers, combat nurses managed to transcend their established roles as wives and mothers. Through her experiences on the front lines, a nurse learned both to use gender expectations and to defy them in order to better care for her patients. Displays of womanly compassion healed a soldier's psychological wounds at the same time that nurses' increasing medical skill mended his physical ailments. Sharing the demanding conditions of winter in the European Theater allowed nurses to discover their strengths beyond the traditional caring and nurturing. And while soldiers qualified their praise for the role of nurses in winning the war, nurses understood that their contribution was equal to that of men. This growing sense of confidence would continue to benefit nurses after the war. By comparing the post-war gains of nurses with those of women who were employed in the war industry, we can see that nurses' professional, educational, and economic advancements far outreach those of any other women's group. Nurses represent the first group of women who were encouraged to work and to believe that having a family did not conflict with their work. When I began this project I expected to find that

nurses had struggled throughout against restrictive gender expectations. Instead, I found women who had the courage to first accept conventional gender expectations in order to perform their professional duties and then to exceed these expectations, both in word and deed, to expand the boundaries of the woman's sphere.

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Overbank Flooding and Sedimentation Patterns in a Floodplain Environment, Lower Guadalupe River, Texas

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Abstract

This study examines the spatial variability of floodplain deposits in a meander cutoff (oxbow) on the Lower Guadalupe River, Texas, in response to a large flood event. During the first week of July 2002, the middle and upper reaches of the watershed received more than 89 cm of rainfall, which exceeded the average annual rate of precipitation and generated basin-wide flooding. A field site was established in Gonzales, Texas to examine the variability of thickness and particle size of the flood deposits. The pattern of sedimentation was considered with regard to local valley-scale controls including, channel geometry, valley and floodplain topography, and vegetation. Standard field and laboratory methods were used to characterize the thickness and grain size of the flood

deposits. Field procedures involved measuring the thickness of the deposits along six, 35-50 m transects extended across the abandoned meander. Laboratory procedures involved standard hydrometer and wet sieve grain size analysis in the Applied Geomorphology and Geoarcheology Laboratory at the University of Texas at Austin. Secondary data sources included United States Geological Survey (USGS) hydrologic stream flow data and USGS 1:24,000 scale topographic maps. The results indicate that there was a large amount of variability in the thickness and particle size of the flood deposits. The average thickness was 10.7 cm, which covered a range between 1.2 cm and 28.8 cm. The particle size (% finer than sand, 0.063 mm) of flood deposits ranged between 17-96 % < sand, with an average of 56 % < sand. Local channel geometry, floodplain topography, and vegetation appeared to be the dominant controls on the patterns of flood deposits.

Introduction

Floodplains of meandering river comprise one of the most complex environments on the earth's surface, and are of interest to a variety of earth science specialists, including geomorphologists and ecologists. Fluvial geomorphologists are interested in the physical watershed processes that influence landscapes; and ecologists are interested in the diversity of habitats associated with riparian environments.

By definition, floodplains include channel and near channel environments that are directly influenced by modern river-related processes, and are comprised of a complex mosaic of depositional features created by the interaction between flowing water and sediment deposition. Lateral accretion processes form channel deposits such as point bars, while flood processes are responsible for the vertical building of floodplains, evident by features such as,

Figure 1 | *Depositional features in a meandering river floodplain (modified from Saucier 1994).*
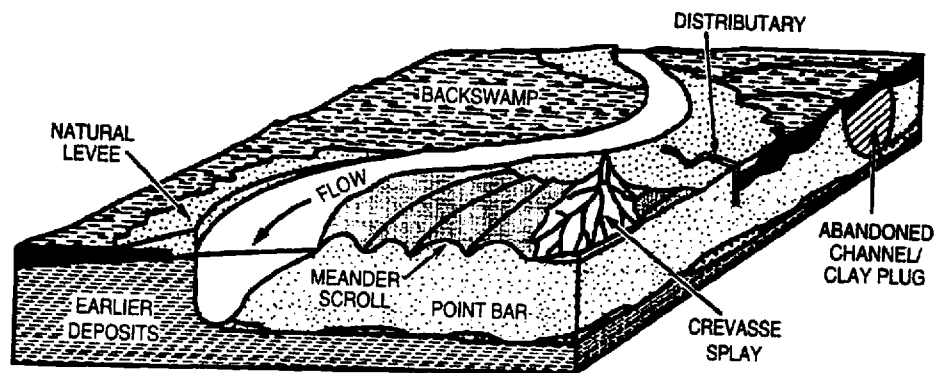

Table 1 | *Dominant processes controlling floodplain deposits, and range in sediment sizes*

Statistic	Thickness (cm)	% finer < 0.063 (mm)
Average:	10.71	55.54
Standard dev:	5.87	21.02
Minimum:	1.15	17.20
Maximum:	28.75	95.86

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Figure 2 | *Model of oxbow cutoff and infilling (after Saucier 1994). (A) original meander bend, (B) cutoff and initial stages of infilling, (C) later stages of oxbow infilling, presence of wetlands. (D) At this stage the oxbow is completely sealed off from the active river channel except during overbank flows.*
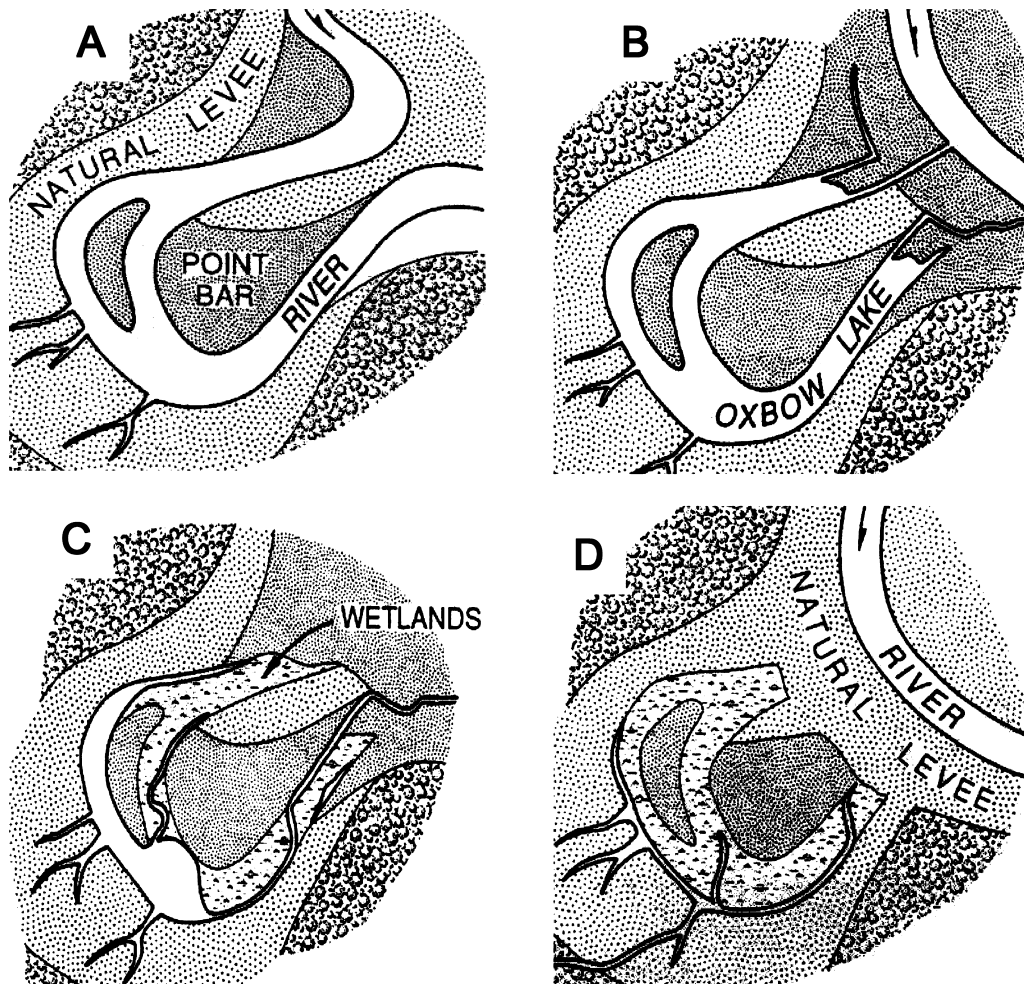
natural levees, backswamps, crevasse channels, splays, etc. (Figure 1, Table 1).

Whereas most of the previously mentioned features result from lateral accretion or overbank flooding, abandoned meander cutoffs (commonly called oxbows) represent a combination of both processes (Figure 1, Table 1). They are formed when the river channel cuts off a meander bend, creating a shorter channel distance and steeper gradient. After cut-off, the oxbow is

eventually plugged with lateral accretion and overbank deposits. At first, lateral accretion provides most of the sediments, consisting of coarse sand and gravel wedges at the upstream and downstream neck. Overbank flooding then becomes the dominant sediment source, contributing primarily finer-grained materials that eventually fill the abandoned channel (Figure 2).

A large flood event in July 2002 provided an ideal opportunity to investigate the spatial patterns of

overbank deposits in an abandoned meander on the Guadalupe River floodplain at Gonzales, Texas. I measured the thickness and particle size of these deposits in relation to local valley-scale controls on floodplain sedimentation, including channel geometry, valley and floodplain topography, and vegetation. These controls influence sediment delivery to and across the floodplain during overbank flooding events.

Problem Statement and Research Significance

Classic studies conducted on the Mississippi River (Fisk 1944, Allen 1965, Page and Mowbray 1982, Saucier 1994) suggest that oxbows contain uniformly fine-grained sediments, hence their lay term "clay plugs". However, more recent researchers (Erskine and Melville 1982, Bridge et al. 1986, Erskine et al. 1992, Hooke 1995) have reported that large floods have been responsible for contributing significant thickness and particle size variability to oxbow sedimentation. Although there have been many flood sedimentation studies (Pizzuto 1987, Mariott 1992, Gomez et al. 1997, Asselman and Middlekoop 1995, 1997, Magilligan et al. 1998), few have dealt specifically with oxbow environments. A goal of this study is to document these results based upon high-resolution sediment data from the July 2002 flood.

From a biological viewpoint, abandoned meanders occupy a sensitive ecological niche by linking the river to its floodplain. Overbank flooding creates a nutrient- and carbon-rich lacustrine wetland environment, supporting habitat for a variety of riparian species (Nilsson and Berggren 2000, Graf et al. 2002). Because the Canyon Lake Dam and Reservoir regulate Guadalupe River discharge, the summer 2002 flood was especially significant because extensive flooding occurred downstream from the reservoir. Thus, these flood deposits help to indicate the downstream impact that a dam may place on sediment sources and loads (Phillips 2001 and 2003), with significance for river regulation practices and riparian restoration (Graff 2001, Stromberg 2001). Furthermore, because event based sediment data has not been previously obtained from the Guadalupe River floodplain, this research provides a comprehensive base line for future investigations.

Oxbow Sedimentation

Although, there are many descriptions of abandoned meander cutoffs and channel infilling (Allen 1965, Lewis and Lewin 1983, Gagliano and Howard 1984, Erskine et al. 1992, Saucier 1994) only a few studies have documented active infilling processes (Hooke 1995). Successive sedimentation events result in a distinctive sequence of geomorphic and ecological change. For example, we can demarcate the contribution of single flood events, (Erskine and Melville 1982, Erskine et al 1992, Hooke 1995, Bridge 1986), which can be extended to interpreting watershed controls over decadal, annual, and millennial time scales.

Erskine et al. (1992), found dramatic differences in flood deposits over the last century. Thin-bedded, fine-grained sediments deposited during early drought regimes (pre-1949), contrasted with thicker, coarser, deposits that accumulated during a flood dominated regime (post 1949). Erskine and Melville (1982) and Bridge (1986) noted a correlation between spatial variability of particle sizes in abandoned meanders, and magnitude of flood events. For example, on the lower reaches of the Macdonald River, Macdonald, Australia, laminations of sandy loam and silty stratifications were overlain by 10 cm of coarse sand deposited by a large flood in March 1978 (Erskine and Melville 1982). Based on these flood sedimentation studies, it is unlikely that oxbow deposits at Gonzales would be uniformly fine grained. Instead, it is expected that the large July 2002 flood may be responsible for contributing variable thickness and particle size patterns to oxbow infilling.

Physical Setting

The Guadalupe River emerges from its spring-fed headwaters in central Texas, commonly referred to as the "Texas Hill Country," and flows more than 600 km before draining into San Antonio Bay and eventually the Gulf of Mexico. Its total drainage area, excluding the San Antonio River Basin (which joins the Guadalupe

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River less than 10 km upstream from the Gulf of Mexico) is 17,400 km².

The Guadalupe headwaters are located in the eastern portions of the Edwards Plateau, which is primarily composed of thick, nearly horizontal, massively-bedded, Cretaceous limestone. Incised valleys, steep slopes, and thin soils characterize this region. Exiting the Edwards Plateau, the river crosses the Balcones Escarpment, a complex system of faults that separates the uplifted Edwards Plateau from the seaward dipping Gulf Coastal Plain units. These units, of late Cretaceous to early Quaternary age, are comprised mostly of Tertiary sandstone and shale (Bureau of Economic Geology 1992). The field site is located along the Lower Guadalupe River in the Gulf Coastal Plain, at Gonzales, Texas, approximately mid way between the Balcones Escarpment and Gulf of Mexico (Figure 3).

Annual precipitation varies within the drainage basin from ~76 cm at its headwaters to ~101 cm nearer to the coast. In central Texas, high-pressure Pacific and low-pressure Gulf Coast systems often stall over the region, dropping massive quantities of precipitation, triggering flash flooding (Baker 1977). During the July 2002 precipitation event, more than 89 cm of rain fell over a period of eight days.

Study Site: Gonzales, Texas

Upstream from Gonzales, the Guadalupe drainage basin comprises 9,039 km², with an average discharge of 632 cubic meters per second (m³/s). The river meanders through a wide valley of Quaternary alluvium, characterized by a sinuosity index of 2.9.

The floodplain is used locally for cattle grazing and natural growth pecan orchards. Thick riparian vegetation consists of trailing and climbing vines, short and tall grasses, dense shrub, and old growth pecan trees. The downstream neck of the oxbow is almost entirely in-filled, and has slowly begun to vegetate (Figure 4), whereas the upstream limb draining to the active channel is lined by stabilized vegetation and is seasonally inundated (Figure 5). The middle bend of the oxbow is seasonally inundated except where a thick clump of

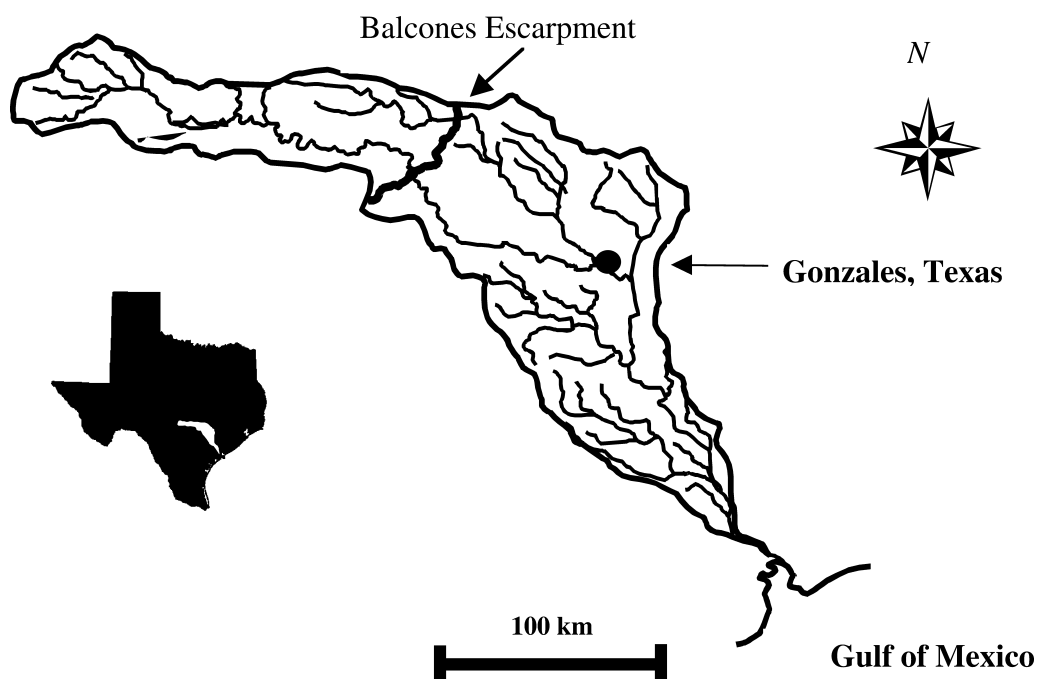**Figure 3** | *Map of Guadalupe River and location of field site, Gonzales, Texas.*

| *Figure 4* | *Downstream neck of partially infilled oxbow, Gonzales, TX. Note fresh deposits on surface.* |

| *Figure 5* | Upstream neck of oxbow, Gonzales, TX. |

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willows and other wetland species have slowly begun to vegetate the oxbow (Figure 6).

Summer 2002 Flood Event

The summer 2002 flood event, of moderate magnitude, persisted 10 days (Figure 7), with a recurrence interval (RI) of 9.5 years (Figure 8). Peak discharge occurred on July 7, 2003 at 1,422 (m³/s) but it was preceded two days earlier by a smaller peak of 1,209 (m³/s). A combination of events upstream was responsible for the multiple, flashy peaks and increased discharge. These include precipitation fluctuations, tributary inputs, and floodwaters that overtopped the Canyon Lake spillway on July 4th, 2002.

Field and Laboratory Methods

Data sources include USGS topographic (1:24,000) and geologic maps (1:500,000), and USGS daily value hydrologic data for the Gonzales Station #08173900. I performed standard field sediment sampling and laboratory particle size analysis during fall 2002 and spring 2003.

Field Techniques

Field sediment sampling consisted of 6 transects run along cross sections of the oxbow from the relict point bar bank to the outer cutbank. Oxbow transects vary between 30-50 m, dependent upon the width of the abandoned channel. Four additional 100 m transects were run from the active bank into the floodplain (Figure 9). I measured transects using a tape, collected samples using a shovel and trowel, and measured sediment depth with a metric ruler. A leaf litter layer buried by the 2002 deposits provided a clear distinguishable marker, as the leaves had not begun to decompose.

The topographic relief of the floodplain surface and local channel geometry were interpreted from 1:24,000 scale maps, these were useful to determine the movement of overbank flow from the main channel across the floodplain. Field observations provided more detailed geomorphic information pertaining to ridges and swales and natural levees, which may influence sediment transport and deposition.

Figure 7 | Summer 2002 flood hydrograph, Gonzales, Texas, USGS gauging station #08173900.
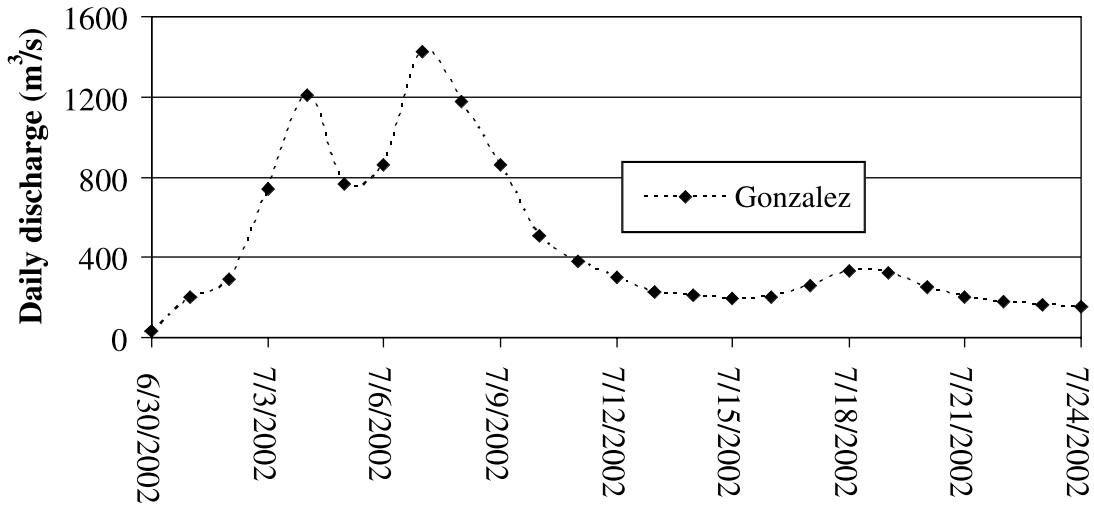

Figure 8 | Flood Recurrence Interval, Gonzales, Texas, USGS gauging station #08173900.
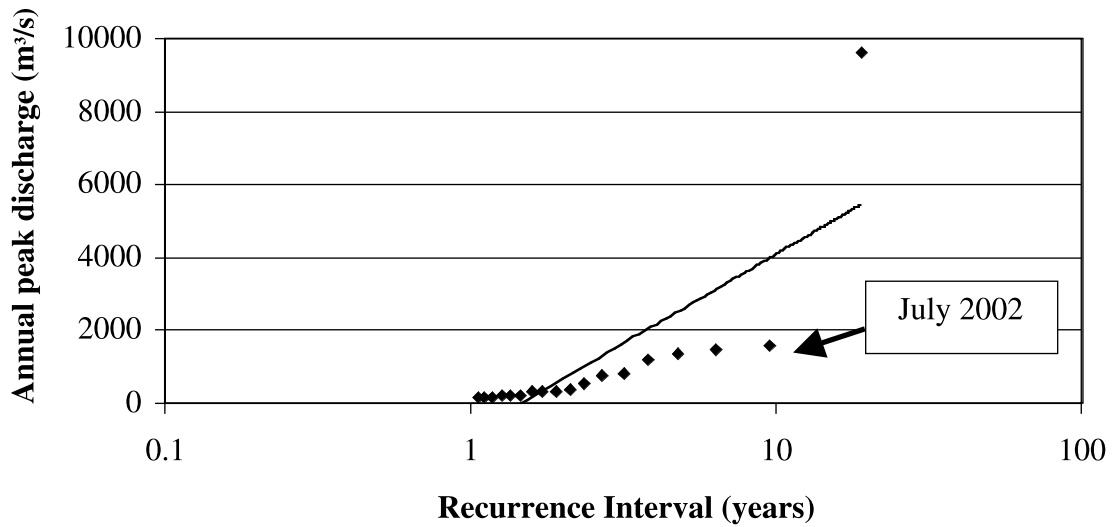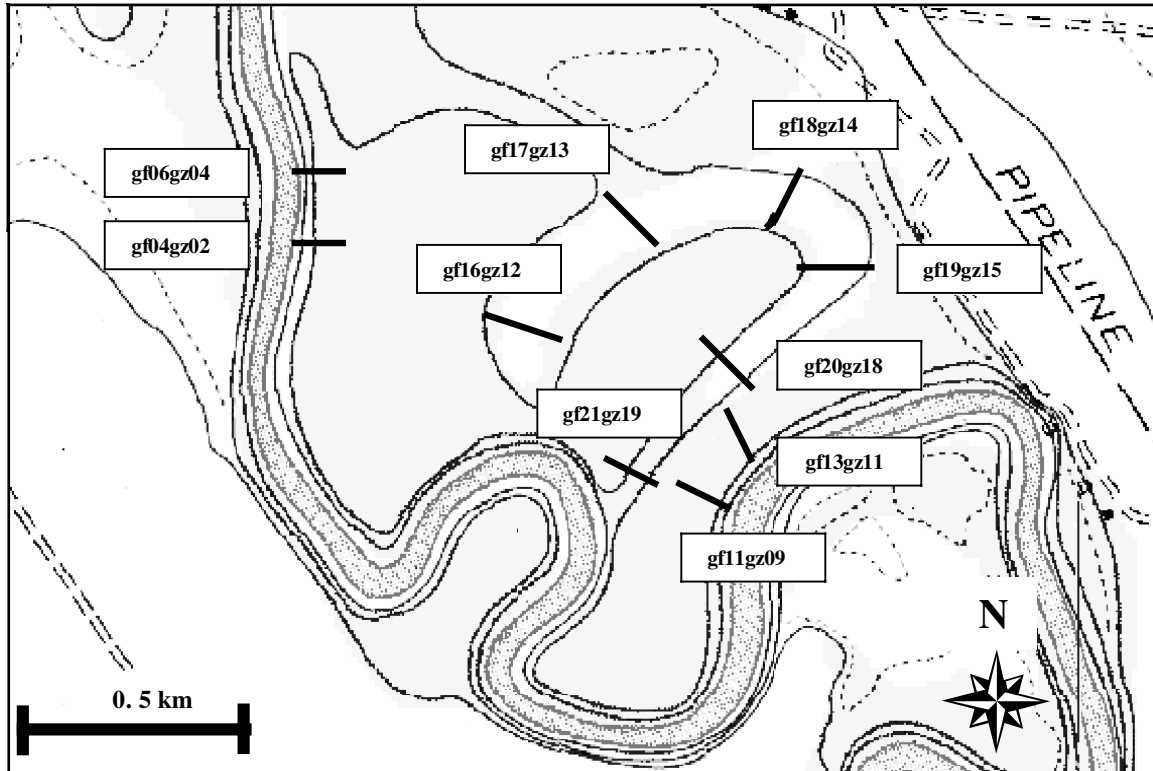

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| **Figure 9** | *Location and identification of transects (length not to scale). Arrows indicate direction of flow across the floodplain (USGS 1987).* |

Laboratory Analysis

I subjected the sediment samples to standard hydrometer and wet sieving techniques at the Geomorphology and Geoarchaeology Lab in the Geography Department at the University of Texas at Austin (see Gee and Bauder 1986), to estimate the particle size distribution of the clay, silt, and sand components in each sample.

The hydrometer analysis detects the clay and silt components (0.002 - 0.063 mm), while the wet sieve technique detects the fine to coarse sand components (0.063 - 2.0 mm). Results from the hydrometer and wet sieve analysis were plotted on cumulative grain size curves in Microsoft Excel, which were used to estimate the % of each sample consisting of particles finer than sand (0.063 mm). This value is calculated as an average using the coarsest percentage recorded from the hydrometer analysis and the finest percentage recorded from the wet sieve analysis.

Results

The data indicate high local variability in thickness and particle size, both between and along transects (Figure 10, Figure 11). Regardless of the high spatial variability, a few trends exist. Transects along the draining neck closest to the active channel, gf21gz17 and gf20gz16, have the thinnest mid-channel deposits, at 1.5 cm and 3 cm respectively. Transects crossing the furthest curvatures, gf18gz16 and gf16gz12, have the thickest mid-channel measurements, 16.0 cm to 13.0 cm, respectively.

Deposits measured near the point bar and cutbank of the abandoned meander were thickest along the upstream neck of the oxbow. Sediment in transects gf20gz16 and gf17gz13 were thickest near the relict cutbank, with depth measurements of 27 cm and 12 cm respectively. The thickest point bar deposit was 23 cm, also measured from the upstream neck along transect gf19gz15.

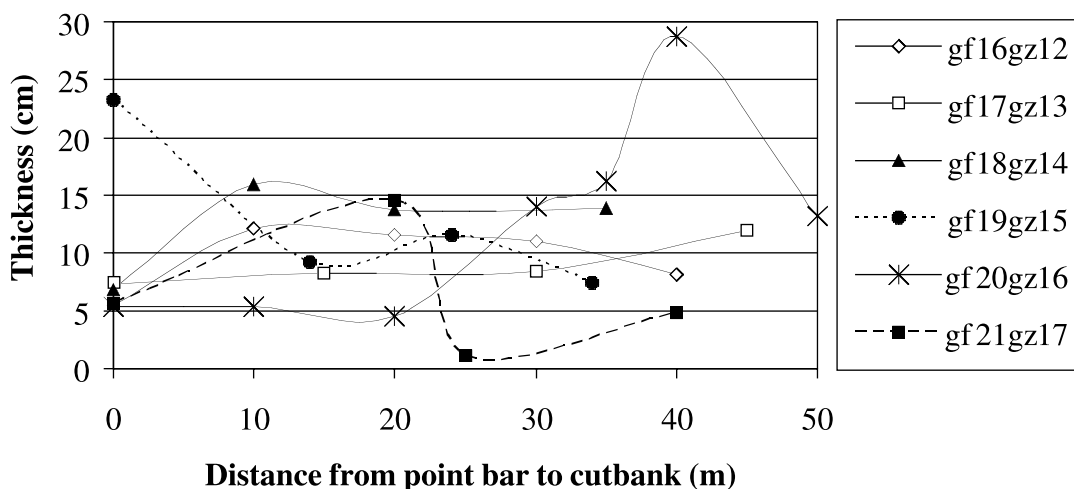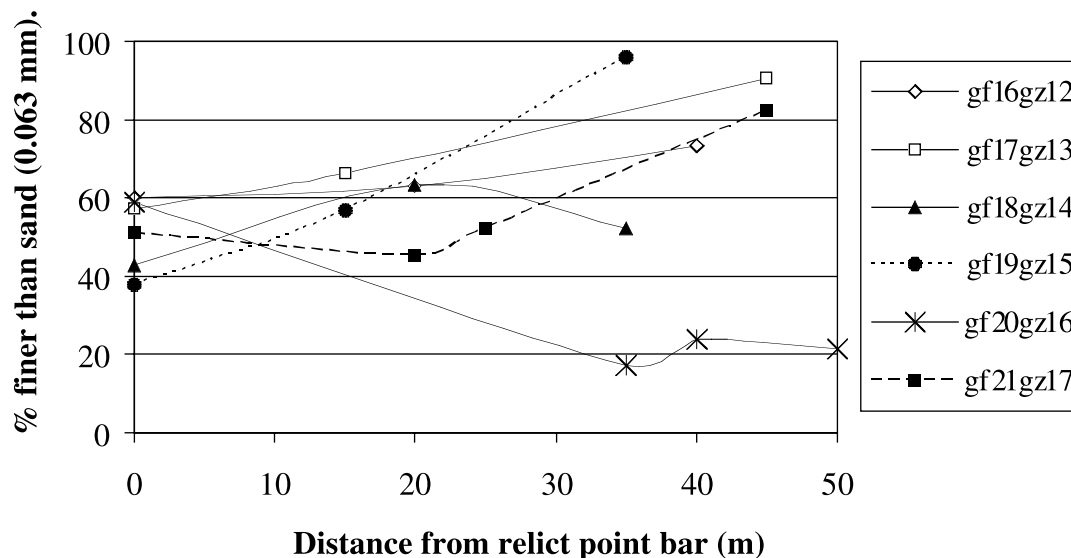**Figure 10** | *Depositional thickness of oxbow sediments, 2002 flood event.*

Figure 11 | *Particle size of deposits represented by % finer than sand values for July 2002 flood event.*

Particle size variability exists between the relict point bar, mid channel, and cutbank of the abandoned oxbow. Transects gf16gz12, gf17gz13, and gf19gz15 exhibit a fining trend away from the pointbar surface closer to the cutbank, whereas gf20gz16, is characterized by a coarsening trend from the point bar to cutbank. Gf20gz16 also represents the coarsest transect overall, with % finer values ranging from 60% - 17% < sand.

Some transects exhibit multiple fluctuations in the % finer than sand content from point bar to cutbank. Gf18gz19 varies from coarsest at the pointbar (43 %) to finest at the mid-channel (64 % < sand) to coarser at the cutbank (53 % < sand). Gf21gz17 is coarsest at mid-channel (45 % < sand), and finest at the cutbank (82 % < sand).

Discussion

In agreement with Erskine and Melville (1982), Bridge (1986), Erskine et al. (1992), and Hooke (1995), this study documents spatial variability in the thickness and particle size distribution in the deposits. It is anticipated that ebbing floodwaters should deposit the coarsest particles first, and finer particles last (Pizzuto 1987). Moreover, low-lying areas should concentrate and retain slackwater from which the finest sediments (clay/mud) slowly settle out.

In the Gonzales oxbow, flow enters the abandoned channel by two mechanisms. First, during below bankfull stage, flow enters the oxbow from the upstream neck of the channel, inundating the oxbow. Second, overbank floodwaters traveling perpendicular across the floodplain enter the oxbow along the entire length of the upstream neck. This combination of discharge sources fills the abandoned channel, and eventually advances over the abandoned cutbank and flows across the adjacent floodplain. Former height and the direction of the floodwater, noted by debris and silt lines, indicate that the floodplain was inundated at least 2 m above the old point bar surface.

Erskine (1992) concluded that particle size within an abandoned meander is dependent on flood regime (magnitude, frequency, duration), and upon the position of the oxbow relative to the active channel. The local stratigraphic variability, i.e. sandy, clayey, sandy stratified layers is consistent with his first criterion. His second

criterion is consistent with my observation that particle size decreases with increasing distance away from the active channel. The coarsest particles settle out nearer to the active river, while the finer particles settle as slackwater veneer. Coarse deposition is associated with the upstream neck gf20gz16 and gf19gz15, whereas the finer deposits are associated with the outer cutbank and downstream limb: gf16gz12, gf17gz13, and gf19gz15.

Abandoned channels may be reactivated during large floods, and even experience temporarily high velocities (Asselman and Middlekoop (1998)). This would result in erosion near the active channel, followed by increased deposition farther away. This, is consistent with the thin coarse deposits associated with gf21gz17 and the thicker deposits associated with gf16gz12. In addition, field observations, of exposed tree roots at the interface between the active and abandoned channel, provide further evidence indicating the occurrence of erosive flow velocities.

Meander curvature of the active channel, relative to the position of the oxbow, is also influential (Hooke 1995). Because flow entered the oxbow during below bankful stage, the oxbow was already inundated when the river breached its banks. Perpendicular cutbank flow coming from the apex of the active meander bend was concentrated in swale depressions linked to the oxbow, creating a locally steepened gradient and supporting a higher water velocity and capacity to carry sediment (Bridge 2003). Thick, coarse deposits along the upstream neck of the oxbow (gf20gz17 and gf19gz15) suggest that water flowing across the floodplain had converged with water flowing into the abandoned channel, resulted in rapid sedimentation.

This theory is also supported by transects gf11gz09 and gf13gz11, taken perpendicular to the cutbank of the active channel, these deposits increase both in thickness and particle size away from the bank and closer to the oxbow (Figures 12 and 13). This is contrary to the expectation, that such deposits should be associated with a natural levee, as seen in levee transects gf04gz02 and gf06gz04; whereby the first 5 m is followed by a gradual decrease in sediment thickness and particle size (Figures 12 and 13).

Along transect gf18gz14, vegetation appears to have influenced local deposition; thick mid-channel to

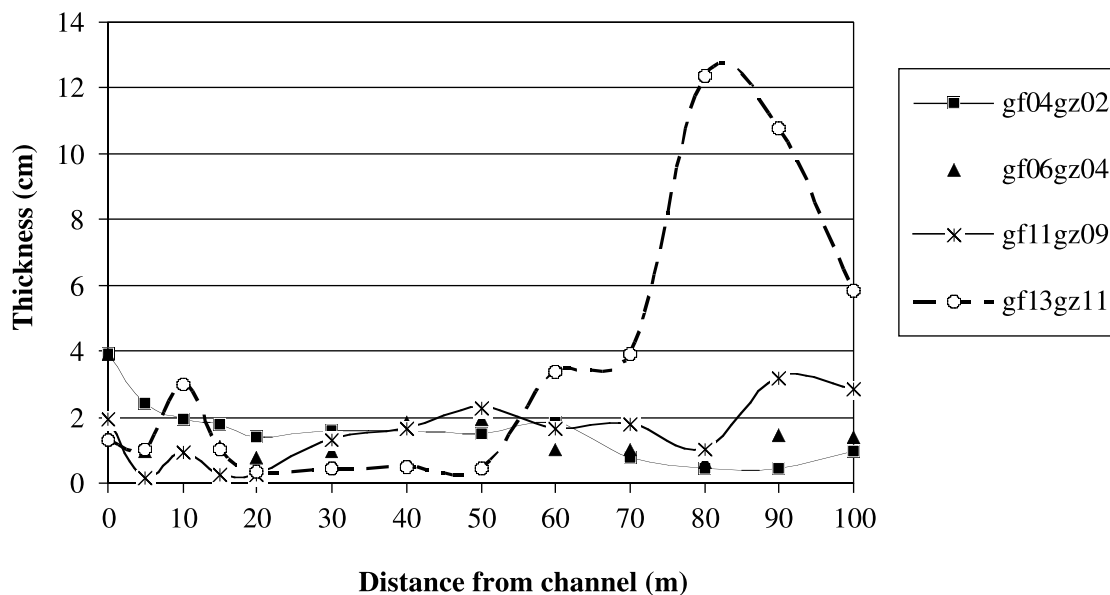**Figure 12** | *Depositional thickness of floodplain deposits, 2002 flood event.*

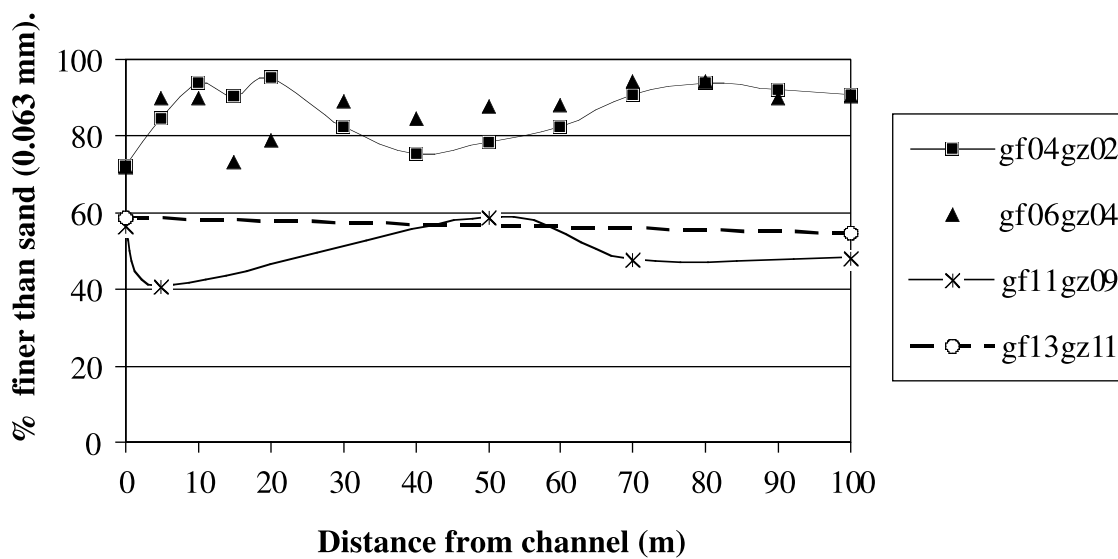**Figure 13** | *Particle size of floodplain sediments, 2002 flood event.*

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| Table 2 | *Descriptive summary statistics, oxbow, Gonzales, Texas.* |

Depositional Process	Floodplain Deposit	Range of Sediment Sizes
lateral accretion	pointbar, ridge and swale topography	gravel - silt
	oxbow infilling (early stages)	gravel - silt
flooding	natural levee	coarse sand - silt
	oxbow infilling (later stages)	fine sand - clay
	backswamp	clay
	crevasse-splay	coarse sand - silt

cutbank deposits are associated with a dense, stand of woody perennials that created a raised ridge surrounded by water. This, however, is only a local effect.

Summary and Conclusions

Oxbow sedimentation associated with the 2002 flood is not uniformly fine grained but rather, it exhibits considerable variation in thickness and particle size. Particle size variability ranges from 17 % finer than sand to 96 % finer than sand, and thickness patterns vary from 1.2 cm to 28.8 cm. In addition, contrary to previous studies, oxbow sediments were coarser than those deposited on surrounding floodplain features. Most sedimentation studies focus on processes over a large scale, however, more emphasis needs to be placed on understanding how flood events influence local floodplain features.

Because oxbows are a sort of bridge in both time and space, they provide valuable data for modeling geomorphic and ecological changes in floodplain environments. Productive future research could be applied to interpreting historic alluvial records or documenting infilling processes from beginning to end. A longer-term study at the Gonzales site would ultimately investigate depositional patterns and ecological responses resulting from future floods, similar to the July 2002 event described here.

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Identification of the AP-1 Element in the 5' Flanking Region of the NMDA Receptor Gene

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Abstract

There are a variety of genes that code for important proteins that regulate functions in the central nervous system. One such is the N-methyl D-Aspertate (NMDA) receptor, located extensively in the vertebrate nervous system. Its functions include mediating excitatory neurotransmissions, synaptic plasticity and memory functions in the brain, as well as other physiological functions in the development of the brain. As with all genes, NMDA receptor gene expression is regulated by different factors present during the gene's cycle in the central dogmatic processes, from transcription to translation. AP1 has been documented as an important transcription factors in many genes, yet little is known about what role it plays in the regulation of NMDA receptor gene expression.

The purpose of this study is to identify AP1 element in the NR2B promoter region and determine its functional importance in regulating NR2B transcription. EMSA was performed to determine the ability of DNA-protein binding. Then, wild type and AP1 site mutant luciferase report gene constructs were used to compare promoter activity. This analysis should provide insights into the contribution of AP1 to the regulation of NR2B gene.

Introduction

There are a variety of genes that encode proteins that have important functions in the central nervous system. One such gene is the N-methyl D-aspertate (NMDA) receptor gene, located extensively in the vertebrate nervous system and expressed in almost all neurons. The NMDA receptor gene, commonly referred to as NMDAR, is a receptor for the neurotransmitter glutamate, the most important excitatory transmitter in the brain. The functions of the NMDA receptor gene include mediating excitatory neurotransmissions, synaptic plasticity (the use-dependent long-term changes in the efficiency of synaptic transmissions between nerve cells) and memory functions. In addition, NMDAR may have involvement in mediating the toxic effects of excessive glutamate. NMDAR has 6 subunits: one NMDAR1 (NR1), four different NMDAR2 subunits (NS2A-D) and one NMDAR3A subunit. These subunits have been showed to play an important function in brain physiology (Forrest et al, 1994; Li et al, 1994). The NR1 subunit, when in association with the NR2 subunit, leads to the formation of highly active receptor channels (Nakanishi, 1992l; Ishii et al, 1993). In addition, the NMDAR1 subclass appears to be the key component required for functional activity (Zukin and Bennett, 1995). However, where the NMDAR1 subunit is expressed constitutively, NR2B expression is highly regulated during the development of the brain (Tabish and Ticku, 2003).

There are two main classes of glutamate receptors based on their biochemical, pharmacological and molecular profiles, ionotrophic and metabotrophic. The NMDA receptor gene is an ionotrophic glutamate receptor located in the vertebrate brain. Characteristics of ionotrophic receptors include heterogeneity in distribution, pharmacology, signaling linkages and physiology as well as mediating synapses with rapid transmission (Wang et al). In addition, ionotrophic receptors are ligand-gated ionic channel for calcium (M. Rahban).

Glutamate in the body has the function of controlling normal cellular activity and cellular responses to extracellular stimulation. Glutamate works by attaching to glutamate receptors, proteins on the cell surface. Oxygen deprivation triggers abnormal buildups of glutamate, which kill neurons by overstimulating them. Overstimulation of the NMDA receptor leads to degeneration and cell death, which is believed to be a result of excessive calcium influx through the NMDAR ion channel (Simon et al, 1984; Choi, 1988). Because of this, NMDA is known to have involvement in exotoxicity and connectedness to such diseases and disorders as trauma, stroke, epilepsy, Huntington's disease and AIDS related dementia (M. Rabhan). NMDA receptor blockers, which are drugs that block these proteins, can prevent glutamate from harming neurons (SFN, 1994). Many of these drugs also contain pain-relieving effects and may restore sensitivity, but they tend to cause psychotomimetic effects or other adverse side effects (Brookoff, 2000). Thus, the manner in which to control the expression of these genes is remains unknown.

Gene expression can be differentially regulated by tissue-specific, developmental and physiological stimuli which can either activate or silence certain genes. Gene expression can be regulated both at the level of transcriptional control (the regulation of the synthesis of mRNA) and by post-transcriptional control. Transcriptional control mechanisms include transcription factors, which are proteins needed for transcription, not including RNA Polymerase II. These bound transcription factors determine promoter activity and can act to both stimulate or to repress the level of gene expression (Quinn, 1996). Thus, the specific enabling transcriptional factors that needs to be targeted in order to most efficiently block the NMDA receptor needs to be determined, but remains unknown.

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The purpose of this study is to identify an element in the NR2B promoter region of the gene and determine its functional importance. The element in question is AP1.

Transcription factor AP1, or activator protein 1, is arranged in the structure of a leucine zipper consisting of a heterodimer of either c-Fos/c-Jun or c-Jun/c-Jun. AP1 binds to DNA at the TGAGTCA binding sequence located upstream from the transcriptional start site, at -1090 base pair spot. It has also been found to enhance the expression of several genes, including methallonthionein IIA, collagenese, phosphoenolpyruvate carboxykinase, stromelysin, and the apiodocyte gene, aP2, as well as modifying the transcription of the osteocalcin gene, the human pi-class glutathione S-transferase gene, and the rat glutathione S-transferase Ya subunit gene (J. Whatmore). AP1 and the ATF/CREB transcription factors were found to play important roles in the regulation of the P-B promoter activity (Berhane and Boggaram, 2001). In addition, AP1 is a key participant in the control of T cell proliferation, cytokine production and effector function. The activity of this transcription factor is found to be highest in T cells in the immune system, suggesting that a subset of T cell-specific coactivator proteins exist to selectively potentiate AP1 function (Oukka, Wein and Glimcher, 2004). AP1 has been found to regulate the expression of genes directly involved in pathogenesis of diseases, tumor promotion genes, especially growth factor-inducible genes, and most immumodulatory genes (Sen and Packer, 1996; Adcock and Caramori, 2001; Bohmann et al, 1987).

Materials and Methods

Cell culture: Primary cortical neurons were prepared from C57BL/6 mouse fetuses. Cortices were isolated from the E14 mice and the cells were dissociated by trituration and resuspended in minimal essential medium (MEM) supplemented with 5% fetal bovine serum, 5% heat-inactivated horse serum, 100 µM L-glutamine, 28 mM D-glucose and 1X antibiotic-antimycotic solution. Cells were plated onto poly-L-lysine coated tissue culture dishes and incubated at 37°C with less than 5% CO_2 level concentration. On the subsequent day, a mixture of 5-fluoro-2'-deoxyuridine and uridine at a final concentration of 20 µg/ml and 40 µg/ml was added to the medium to inhibit non-neuronal cell proliferation.

Electrophoretic Mobility Shift Assay (EMSA): Nuclear extracts from the primary cultured neurons were prepared. Complementary DNA oligonucleotides were annealed and then labeled with [^{32}P] ATP and T4 polynucleotide kinase. Nuclear extract (10 µg protein) was incubated for 20 minutes with the labeled DNA probe in 20 µl of binding buffer containing 10 mM Tris-HCl, pH 7.6, 50 mM NaCl, 1 mM EDTA, 1 mM DTT, 5% glycerol, 1 µg/µl bovine serum albumin, and 2 µg of poly-d (I-C). For supershift assays, 2 µg of c-Fos and c-Jun antibody was added and the reaction continued for 15 minutes. Afterwards, 6X loading buffer was added and subsequently loaded onto 5% nondenaturing polyacrylaminade gels and electrophoresis was carried out for 2 hours at 185 volts until the first dye ran out of gel. The gel was allowed to dry for 1hour at 80°C. The sample was then exposed to phosphor screen at room temperature for 12-16 hours.

Luciferase Vector Construction and Site-directed Mutagenesis: A set of NR2B promoter regions, differing in the location of their 5' ends (-800, -1224, -1629, -2104, -2255, -2483, -3004 and -5319bp) were prepared by PCR. The M1 clone (NCBI accession number: AF 033356) of the mouse genomic DNA as used as template. The forward primers were synthesized corresponding to the upstream sequences of desired promoter regions with an added 5'-flanking *Kpn*I site and the reverse primer corresponding to bp +30 relative to the reported transcription start site of the mouse NR2B gene with an added 3'-flanking *Nco*I site. PCR products were sub-cloned into the same restriction sites of the promoterless luciferase reporter plasmid pGL3-Basic. Site-directed mutagenesis was carried out by using the QuikChange II XL Site-Directed Mutagenesis kit. All constructs and mutants were confirmed by restriction mapping and sequencing.

DNA preparation: In order to obtain enough purified DNA through amplification, DNA preparation via transformation and maxprep were conducted.

Transformation: Competent cells (GM cells) were thawed on wet ice at the same time Falcon 2059 tubes

were being chilled. Fifty microliters of the competent cells were put into the chilled Falcon tubes along with 50ng of the DNA. This solution was incubated on ice for 30 minutes. The mixture was then heat shocked in 42°C for 45 seconds and returned to the ice for 2 minutes. After this time, 500 μl of SOC solution was added and the solution was put into a 37°C shaker for 30-90 minutes. Afterwards, 20 μl of the solution was spread out onto ampicillin agar plates, which were incubated in 37°C for 12-16 hours. After incubation, colonies were inoculated into 500 μl of TB solution and placed in the shaker for 12-16 hours.

Maxprep: According to the manufacturer's protocol, a 10ml overnight culture was pelleted by centrifugation at 25°C at 14,000 rpm. The pellet was then resuspended in 250 μl of cell resuspension solution. Two hundred and fifty microliters of cell lysis solution was added before the mixture was gently inverted four times to mix. Afterward, 350 μl of neutralization solution was added before gently inverting the mixture to mix. The next step of the process was the binding of the plasmid DNA. The resulting mixture was centrifuged at 14,000 rpm for 2 minutes at 25°C. Spin columns were inserted into new, labeled collection tubes. The clear lysate was transferred into the spin columns and centrifuged at top speed for 1 minute at 25°C. The flowthrough was discarded and the spin column was reinserted into the collection tube. In order to wash the solution, 750 μl wash solution was added into the solution. This was centrifuged at 14,000 rpm for 1 minute. The flowthrough was discarded and the spin column was reinserted into the collection tube. The final process, elution, was achieved by transferring the spin column into a sterile 1.5 ml microcentrifuge tube. Sixty microliters of nuclease-free water was added to the spin column and centrifuged at top speed for one minute at 25°C. The spin column was then discarded and the resulting DNA stored at -20°C or below.

Transient transfection and luciferase assay: Primary cultures of cortical neurons were grown in 12-well plates and transfected on DIV 5 using a modified calcium phosphate technique according to the recent method described by Desai et al.

Transfection: DNA, H_2O and calcium phosphate were placed into a test tube. As Hepes Buffer was vortexed, drops of DNA calcium chloride were added. It was then incubated without light for 30 minutes. The resulting mixture was added drop by drop in a circular manner to the previously incubated cells. The cells were then incubated for 10 minutes in 37°C. After the incubation, the cells were centrifuged with a parafilm cover at 300 rpm for one minute and incubated again for 30-90 minutes. The cells were then washed with DMEM twice. Cell growth medium was then replaced and the cells were incubated in 37°C for 48 hours.

Luciferase assay: Luciferase is a protein that is detectable when expressed in the NR2B gene, thus, acts as a "reporter" of the level of expression of the gene. A promoterless vector, pGL3-basic, was purchased. A promoter containing the AP1 element is inserted into the PGL3-basic vector in the place where the promoter would be. Cells were harvested for 48 hours after transfection for luciferase activity assayed in a Turner Designed TD-20/20 luminometer using the dual luciferase assay system according to manufacturer's protocol (Promega).

Results

Analysis of binding ability of DNA-protein complex: EMSA was used to determine the DNA-protein binding ability of AP-1. Competition analysis confirmed specificity in DNA binding. Effective competition was achieved in the graded wild-type competitors (Lanes 1-4) by using unlabeled probes, which were not used in the mutations. The lack of a change in bands for the mutations reaffirmed that binding is specific. In the supershift analysis when antibodies were added, the shifted bands were obtained (Lanes 8-9). The results indicated that there were both C-Fos and C-Jun present in the binding complexes. However, in Lane 10, when IgG antibody was put into to the reaction, a supershift band could not be found, thus adding the further evidence of the specificity of the binding (Figure 1).

Analysis of functional importance of AP-1: The luciferase reporter gene was used to determine the functional importance of AP-1 element. After the

| *Figure 1* | *Supershift competition analysis confirmed specificity in DNA binding.* |
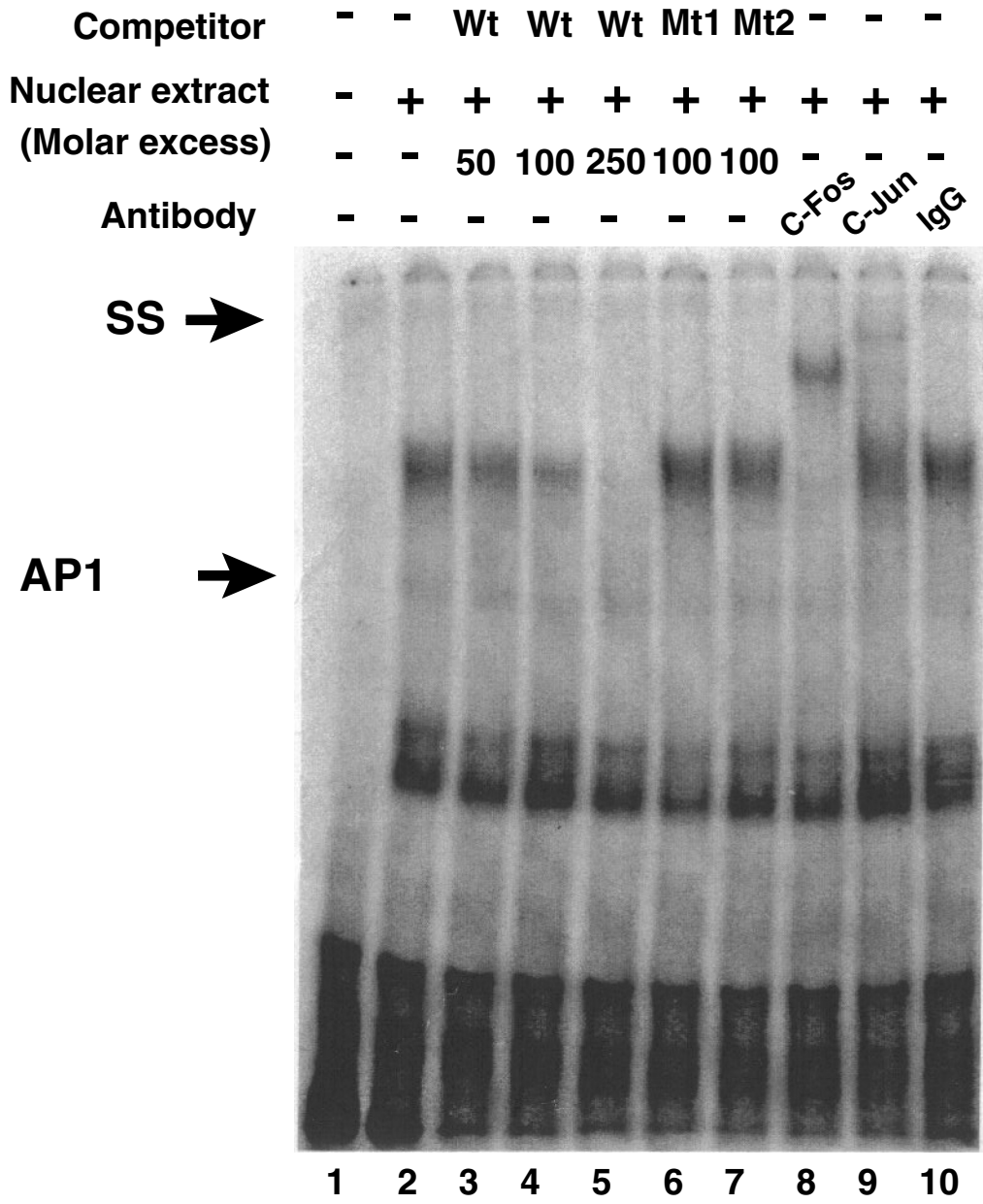
Supershift competition analysis confirmed specificity in DNA binding. Additionally, results indicated that there were both C-Fos and C-Jun present in the binding complexes. However, in Lane 10, when IgG antibody was put into to the reaction, a supershift band could not be found, thus adding the further evidence of the specificity of the binding.

Figure 2 | *Luciferase Activity.*
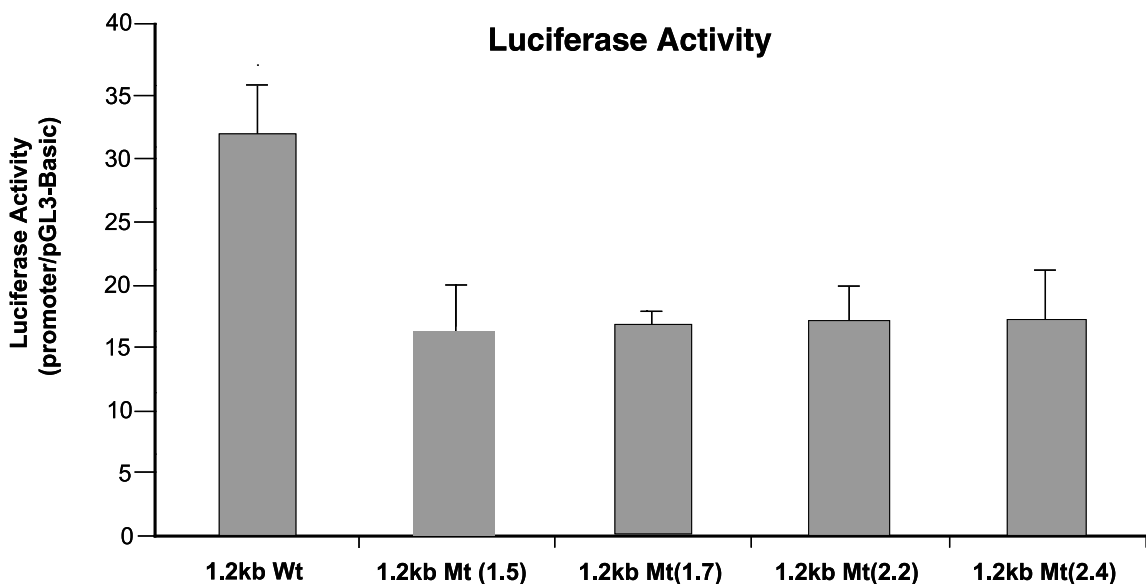
Luciferase analysis of the transfected cells showed the luminometer reading substantially increased compared with pGL3-Basic; the -1.2 kb construct showed approximately twofold increase.

determination of the AP-1-specific binding, luciferase reporter gene constructs of NR2B promoter region extending from -1.2 kb to +30 bp were transfected into primary cultured cortical neurons. Luciferase assay of the transfected cells showed the luminometer reading substantially increased compared with pGL3-Basic; the -1.2 kb construct showed approximately twofold increase (Figure 2). The reading of the mutants was reduced, indicating the functional importance of the intact sequence of AP-1 element.

Discussion: AP-1, a leucine zipper heterodimer of C-Fos and C-Jun, has been known to enhance many genes, including those in the immune system and those dealing with disease. Because of its involvement in the regulation of important immunomodulatory genes, it serves interest to know of what other body systems AP-1 has regulatory importance. The body system in study is the nervous system, with the NMDA receptor gene being the gene analyzed. The present study has demonstrated that AP-1 may also have enhancing ability in the NR2B gene. Evidence has shown that AP-1 binds to

DNA and is sequence-specific about its binding. Additionally, present research has shown that AP-1 is functionally important in the NR2B promoter. This importance is also dependent on sequence specificity.

The findings can be speculated to have significance in the study of excitotoxicity of neurons due to the overstimulation with glutamate. According to David Latchman of the Institute of Child Health, drugs which target transcription are widely used for therapeutic purposes. Research is being conducted to understanding the mechanism of action of these drugs and the mechanisms of transcriptional regulation in order to initiate study of new drugs isolated on the basis of their ability to modulate either the synthesis of transcription factors, the regulation of their activity by ligands or phosphorylation events, their protein-protein interactions or their binding to DNA (Latchman). Current opiates used as NMDA receptor blockers, such as methadone (meth), ketamine (Special K), phencyclidine (angel dust) and levorphanol (levo-dromoran) are not only illegal, but also cause side effects such as

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hallucination and altered ability to function due to an influx of chemicals to the brain. Side effects from medicines can be minimalized by more effective targeting of problematic elements. Thus, the knowledge of the functional transcription factors should not only aid in studies of this sort, but also in studies dealing with excitotoxicity.

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Community-Based Natural Resource Management, Gender, and Sustainable Development

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Introduction

The term "development" has been defined numerous ways, but one intriguing perspective is that of "a process of expanding the real freedoms that people enjoy" (Sen, 1999, 3). In this context, development is both a means and an end, with the process carrying equal importance as the end product (Isham et al, 2002). People living in rural areas of East Africa are highly susceptible to the cycle of poverty and environmental degradation. By fusing the two objectives of environmental sustainability and economic development within the traditional regulatory mechanisms of a community, a mutually reinforcing feedback loop can be established. Economic growth combined with human development will lead to greater capabilities for a community; add to this combination local

empowerment, and a powerful recipe is created for defense against unfreedoms and offense in gaining greater freedoms.

Community-Based Natural Resource Management (CBNRM) programs have three primary objectives: (1) to successfully conserve biodiversity and natural resources in an area and (2) facilitate the establishment of economic sustainability within each community while (3) preserving the cultural heritage of each area. CBNRM programs have the capacity to facilitate sustainable development if three main issues are addressed in their creation and implementation. First, projects need to be gender-sensitive, and some targeted specifically at women. The unique agency of women should be utilized as one of the major mediators of economic and social change (Sen, 1999, 202). Second, development practitioners need to assess each community's social capital in order to create programs that have the potential to allow for sustainable development, to produce benefits for the majority of individuals, and to encourage participation. Third, as land-use rights in Kenya are detrimental to an individual's ability to earn sufficient monetary benefits from conservation, archaic land-use policies and laws need to be reviewed and appropriately revised to meet the current needs of wildlife and humans.

Gender and Development

Two main issues relating to gender may affect the success of community-level development programs. First, development is gender-sensitive, meaning programs affect men and women differently. Until the 1980s, "[Western development agencies] erroneously thought that if men were better off, women and general family welfare would improve as well" (Gordon, 2001, 283). Research within the past decade has revealed that gender is a significant determinant in the impacts of development initiatives, and women's well-being and agency is more strongly connected than men's to economic development and children's health (Braidotti, 1994; Koopman, 1997; Sen, 1999; Young, 1997). "Well-being is a measure of actual and potential quality of existence; it encompasses both the attainments of an in-

dividual and the choices that he or she enjoys" (Isham et al, 2002, 7). Therefore, if development initiatives are to succeed they must be gender-sensitive.

Second, community development depends on the support and cooperation of the community. Labor roles in East Africa, especially in rural areas, are highly segregated along gender lines (Gordon, 2001; UNDP, 2003). Stark differences in gender labor roles, legal and cultural rights, and income-spending power differentials lead to disproportionately negative effects on women. This disparity, usually exacerbated by the institutionalized oppression of women, creates hostility within the female population towards development programs. Thus, women will not support these initiatives, and often work against them covertly. Development projects will fail if half the population of a community is working against them and households are divided over them.

As Hildegarde Hannum (1997) stated, "The most local situation of all, the smallest political unit, is the home. Here is where effective action towards social transformation begins" (52). The key to decentralization and public participation lies in securing the support of communities at the household level. Throughout most of Africa, women are the center of the home. This is especially true in the case of pastoral tribes, including the Maasai of Kenya. In these communities, men spend most of their time traveling with the cattle, while women spend their time working at home and taking care of family. If CBNRM programs are to take root in these communities, become successful and self-sustaining, the projects must be organized to include women. Doing so will ensure inclusion of the home.

Imbrikani Group Ranch Case Study
Background

A case study was undertaken in East Africa to explore the effects of CBNRM programs on a group Maasai women within Imbrikani Group Ranch. Imbrikani occupies 129,895 hectares of land and lies in the traditional Maasailand of southern Kenya. It is one of six group ranches established under the Group Representatives Act of 1968 that surround Amboseli National Park. At the time of the ranch's founding, all male

residents were declared "official" members, a title that continues to be passed down the male lineage of their families. Official members are allowed to vote for the ten members of the management committee, who are responsible for allocating all communal income to the ranch, organize all land-use, and are currently overseeing land privatization.

Imbrikani has experienced an influx of projects and resources for development and conservation during the past decade. Projects focus on at least one of three categories: (1) providing direct financial benefits to communities from local natural resources, (2) assisting in funding human development, and/or (3) conserving the land and biodiversity. Stakeholders in Imbrikani group ranch include Imbrikani residents, themselves; the Kenyan national government, and four other specific governmental and nongovernmental agencies: Kenya Wildlife Service, Richard Bonham Safaris Co., Maasailand Preservation Trust, and African Conservation Centre. These four agencies facilitate a variety of Community-Based Natural Resource Management programs within the group ranch.

Methodology

Primary and secondary data were collected during the field study dates of September 6 to October 9, 2003. Primary data were obtained through informal, semi-structured interviews with female and male heads of household, elected community representatives, government officials, Kenya Wildlife Service game wardens, health practitioners, and other stakeholders in Imbrikani group ranch. Interviews were conducted within Imbrikani town. Informal, semi-structured interviews were chosen for data collection because they allow interviewees to share more information than a standardized questionnaire and they enable easy comparison of responses to questions.

Interviews centered around two main topics:

(1) structure and benefits of CBNRM programs and
(2) socioeconomic data collection.

The first topic consisted of gaining information on six main questions:

(1) Have you or your family ever received any type of benefits from the various conservation programs in the area? If yes, what kind, when, and how often?
(2) Have you seen any benefits to the community from the various conservation programs in the area? If yes, how has the community benefited, who benefits in particular?
(3) Have you seen any changes, positive or negative, to the community due to the conservation programs? If yes, what and when?
(4) In your opinion, are there any ways the conservation programs can be restructured to benefit more people in the community? If yes, how?
(5) How have women been affected by the conservation programs?
(6) What would enable women to help themselves and help their families?

When asked about the first topic, interviewees were not given a list of answers to choose from, therefore they often responded with more than one answer. Because more than one answer was usually given, the data based upon these responses does not add up to one hundred percent. Each percentage relating to the individual responses represents the percentage of women out of all the interviewees who gave that answer.

At the end of the interview, subjects were asked if they would mind answering personal questions. Thirty-six out of the forty-nine women interviewed agreed to answer four questions relating to their socioeconomic status:

(1) What was the highest level of school you attended?
(2) How many children do you have and how many are enrolled in school?

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(3) How many people live in your house?

(4) Are there times when there is insufficient food to feed everyone in the house?

Interview responses were analyzed to provide quantitative statistical data. Secondary data sources included program reports from the African Conservation Centre and income and expenditure reports from the Maasailand Preservation Trust.

Primary Data Findings

CBNRM Impacts

Forty-four (90%) of the women polled responded that their family had never received any direct benefits from the CBNRM program, four women (10%) replied they had received benefits in the form of school fees assistance, livestock compensation, and/or money from the management committee to help them buy food or pay a medical bill.

The most widely perceived benefit to the community was assistance in paying school fees. Some women stated that community benefits included aid for the poor, improved healthcare, new classrooms for the local school, and increased income-earning opportunities. Significant numbers of women stated that they did not believe their community had benefited at all from the CBNRM programs, or that some positive changes may have occurred but they did not know of them because they never left the immediate environs of their house. Exact data on perceived community benefits are shown in Figure 1.

A wide variety of responses were given on how to promote development in the community, and how to help women provide for themselves and their families. The most popular recommendation was that more opportunities for children and adults to receive general education would help promote development in the community. Some women believed that increased financial income or loans would assist with development. A significant number of women said basic needs must be met for all community members before any steps towards economic development or conservation can occur. Exact data on women's recommendations for development in Imbrikani are shown in Figure 2.

Socioeconomic Indicators

Women's Education

Twenty-four women (67%) of the respondents had never attended school, six women (17%) had attended primary school, three women (8%) had attended secondary school, and three women (8%) had graduated from secondary school.

Children's Education

Eleven (30%) of the women said all their children were enrolled in school, nine women (25%) had 1-20% of their children in school, six women (17%) had 40-60% of their children in school, four women (11%) had 60-80% of their children in school, and six women (17%) had no children in school. Only children old enough to attend school were considered in this question.

Food Security

Eight women (22%) responded that their households always had enough food. Women who responded that their family had an inadequate food supply at times were asked if this rarely occurred (7 women, 19%), occurred during the dry season (21 women, 59%), or if they never possessed enough food (0%). It should be noted that the dry season in Imbrikani averages nine to ten months out of the year.

Secondary Data Findings

The Kenya Wildlife Service (KWS) allocates approximately $10,000 each year from its revenue-sharing program to Imbrikani. This money is distributed by KWS to programs recommended by the management committee. The majority of this money goes towards providing scholarships for students to attend secondary school. The largest portion of money that the committee directly handles comes from bird hunting fees, cropping, land leases, and other fees paid by the Richard Bonham Safari Company (Table 1). A portion of this money was spent on building a maternity hospital in Imbrikani. Records documenting the allocation of the remainder of these funds could not be located.

Discussion

Due to the restricted nature of this research project several limitations were experienced in gathering data. The primary hindrances to information-gathering were (1) the short time period spent in the field, (2) difficulties with transportation, and (3) the paucity of financial accounts for the allocation of group ranch revenue. Though these circumstances produced a less than ideal assessment of development in Imbrikani, some general conclusions can be drawn from the research.

Many programs exist within Imbrikani to facilitate and improve conservation and development efforts. However, in speaking with the women of Imbrikani it is apparent that the expected positive repercussions on the community from the CBNRM efforts are not occurring. While the majority of CBNRM programs located in Imbrikani range from fifteen years to several months old, one cannot yet state definitively whether any of them have succeeded or failed. The nature of CBNRM is that immediate results should be seen in some types of programs, such as incentives to decrease poaching, whereas results of other programs, such as educating parents on the value of school, may not be seen for a generation or two. Though it can not be stated yet whether these various development initiatives have succeeded or failed, it is apparent that in general they are not positively affecting women and children. Several causal factors, including gender inequity, breakdown of social capital, deterioration of traditional regulatory mechanisms, and inadequate management capabilities within the group ranch, are responsible for the lag between initiatives and progress.

Charles Lane stated "It is perhaps only wishful thinking to hope that traditional land tenure systems could provide coherent management of rangeland resources today. It may be too late to re-animate customary communal land management when laws and administrative provisions about them are changing in the opposite direction" (1998, 23). Among the Maasai it appears the opportunity for a successful communal land management system still exists if due courses of action are taken. Contrary to the often-held belief that communal property is inherently destructive, studies of African pastoralism have revealed that the traditional communal property systems often promote rangeland conservation (Kituyu, 1998). Lane believes one of the primary reasons a communal system can no longer work is because "kinship and other social linkages that once held pastoral land tenure systems together have been either destroyed or severely undermined" (23). However among the Maasai in Imbrikani, especially the women, familial and social bonds still remain the center of life and community. Unfortunately the Maasai are becoming further marginalized and unable to support themselves; therefore, they tend to believe the propaganda that they will all become rich from land privatization. It seems possible that with the necessary outside support to strengthen positive social capital and impart credibility and importance to the traditional regulatory mechanisms, communal land management can be sustainable again. Land privatization experiments in neighboring group ranches have thus far resulted in greater wealth inequalities in these communities and unsustainable land use (Warinda, 2001).

Recommendations

The first step in moving towards community-based natural resource management should be assessing the social capital of the Maasai living within group ranches on community and subcommunity levels. After this is undertaken, programs can be created to support existing positive social capital, such as social cohesion, conflict resolution, bonds, linkages, and trust. Correspondingly, methods to diminish the weak forms of social capital, such as exclusionary bonds, oppressive institutions and unsustainable traditions, should be implemented.

The second course of action should be increasing education. Instruction among the group ranch residents on the value of education for all, literacy, civil and human rights, wildlife, conservation, development, management, and available resources should be undertaken. Development practitioners should continually pursue education on Maasai culture and remain updated on current research. Women are far less likely to attend school than men; therefore, time and resources need to be spent teaching men about the importance of educat-

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ing women. Due to the high interest expressed by women in loans to start businesses, seminars should be offered to women on the loan resources available to them and the loan payback process. These seminars should also present material relating to running a profitable business such as accounting, accountability, labor, market access, and product quality.

Third, women's groups should be tapped for their social capital and organizational networks. Involving women in development and allowing them to work as free agents will assist in achieving their personal well-being and development for the entire community. Additionally, empowering women to work as free agents will decrease their self-view as oppressed and assist in creating a more integrated society.

Fourth, a new management system needs to be established for the group ranch in order for benefits to be equitably distributed, the natural resources efficiently managed, and opportunities for economic development to flourish. A system to supervise the management committee elections to make sure they accurately represent the community's desires needs to be set in place. A process for each community to hold its management committee accountable for their decisions and actions needs to be implemented to end corruption and mismanagement. "As the twenty-first century unfolds, Africa will need a rebirth or reawakening, not just of learning, but of a new sense of public accountability" (Zack-Williams, 2002, 13).

Finally, researchers should continue to study CBNRM programs, development, social capital, and gender issues. Specific action plans should be created outlining methods for greater well-being and freedom for women in Imbrikani, rather than assuming this will occur as a byproduct of gender neutral development efforts. More studies examining the effects of CBNRM programs on conservation and biodiversity should be undertaken as well.

Conclusion

A wide array of factors can affect the outcomes of development initiatives. As evidenced in this research, it is not enough to offer resources and establish projects.

CBNRM programs must engage the community and be embedded in community values to be productive and successful. "There is a great potential in marrying this traditional knowledge and experience with modern technologies and techniques to forge a distinctively African approach to sustainable development" (Ghai, 2000, 163).

Development projects must be community-based, but communities must first learn the skills to organize and manage these projects. All sectors of a community should be involved in CBNRM projects to ensure cohesive community action, equitability, and sustainability. Gender-specific development is not simply rhetoric to promote general women's equality. Unless development programs are gender-specific, and targeted specifically at increasing women's financial independence, well-being, and free agency, they will fail to produce significant effects on households. Actions must be taken to attain education for the majority of women in order to create a population that is capable of responsibly utilizing their resources.

CBNRM has the potential to fill the vacant role of governance created by absent governments and weakening social capital in rural East Africa. Within populations of indigenous peoples who have maintained close ties to their traditions but whose social infrastructure is crumbling due to their weakening economic security, CBNRM can be of special assistance. Rather than creating a strong state government that becomes involved in the management and enforcement of minute issues, and that will consequently have culturally destructive and disparate effects on different communities, CBNRM offers a system of strong local governments mediated and supported by the state government. This system is highly applicable in East Africa, where various tribes and clans form a patchwork of contrasting social, cultural, and economic situations within the borders of one country (Gordon and Gordon, 2001). Through CBNRM communities can provide for themselves, promote development within the framework of their own society, and retain or even strengthen their unique cultural heritage. An executive, central government should serve to foster market access, promote international cooperation, and facilitate development. In countries

with distinctly different regional values, traditions, social capital, human development, and economic security, regional governments can be more responsive to local populations.

Acknowledgements

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