

# MCNAIR SCHOLARS PROGRAM



*2011 McNair Research Journal  
Montana State University*

© Copyright 2011

*Ronald E. McNair Postbaccalaureate Achievement Program  
Montana State University  
240 Gaines Hall, PO Box 172560  
Bozeman, MT 59717*

*Production of this manual was made possible through funding by the  
U.S. Department of Education.  
The McNair Scholars Program is a TRiO Program.*

**TRiO**

**RONALD E. MCNAIR  
POST-BACCALAUREATE  
ACHIEVEMENT PROGRAM**



# McNair Research Journal

## Montana State University

Spring 2011

Volume 1

### Table of Contents

McNair Program Staff	i
Acknowledgements	ii
<b>Camilla Armijo-Grover</b>	1
Is Selectivity the Best Method for Aid Allocation	
Mentor: Christiana Stoddard, Ph.D.	
<b>Deb Blanchard</b>	17
Unmasking the Superhero: Analyzing Junot Diaz's <i>The Brief Wondrous Life of Oscar Wao</i> as "Multicultural Hybridity" Literature	
Mentor: Bridget Kevane, Ph.D.	
<b>Dewey Brooke</b>	39
Analysis of phospholipase activity in adeno-associated virus particles by liquid chromatography/mass-spectrometry	
Mentor: Brian Bothner, Ph.D.	
<b>Kelsey Guffey</b>	49
Foraging Ecology of Bison in a Mixed Grassland-Steep Ecosystem	
Mentor: Clayton Marlow, Ph.D.	
<b>Treacy Gumeson</b>	73
Toward a Holistic Model of Managing Symptoms of Posttraumatic Stress Disorder in Montana Veterans	
Mentor: Lawrence Gross, Ph.D.	
<b>Eric Hansen</b>	101
Analysis of Non-Motorized Use In Grand Teton National Park 2010	
Mentor: Pat McGowen, Ph.D.	
<b>Jacob Hunter</b>	168
Moments in Time	
Mentor: Chris Livingston, M.Arch. II	

<b>Jordan Kennedy</b>	176
Rheological Characterization of Thermally Reversible Gels	
Mentor: Jennifer Brown, Ph.D.	
<b>Dustin Kuipers</b>	189
Cosmology of Incarceration: American Indians in Prison	
Mentor: Walter Fleming, Ph.D.	
<b>Megan Malone</b>	214
Water, the Essence of Survival and the Symbol of Oppression: Gender Inequalities	
Collide with Development	
Mentor: Leah Schmalzbauer	
<b>Zachary Morris</b>	251
X-Ray CT Scanning Techniques on Soil Samples	
Mentor: Robert Mokwa, Ph.D.	
<b>Shelby Rogala</b>	289
Establishing an International Voluntouring Ethic	
Mentor: Kristen Intemann, Ph.D.	
<b>Jocee Stirling</b>	303
The Impact of Management Intensive Grazing	
Mentor: Chuck Coffey, Ph.D., Clayton Marlow, Ph.D.	
<b>Francisco Velasco</b>	
Asymmetrical Conflict: Sleep Deprivation as a Precursor to PTSD Among Veterans	315
Mentor: Michelle Meade, Ph.D.	

# McNair Program Staff

## Principal Investigator

Gregory Young, Ph.D.

Vice Provost for Undergraduate Education

## Program Director

Shelly Hogan, Ph.D.

## Program Assistant

Elise Coy

## Faculty Mentors

Graham Austin, Ph.D.

Business

Brian Bothner, Ph.D.

Chemistry & Biochemistry

Jennifer Brown, Ph.D.

Chemical & Biological Engineering

Walter Fleming, Ph.D.

Native American Studies

Lawrence Gross, Ph.D.

Native American Studies

Shawna Heiser, M.S.

Psychology

Shelly Hogan, Ph.D.

Health & Human Development

Kristen Intemann, Ph.D.

History & Philosophy

Minette Jessup, M.S.

Business

Bridget Kevane, Ph.D.

Modern Languages & Literatures

Lori Lawson, M.S.

Liberal Studies/Honors Program

Chris Livingston, M.Arch. II

Architecture

Clayton Marlow, Ph.D.

Animal & Range Sciences

Pat McGowen, Ph.D.

Western Transportation Institutes

Michelle Meade, Ph.D.

Psychology

Mary Miles, Ph.D.

Health & Human Development

Robert Mokwa, Ph.D.

Civil Engineering

Leah Schmalzbauer, Ph.D.

Sociology

Michael Sexson, Ph.D.

English

Stephen Sofie, Ph.D.

Mechanical & Industrial Engineering

Christiana Stoddard, Ph.D.

Agricultural Economics/Economics

## **Acknowledgements**

The McNair staff would like to commend the scholars on their pursuit of academic excellence. We would like to express a grateful and sincere thank you to the faculty mentors for supporting the McNair Scholars Program at Montana State University. Also a special thank you to the Office of the Provost and University College.

## Is Selectivity the Best Method for Aid Allocation?

Cami Armijo-Grover

**Abstract:** This paper questions the wisdom of using selectivity to allocate aid to developing countries, by looking at the link between governance quality and the effective use of aid dollars to decrease poverty. After comparing 10 “better” governed countries to 7 “poorly” governed ones we found a weak relationship between increased aid and a greater decrease in poverty in the latter. Case studies of Jordan, Yemen, Ghana and Uganda proffer insight into the conditions under which selectivity works.

The aim of the World Bank when it was first formed in 1944 at the Bretton Woods Conference was to help European countries rebuild after the destruction of World War II. Upon completion of this goal, the bank committed itself to helping developing countries to build their economies. Their approach in accomplishing this has been varied over the years. Initially state government assistance was seen as essential to development and money was lent to governments primarily for infrastructure projects. This approach, known as ‘top-down’ because money is given to governments (those at the top) with the belief that it will eventually trickle down to the poorer masses through increased spending on social services, lasted until the end of the 1970’s. In the early 1980’s a switch was made and lending was made to help develop a market-led system rather than the state-led as was previously the case. Under the market-led approach countries underwent structural adjustment programs where economies were liberalized, deregulated and state owned enterprises were privatized. Additionally lending was generally made conditionally, meaning that in order for a country to receive money it often first had to agree to a set of policies or conditions that it would adopt. Conditionality, used by the World Bank, the IMF, and many other development agencies continued to be used through the mid-1990’s (Crawford, 2006, P 116-7).

From the late 1990’s through to today the World Bank has lent money to developing countries on the premise of ‘selectivity’ an approach that is characterized by “channeling relatively more aid resources to poor countries with reasonably good institutions and policies” (Burnside and Dollar, 2004, P3); that is, those countries who are deemed to be well governed are more likely to receive aid funds than those who are less well governed. Though it was the World Bank who brought us this concept of selectivity, it was not long before it was adopted by a wide range of development agencies. As Crawford tells us, “Following its introduction by the World Bank, it is well known that good governance has been adopted as a policy objective almost universally by international development agencies, for example, by the regional development banks, by UN agencies such as UNDP, by the IMF since 1997, and by most bilateral agencies such as Danida (Danish International Development Assistance) and the UK’s Department for International Development” (Crawford, 2006, P 119).

It is this newest trend of selectivity in World Bank aid allocation that this paper examines. Section 2 will focus on previous research done on selectivity across all aid agencies (not just the World Bank) and whether it seems to be the best method for the allocation of aid money. Section 3 will look at new data to see if there is evidence that countries with better governance, as defined by World Bank Governance Indicators, are better able to use aid dollars given them. Section 4 will look at case studies of World Bank loans given to Uganda, Ghana, Jordan and Yemen to see if their experiences fit with the overall data. Section 5 will conclude.

## Section 2 – Previous Research

The argument that better governed countries (those who have sound institutions and policies in place) are more likely to allocate aid funds more appropriately is an intuitive one. It simply makes sense that the more corrupt a government is, the less likely it is to distribute funds effectively. Instances of government abuse of aid money can be found in Zaire under Mobutu Sese Seko, Nicaragua at the time of the Somoza dynasty and the Philippines under President Ferdinand Marcos (Hout, 2007, P 135). But intuition is not always correct and must be backed up by hard evidence before it can be conclusive.

In “Aid, Policies and Growth”, Burnside and Dollar analyzed the effectiveness of aid on various countries by using the Sachs-Warner Index (which looks at budget surplus, the inflation rate and trade openness) to judge institutional and policy quality and a World Bank database on foreign aid to measure the amount of aid to each country. They used 275 observations to look at 56 countries over six four year time periods from 1970-1973 until 1990-1993. They concluded that, “on average aid has had little impact on growth, although a robust finding was that aid has had a more positive impact on growth in good policy environments. Our results indicate that making aid more systematically conditional on the quality of policies would likely increase its impact on developing country growth” (Burnside and Dollar, 2000, P 864). This paper generated much debate on the subject, with some economists agreeing with Burnside and Dollar’s assessment, and others questioning its methods and the robustness of its conclusions.

Easterly, Levine and Roodman attempted to recreate the findings of Burnside and Dollar exactly (2003). They were able to duplicate the results using the same countries, sources and time periods used previously, but things changed when they added new data that had become available and extended their analysis to 1997. Now they had 356 observation in 62 countries in seven time periods to look at and they found that the Burnside and Dollar conclusions that supported the idea that better policies and institutions lead to faster growth, “do not hold when we use new data that includes additional countries and extends the coverage through 1997” (Easterly et al., 2003).

Other development economists created their own, different methods to test the idea that success of aid is conditional on effectiveness of governance. Hansen and Tarp’s assessment included both the good-governance/better used aid interaction and the idea of decreasing marginal returns to aid flows (2001). They also began with the Sachs-Warner Index but added measures of the state of the financial system (measured by M2 relative to GDP), political instability and government bureaucracy (measures of ethnolinguistic fractionalization, assassinations and a measure of institutional quality), and the initial levels of per capita GDP. In one of their regressions they are able to arrive at the same conclusions as Burnside and Dollar “but only through a statistically invalid reduction of our model and sample data” (Hansen and Tarp, 2000, P 553). Overall, Hansen and Tarp find that aid does increase the growth rate via investment regardless of the effectiveness of the government.

Due to the amount of backlash received by the publication of “Aid, Policies and Growth”, Burnside and Dollar published another paper in 2004 in which they created a new dataset that looked exclusively at the 1990’s. Rather than using their previously constructed measures of governance quality, they chose instead to use the new Governance Matter Indicators compiled by Kaufmann, Kraay, and Zoido-Lobaton. This dataset compiles 300 governance indicators for 150 countries, groups these indicators into 6 basic categories (Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption) and gives each category a score of -2.5 to +2.5 (Kaufmann et al., 1999). They test the following three hypotheses:

1. Aid contributes positively to growth in all countries
2. Governments with better policies and institutions see more growth from aid than governments with poorer policies and institutions
3. Aid does not contribute positively to growth in any country

Using this new method of calculation, Burnside and Dollar arrive at hypothesis 2, again finding that the quality of institutions and policies does affect the extent to which aid impacts growth. They point to case studies such as European growth under the Marshall Plan post World War II, individual projects in countries such as South Korea, Kenya and Zimbabwe and agreement from 84% of “opinion makers” from various developing and developed countries that support their claim that good governance is the key to aid effectiveness. They also argue that the old system of conditionality has not worked, but perhaps donors will be able to influence recipient’s policies and institutions in the future if developing country governments know in advance that they must make certain reforms in order to receive aid assistance.

Collier and Dollar (2001) reach similar conclusions to those of Burnside and Dollar when they look for the best method to maximize poverty reduction around the world in order to meet the Millennium Development Goal of halving world poverty by 2015. They use the \$2 per day poverty line to measure both current and expected poverty under the scenario for aid allocation that they propose. The Country Policy and Institution Assessment or CPIA (which classified governments within countries as very poor, poor, moderate, good, and very good) is used to measure effectiveness of government policies and institutions. Additionally a poverty elasticity of 2 is used for all countries, rather than finding each country-specific elasticity, as it has been shown in the past to be the median (Ravallion and Chen, 1997). The authors present support that worldwide poverty rates would decrease by more under the selectivity method than the current method of aid allocation where some aid is given selectively and other aid is given for political, strategic or commercial reasons. It is further argued that the 1996 allocation of \$38 billion in aid could have been 50% more effective under their methods. They claim that it would have had as much impact as \$56 billion under the actual allocation system. Clarification is made that the intention of selectivity is not to discontinue all aid to badly governed countries and give it only to those that are better-governed (who may also be better off), but rather, “For countries with similar policy, aid should increase with the level of poverty because the growth promoting-effect of aid has more poverty effect in a very poor country. For countries with similar levels of poverty, aid should increase with the level of policies because it has a larger growth effect in the better policy environment” (Collier and Dollar, 2001, P 1792-3). It is noted that over time, as poverty levels decline, so too would the amount of aid a country receives.

Mosley, Hudson and Verschoor (2004) agree with Collier and Dollar that selectivity is a better approach to development than conditionality was, but they propose another method of aid allocation that they have termed ‘New Conditionality.’ Their proposed concept is based on 3 principles:

- Aid should be broken down into various dimensions – “aid for policy reform, accelerated debt relief under the Highly Indebted Poor Countries initiative, and social-sector aid for education, health, rural infrastructure, etc.” If a country has a ‘very good’ governance rating they will be eligible to receive all three types of aid, whereas countries that are ‘moderate to poor’ will only receive social-sector aid.
- In certain cases governments will be bypassed and aid will go directly to NGOs or even the private sector at times. Kenya, Bangladesh and Zambia are examples of countries where aid money has been funneled through NGOs due to governments that rate as ‘moderate to poor.’
- Gentle social, political and economic pressure can be applied to advocate conflict prevention, foster democracy and equal citizenship and fight corruption through this more long-term approach.

Their regressions focus more on the impact that aid has on poverty, rather than the traditional method of looking at the impact of aid on GDP growth. They do this by looking at what aid does to public expenditure, specifically ‘pro-poor’ expenditure such as those for health, primary education, water and sanitation, rural roads and agricultural extension services. They then estimate sector-specific poverty elasticities. Inequality and corruption are also taken into account in their model and the results of their regressions are very different from the findings of Collier and Dollar (2001) who used a standard poverty reduction elasticity of 2, but when inequality and public spending are factored into the poverty equation a growth elasticity of headcount poverty reduction of 0.48 is found. This is a very conservative estimate since an increase in growth leads to an increase in pro-poor expenditures resulting in a poverty reduction elasticity of 0.92. This tells us that for every 1% extra growth, poverty decreases by less than 1%, rather than decreasing by 2% as Collier and Dollar found.

Mosley, Hudson and Verschoor give examples of countries such as Ethiopia, Mozambique, Tanzania and Uganda where this idea of ‘new conditionality’ has worked saying that,

In all of these cases a virtuous circle operated that contradicts the Collier-Dollar proposition of donors having no influence and, as a consequence, there have been more opportunities to turn potential into actual aid leverage. Needless to say, this process did not always run smoothly and exactly how this process has occurred, in the places it has, is not always completely clear but one key element in it appears to be that, in those places, aid donors made themselves a political as well as a financial asset to recipients – in part through a negotiating style characteristic of a new cluster of donor influence, which we have termed ‘new conditionality’ (Mosley et al., 2004, P F229).

While it is true that certain countries may be hurt by selectivity (low-income, low-inequality countries like Mozambique who tend to score low in governance indicators), ‘new conditionality’ is not without its pariahs. Middle-income, high inequality countries such as Honduras would receive about half as much aid money under ‘new conditionality’ as they would under selectivity, due to the presence of an equality measure accounted for in this model, though emphasis is put on the estimate that this new method would be 12% more effective per year than the one proposed by Collier and Dollar.

Overall, previous studies done on the successfulness of selectivity have not reached a consensus. Some believe it is the best approach and have credible methods of data analysis to back them up. Others use equally plausible data to conclude that selectivity should not be used to allocate aid. Let’s look now at some possible explanations for the disagreements.

A large part of the reason the effectiveness of selectivity is disagreed upon may be because those creating the models cannot agree upon the best methods for testing it. Nearly every time the theory of selectivity is examined something new is added to or taken away from the model, even when those assessing it have done so in the past. This lack of agreement as to what most needs to be accounted for in the model is a fundamental one, but there are other discrepancies as well.

One issue is that there are so many definitions of “good governance” and one has not yet been found that everyone can agree on. And even if an organization such as the World Bank or Millennium Challenge Corporation has hit upon a definition that they like, who is to say that it is right (Crawford, 2006, P 119)? After all, they are outsiders and without the feedback from the

citizens within a country how can they tell how good the governance really is? While it is true that there are some countries in this world that have truly terrible (or exceptionally wonderful) governments, what about those that are more in the middle? (Easterly, 2006, P 136-7). Without a better system for judging the effectiveness of governments, aid agencies should not be too quick to favor one governance rating system over another. Rather than relying on any one governance indicator, Hout argues that development agencies should, “define the conditions under which they would no longer be prepared to support particular countries” (Hout, 2007, P 136) and if a development agency does decide to stop supporting a particular government, then they can move to supporting the population through non-governmental aid channels, a view shared by Easterly (2006). Additionally, the CPIA, one of the most used indicators to judge a countries governance quality, is accused of being neo-liberal in its approach, putting too much emphasis on economic growth and none on democracy, political participation, the rule of law, and human rights. It is further argued that the human development definition of development includes some aspects of health and education rather than solely GDP per capita as the CPIA does. This means that a country such as Cuba can come in 52<sup>nd</sup> in the Human Development Index in 2005, but still be considered “out of bounds by the World Bank” (Hout, 2007, P 137).

Another argument against selectivity heralded by a number of prominent economists is the idea that while there is a correlation between bad governance and slow economic growth there is not necessarily causality. It is argued that in many cases countries may have bad governments because they are poor, rather than the opposite (Easterly, Sachs, Hout). Jeffrey Sachs explains it well when he says,

As a country’s income rises, governance improves for two major reasons. First, a more literate and affluent society is better able to keep the government honest by playing a watchdog role over government processes. Newspapers, television, books, telephones, transport, and now the Internet, all of which are vastly more available in rich countries, enhance this watchdog function and empower civil society. Second, a more affluent society can afford to invest in high-quality governance. When governments are backed by ample tax receipts, the civil service is better educated, extensive computerization improves information flows, and the public administration is professionally managed (Sachs, 2005, P 312).

While this idea makes a lot of sense the little research that has been done on the subject has shown nothing more than that bad governments do cause poverty (Easterly, 2006, P 116).

Until the above issues are resolved, there is no reason to believe that there will be any agreement on whether or not selectivity is the best method for aid allocation, though it will no doubt continue to be used by many well-known organizations such as the World Bank, the IMF and the UNDP. After all, these organizations must use some system to allocate aid and the previous method of conditionality has proven to be highly ineffective. The continued use of selectivity does not mean that we should judge “poorly” governed countries too harshly because, as William Easterly reminds us,

There is a lot of variation, both across developing countries and within governments as to quality of government officials. There is a layer of capable, honest, well-meaning technocrats in almost every government, who themselves are a promising group of Searchers looking for a way to increase opportunities for poor people (Easterly, 2006, P. 102).

### Section 3 – Looking at the Effect of Governance on Poverty

The aim of this paper is to look at the impact that good or bad governance has on the effectiveness of using foreign aid to reduce poverty. To do this analysis, measures of poverty, aid and governance must be used. The \$2 per day poverty line will be used in lieu of GDP per capita. The drawback to using the \$2 per day measure is that it is not generally calculated on an annual basis for each country and therefore restricts the number of countries that can be included in the sample. In order to compensate for this lack of data 3 year time frames will be used – 1996-1998, 1999-2001, 2002-2004, and 2005-2007, though the number of countries with even that much data remains limited. To see how poverty has increased or decreased in the individual countries we will look at the change in the \$2 per day poverty line as a percentage of the population from the 1996-1998 time period to the 2005-2007 time frame.

Two measures of aid will be used. The first is the average amount of Official Development Assistance (ODA) that countries received over the whole 12-year period. ODA is defined by the Organization for Economic Co-operation and Development as “Flows of official financing administered with the promotion of the economic development and welfare of developing countries as the main objective, and which are concessional in character with a grant element of at least 25 percent (using a fixed 10 percent rate of discount)” (OECD, Glossary of Statistical Terms). It is important to assess countries using ODA as a percentage of GNI because the economies of certain countries are substantially larger than others. Looking at percentages of GNI puts all countries on equal footing. The second measure used records actual dollar amounts received for ODA and aid (calculated in constant 2007 \$US). These actual dollar amounts are what potential donors want to look at to see where their money would have the most (potential) impact. The two methods will be compared to see if they are consistent with each other.

While there are many governance indices in use today, one of the most popular ones remains the Governance Matter Indictors mentioned in Section 2 above, developed by Kaufmann, Kraay, and Zoido-Lobaton. The following 6 broad categories are taken into account:

- Voice and Accountability (the degree to which a country’s residents have a say in choosing their government in addition to a free media, freedom of expression and freedom of association)
- Political Stability and Absence of Violence (how likely the public perceives the government to be overthrown or destabilized)
- Government Effectiveness (how public service, civil service, policy creation, implementation and commitment are perceived)
- Regulatory Quality (how the government creation and implementation of private sector policies and regulations is perceived)
- Rule of Law (how effective the police and judicial system is as well as laws governing property rights and contract enforcement)
- Control of Corruption (again based on public perception)

The data that goes into this index contains hundreds of variables drawn from 35 individual data sources from various parts of the world. The most recent report gives a score of -2.5 to +2.5 (with higher numbers corresponding to better governance) for each of the 6 categories to 212 countries on a yearly basis from 1996 to 2008 and it is from these scores that the effectiveness of governance will be judged within the countries in the data sample (Kaufmann et al., 2009). For simplicity sake the scores in each of the 6 categories for each

individual year are averaged together to give an annual governance score and then the annual scores for the years between 1996 and 2007 are averaged together to give each country only one overall governance score for the entire 12 year time period. In this way we can see which countries were better governed throughout the entire time period.

Of the countries that have adequate data on the \$2 per day and ODA as a percentage of GNI variables, the ones that receive less than 1% of their annual GNI from ODA are excluded, leaving only 23 countries. The average governance scores of included countries range from a +0.05 for Jordan to a -1.41 for Burundi. These 23 countries are then broken down into those that are comparatively well governed, those that are less well governed, and those that are in the middle. This analysis captures only those countries that fit into the top and bottom categories. Ten countries are considered to be “well” governed, though the scores in this category range from a +0.05 to a -0.45, and 7 countries considered to be “poorly” governed, receiving scores from -0.71 to -1.41. These countries are graphed in Figures 1 and 2 with Average ODA as a percentage of GNI on the x-axis and the Change in the percentage of the population living on \$2 or less per day on the y-axis with the country name and World Governance Indicator scores written next to each data point.

Figure 1 shows nine out of ten well-governed countries have poverty levels that are either decreasing or remaining the same, giving the impression that good governance may indeed lead to efficient allocation of aid dollars. But when a line of regression is added, it appears that the more ODA given to these countries, the less poverty decreases (as defined by the \$2 per day measure).

Figure 2 reveals that only five out of seven of our poorly governed countries show a decrease in poverty over the 12-year time period. This time when a line of regression is added it shows that additional ODA leads to a decrease in poverty, though not by a substantial amount.

Figure 1

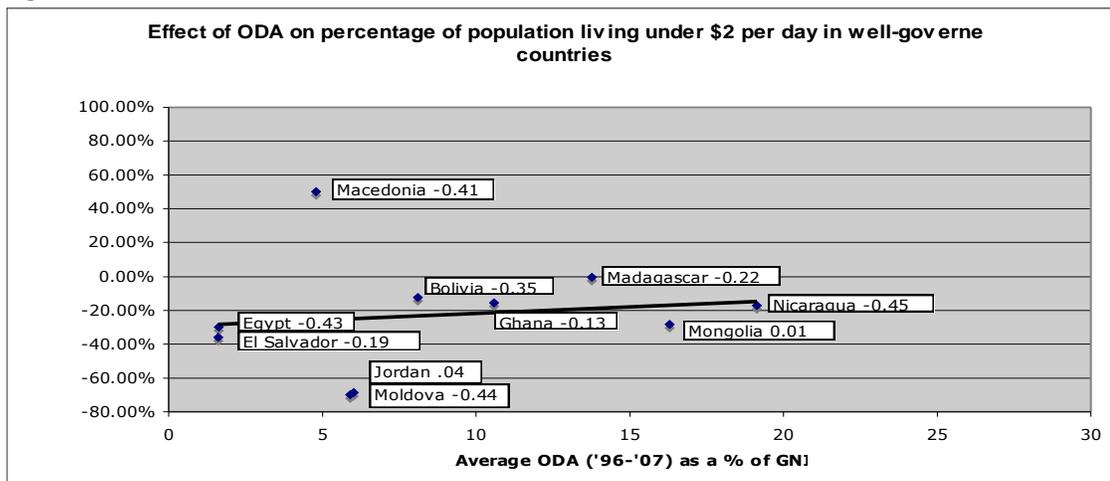
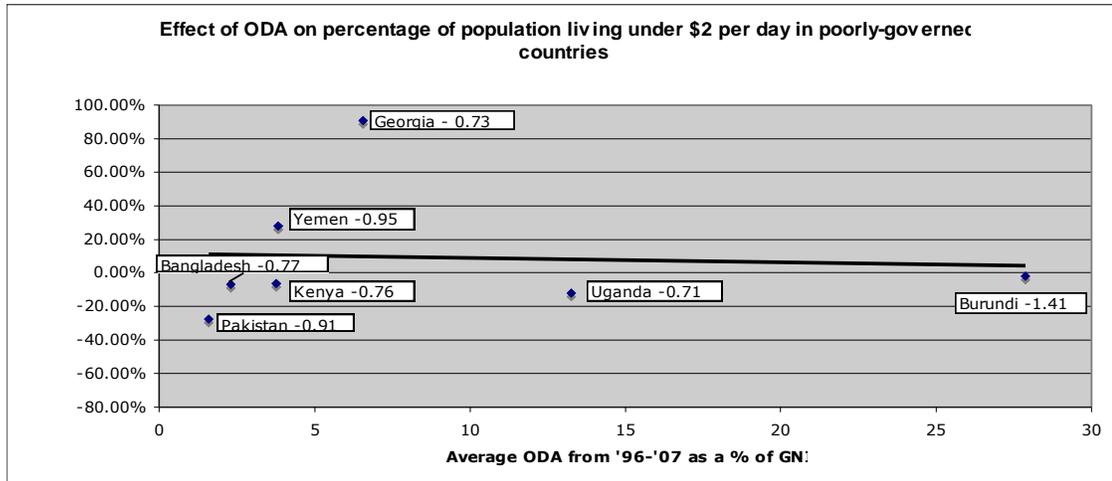


Figure 2



Figures 3 and 4 look at actual dollar amounts of ODA, this time including additional forms of aid. When a line of regression is fitted to the better-governed countries plotted in Figure 3, we see that there is almost no relationship between the amount of aid received and the change in the percentage of the population living on \$2 or less per day.

Fitting a line of regression to the less well-governed countries of Figure 4 emphasizes what was seen in Figure 2 – the more aid dollars given to “poorly” governed countries, the greater the decrease in poverty.

Figure 3

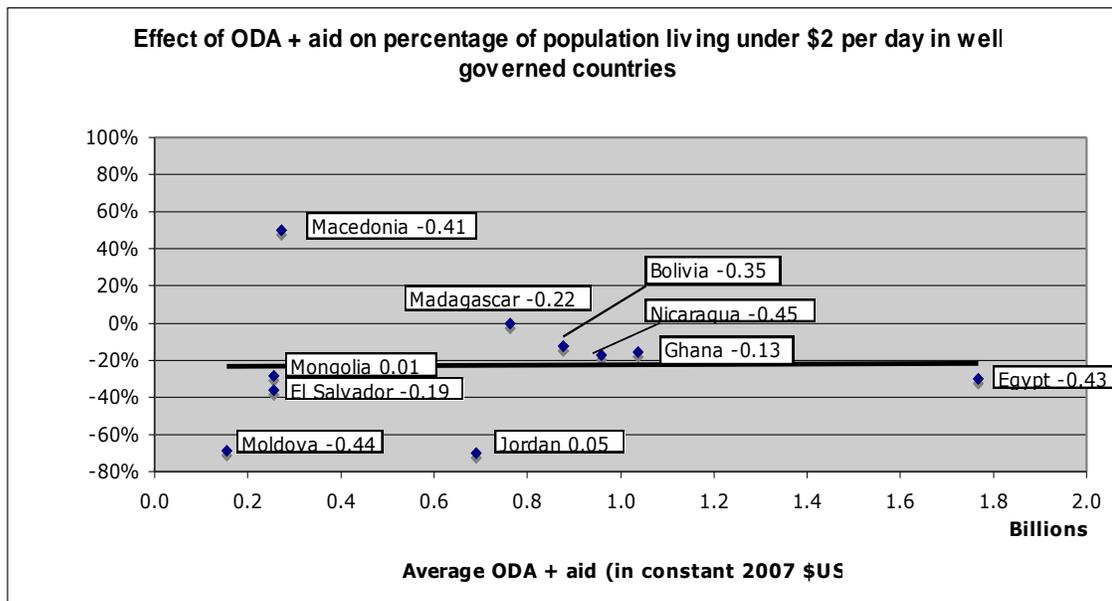
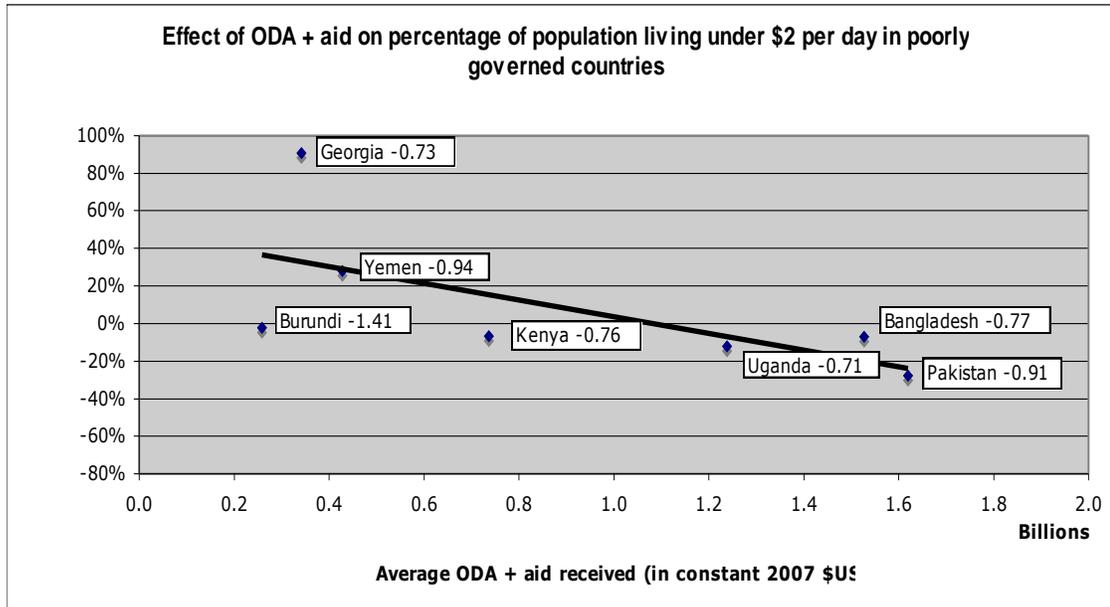


Figure 4



This model is of course very crude and therefore is not entirely conclusive. To begin with there are only 17 developing countries that were able to be included and there was nearly as much variation of the World Governance Indicators within the two categories (well governed versus poorly governed) as there was between them. After all the 10 well governed countries scores differed from best to worst by .5, the 7 worst governed countries scores were spread over a range of .69, and there was only a difference of .25 between the 2 categories. Additionally averages over long time periods were used, such as to calculate a single 12-year governance score and the average amount of aid a country received within that 12-year time frame. This use of averages may cause distortion by not reflecting the true values of the datum though it keeps things simple and makes the data easier to work with. It must also be remembered that occurrences such as political or civil unrest may contribute to the effectiveness that ODA has on poverty, but these may not be accounted for in the World Governance Indicator scores.

Looking at case studies and comparing two countries that are similar may help compensate for the lack of strong evidence found in the previous models. Unfortunately there are few countries with enough data to be used so we must be content using countries that lie in the same geographic region, regardless of what other similarities or differences they may have.

#### Section 4 – What the case studies indicate

The World Bank Group is made up of two different types of institutions called the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA), which provide very different types of funds to countries around the world. The IBRD makes loans at market rates to middle-income countries and those poorer countries that are deemed to be creditworthy while the IDA provides interest-free loans and grants to the world’s poorest countries. Although loans are given for a variety of different projects including education, health, infrastructure and natural resource management the overriding purpose of every loan or grant is to decrease poverty, hence the World Bank motto of,

“Working for a World Free of Poverty.” It is this combination of IBRD and IDA loans that will be examined in the four case study countries. And again the percentage point change in the \$2 per day measure will be used in order to compare the effectiveness of World Bank loans within countries depending on their World Governance Indicator scores.

The first two countries to be compared come from Africa – Ghana and Uganda. Ghana has 24 million people, made up of more than 100 different ethnic groups who live with each other in relative peace. In Uganda there are 32.4 million people who speak 40 different languages, with no single ethnic group making up a majority of the population. Unlike in Ghana, there is conflict in the north of Uganda. Both countries have substantial amounts of natural resources and both are predominantly Christian (with Muslims being the next largest religious majority).

Table 1 shows the average World Governance Indicator scores for these two countries for each of the years between 1996 and 2007. The data in this table indicates that while Ghana’s governance scores have fluctuated they have improved overall in the 12-year time frame. Uganda’s scores got worse in the late 1990’s until 2002, after which time they began to improve, producing an average score in 2007 that is nearly identical to the one they received in 1996.

A glance at Figure 5 reveals nearly identical loan patterns between the two countries, with the amount of the loans increasing and decreasing in the same years for both. However, Ghana routinely borrowed more World Bank funds per year for an average of 40% more IBRD and IDA loans over the 12 years. If the theory of selectivity holds the higher governance indicator scores received by Ghana coupled with the increased amount of loans received should lead to greater poverty reduction within Ghana, but this does not seem to be the case. Figure 6 indicates that, over the 12 year period, the percentage of the population living on \$2 per day or less decreased by 9.73 percentage points for Ghana, while in Uganda it decreased by 10.35 percentage points. When the percentage point decrease in the \$2 per day poverty level is divided by the total amount of IBRD and IDA loans made by the World Bank and multiplied by a billion we are able to see what percentage of the population was lifted out of poverty for each \$1 billion borrowed. This measure is especially useful because it controls for population size, making it easier to compare countries that do not have similar numbers of residents. For Ghana the number is -.283 (the negative sign indicating a decrease in poverty), for Uganda it is -.419 revealing that, though Uganda’s governance scores are lower than those for Ghana, each billion borrowed from the World Bank is 48% more effective at alleviating poverty, as measured by those living on less than \$2 per day. In comparing these two African countries it does not appear that selectivity is the best allocation of aid dollars. In this case study the less well-governed country (Uganda) used loan dollars more effectively to reduce poverty.

Table 1

Country	1996 AVERAGE	1998 AVERAGE	2000 AVERAGE	2002 AVERAGE	2003 AVERAGE	2004 AVERAGE	2005 AVERAGE	2006 AVERAGE	2007 AVERAGE
GHANA	-0.283	-0.285	-0.087	-0.213	-0.163	-0.180	-0.044	0.094	0.073
UGANDA	-0.569	-0.709	-0.823	-0.851	-0.729	-0.698	-0.663	-0.595	-0.598
JORDAN	0.068	0.062	0.079	-0.124	0.026	0.066	0.050	0.020	0.075
YEMEN	-0.770	-0.865	-0.942	-1.055	-1.006	-1.082	-1.007	-0.981	-0.9864

Figure 5

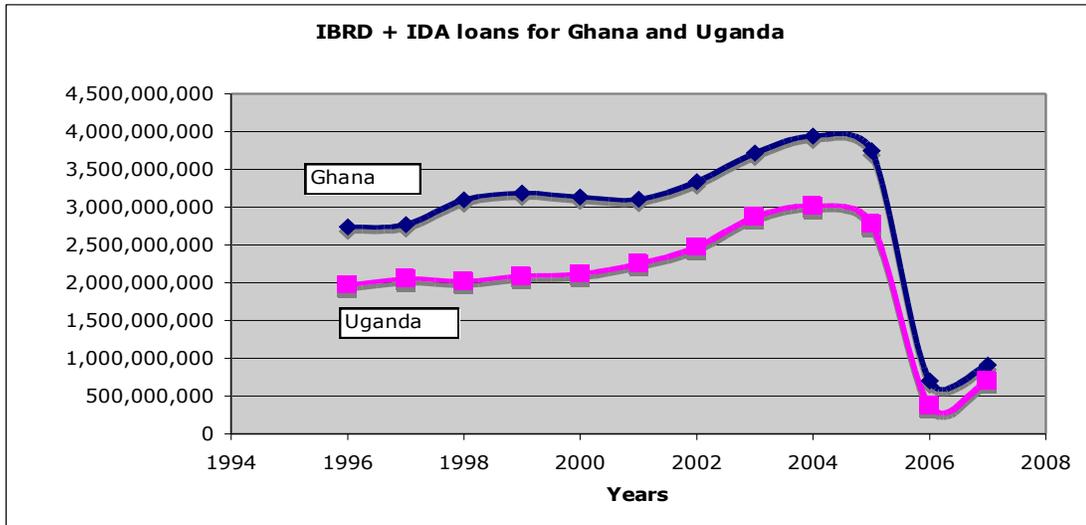
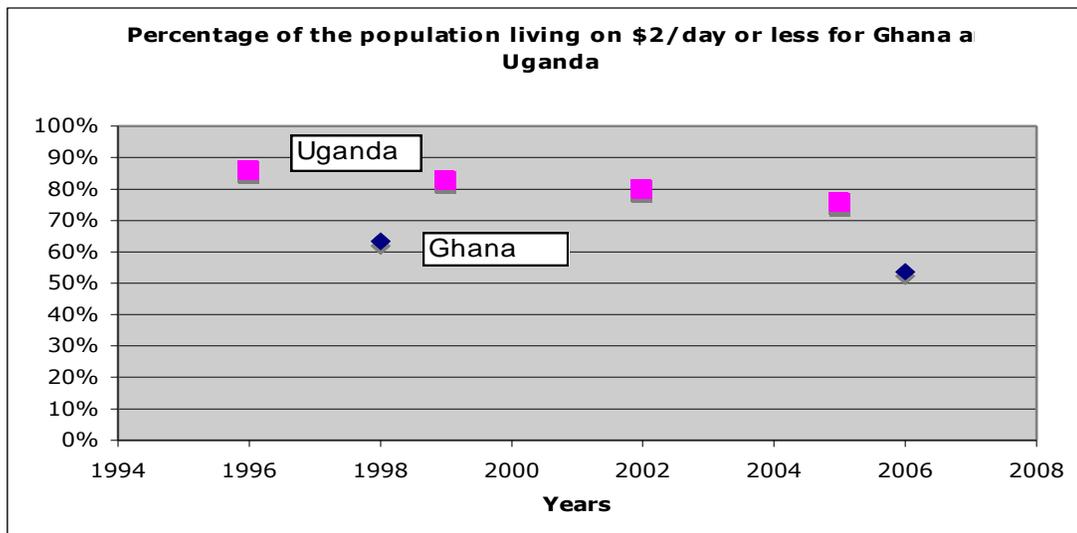


Figure 6



Let's turn now to the two Middle-Eastern countries of Jordan and Yemen. Both countries are predominantly Muslim and are in the same region (separated by Saudi Arabia) but this seems to be where the similarities end. At 28 million, Yemen has a much greater population than Jordan's 5.1 million. Additionally, Yemen is well endowed with oil and natural gas deposits (though currently focuses on extracting only the oil), while Jordan has very limited resources. Jordan, which has a constitutional monarchy with a representative government, enjoys relative

peace. Yemen on the other hand, is a President Republic with a bicameral legislature and has a problem with civil unrest in the northwest of the country.

There is a greater spread between the governance indicator scores of Jordan and Yemen than there was for Ghana and Uganda as can be seen in Figure 1. The scores for Jordan varied some but remained fairly stable overall, but the governance scores for Yemen got progressively worse between 1996 and 2002 and then began to stabilize and are slowly improving. Figure 7 shows that while Jordan’s borrowing has remained fairly stable at around \$1 billion per year (with a slight decline in recent years), Yemen has borrowed increasingly more from the World Bank. Poverty as measured by those living on \$2 per day or less decreased by 8.04 percentage points in Jordan, and actually increased by 10.25 percentage points in Yemen. When you look at how effective each billion dollars lent was at decreasing poverty in these countries you get a  $-.754$  for Jordan (the negative sign once again denoting that it is a decrease in poverty) and a  $+.643$  for Yemen. So in this case, the concept of selectivity does seem to fit – Jordan, the country with the higher governance score is significantly more effective at using World Bank loan monies to alleviate poverty.

Figure 7

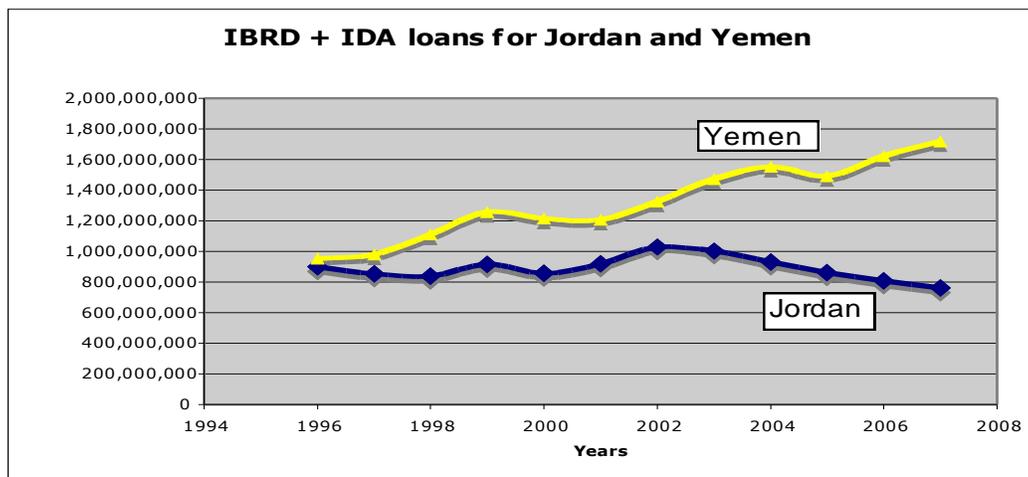
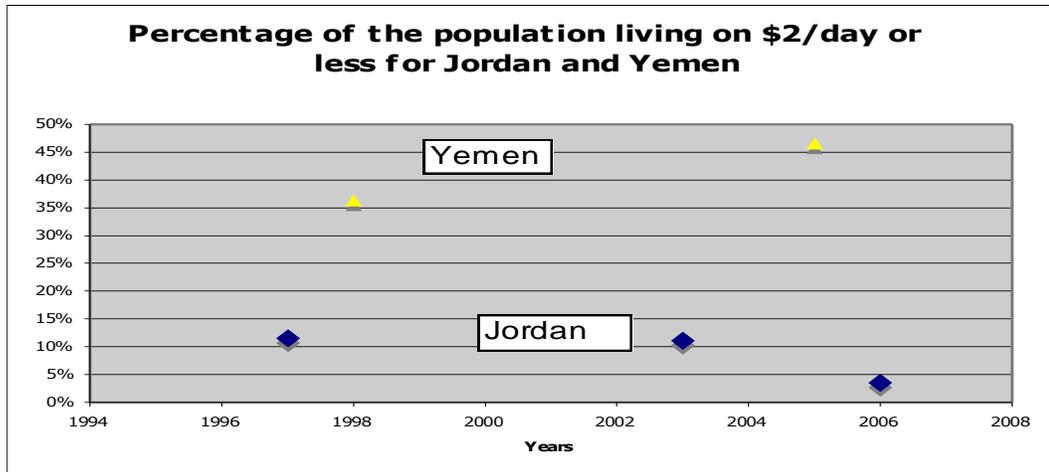


Figure 8



### Section 5 – Conclusion

While the idea that World Bank funds and other forms of aid should be apportioned on the basis of selectivity makes instinctive sense, the evidence does not always support this as the best method for aid allocation. Burnside and Dollar found evidence in two separate studies published in 2000 and 2004 that supported the theory of selectivity (as did Collier and Dollar in 2001), but other economists who have done similar work have been unable to duplicate their results. A large portion of the problem stems from the inability of model makers to agree on what sorts of policies “good” governments possess. Some believe that the focus should be more on a government’s economic policies; others believe that every country is different and therefore may have better success with a different combination of policies than those that have worked in the past so we shouldn’t try to apply a “one-size fits all” set of policies everywhere. Furthermore, while evidence exists that there is a correlation between how well a country is governed and its rate of economic growth, causality has not yet been proven. It is just as likely that economic growth leads to better governance as it is the other way around.

When various developing countries are compared based on the \$2 per day poverty measure and the amount of Official Development Assistance received it appears that more aid money given to less-well governed countries results in a greater decrease in poverty than when more aid is given to better-governed countries. This indicates that selectivity does not hold in the developing countries within the model. It must be remembered however that only 17 countries were able to be included due to lack of data on the measures used and the need to separate those countries that had data into “good” and “bad” governance, leaving out the countries that rated in the middle of the scale.

Looking at the case studies of World Bank loans made to Ghana and Uganda reveals that Uganda, the country with lower World Governance Indicator scores, is actually more effective at using loan money to decrease poverty (as measured by the percentage of the population living on \$2 per day or less). In this case selectivity may not be the best method for allocating funds. However, it must be noted that while Ghana received better governance scores, the difference between the scores for the two countries was not exceptionally large. Selectivity may work better when comparing Jordan to Yemen. Jordan has notably better World Governance Indicator scores and is considerably more effective at using World Bank loan funds to decrease poverty than Yemen (note that Yemen actually saw a 10 percent increase in poverty). Perhaps what

these case studies highlight is that selectivity is more likely to work when applied to countries on the polar ends – those with the best and worst governance overall, while developing countries that fall into the middle should be considered more carefully. After all, corruption ratings are not exact and contain a high margin of error. According to Easterly, “The high margin of error reflects the difficulty that different outside rating agencies have reaching consensus on which countries are more or less corrupt. It looks like selecting good governments is not so easy” (P. 137).

Works Cited

- About Us." *World Bank*. The World Bank Group, 17 Mar. 2010. Web. 15 Aug. 2010.
- Burnside, Craig, and David Dollar. "Aid, Policies, and Growth." *The American Economic Review* 90.4 (2000): 847-68. Print.
- CIA - *The World Factbook*. Web. 21 Sept. 2010. <<https://www.cia.gov/library/publications/the-world-factbook/>>.
- Collier, Paul, and David Dollar. "Can the World Cut Poverty in Half? How Policy Reform and Effective Aid Can Meet International Development Goals." *World Development* 29.11 (2001): 1787-802. Print.
- Crawford, Gordon. "The World Bank and Good Governance: Rethinking the State or Consolidating Neo-liberalism." *The IMF, World Bank and Policy Reform*. New York: Routledge, 2006. 115-41. Print.
- Dollar, David, and Lant Pritchett. *Assessing Aid: What Works, What Doesn't, and Why*. Washington, D.C.: Oxford UP, 1998. Print.
- Easterly, William Russell. *The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done so Much Ill and so Little Good*. Oxford: Oxford UP, 2007. Print.
- Easterly, William, Ross Levine, and David Roodman. *New Data, New Doubts: Revisiting "Aid, Policies, and Growth"* Working paper no. 26. Washington, DC: Center for Global Development, 2003. Print.
- Hansen, Henrik, and Finn Tarp. "Aid and Growth Regressions." *Journal of Development Economics* 64 (2001): 547-70. Print.
- Hout, Wil. *The Politics of Aid Selectivity Good Governance Criteria in World Bank, US and Dutch Development Assistance*. London: Routledge, 2007. Print.
- Kaufmann, Daniel, Aart Kraay, and Massimo Mastruzzi. *Governance Matters VIII*. Working paper no. 4978. Washington, DC: World Bank, 2009. Print.
- Kaufmann, Daniel, Aart Kraay, and Pablo Zoido-Lobaton. *Governance Matters*. Working paper no. 2196. Washington, DC: World Bank, 1999. Print.
- Mosley, Paul, John Hudson, and Arjan Verschoor. "Aid, Poverty Reduction and the 'New Conditionality'" *The Economic Journal* 114 (2004): F217-243. Print.
- "Official Development Assistance." *OECD Glossary of Statistical Terms*. Organization for Economic Co-operation and Development, 28 Aug. 2003. Web. 17 Aug. 2010. <<http://stats.oecd.org/glossary/detail.asp?ID=6043>>.
- Ravallion, Martin, and Shaohua Chen. "What Can New Survey Data Tell Us about Recent Changes in Distribution and Poverty?" *World Bank Economic Review* 11.2 (1997): 357-82. Print.
- Sachs, Jeffrey. *The End of Poverty: Economic Possibilities for Our Time*. New York: Penguin, 2005. Print.
- World Bank. World Development Indicators. 2010. Raw data. <<http://data.worldbank.org/indicator>>.
- "World Economic Outlook Database." *International Monetary Fund*. International Monetary Fund, Apr. 2008. Web. 15 Aug. 2010.

**Unmasking the Superhero: Analyzing Junot Díaz's  
*The Brief Wondrous Life of Oscar Wao* as  
"Multicultural Hybridity" Literature**

**Deborah Blanchard, English/Modern Languages - Spanish  
Bridget Kevane, Ph.D., Mentor  
Department of Modern Languages and Literature**

**ABSTRACT**

*The term "American Literature" alludes to a hybridity of text and meaning that combines the different languages and cultures that make up America's writing landscape. When literary students begin to learn about "American Literature," they are first exposed to a predominantly Euro-American canon and then possibly to a multicultural grouping of American authors set up to represent the rest of America ethnic writing. Exposure to these "other" literatures raises the following questions: How does multicultural American literature fit into the larger Euro-American canon? Should the two groups remain separate or should they be woven together? How does the "mainstream" reader engage with the multicultural text in a meaningful manner without stereotyping groups of fellow Americans based on one or two works? Utilizing familiar themes that are a part American popular culture and literature, while engaging with the text, allows for meaningful analysis without losing the important messages the text may be trying to relay.*

**Introduction**

Students of multicultural literature frequently face the challenge of how to interact and relate to a text when they have no firsthand experience in understanding other American subcultures outside of their own "mainstream" experience. How does a student from rural America relate to the urban lifestyle in one of New York City's boroughs? How does the white all-American athlete from a "good" school relate to the inner city kid with darker skin going to a lesser-funded inner city school? Can a non-traditional aged student relate to the youth that encompasses college life? All of the individuals mentioned in the above questions are typical stereotypes relied upon when discussing polarizing ends of society's spectrum. Although, for the purposes of this paper, the word "mainstream" is being used to label the majority white

American experience in the United States, this kind of stereotyping stunts the ability of readers to fully interact with multicultural literature beyond reading it in terms of race and ethnicity. These kinds of questions about how one relates to a culture or lifestyle different from one's own experience fueled the research utilized in this paper. I chose as my primary piece of literature *The Brief Wondrous Life of Oscar Wao* by Junot Díaz, because it provides many ways for different readers, from different backgrounds, to engage and interact with the literature and find meaning within the text. An examination of how the *aesthetic styles* utilized in Díaz's novel – the science fiction and fantasy genres, comic book characters and superheroes, and religious themes – provides a bridge of understanding for mainstream readers to engage with multicultural literature even if unfamiliar with the American subculture out of which the author and the literature grows.

After *The Brief Wondrous Life of Oscar Wao* won the 2008 Pulitzer Prize, it was picked up by academics in the multicultural literature classroom to discuss a variety of issues facing U.S. Latinos. It is a novel used to exemplify U.S. Latino literature and the issues surrounding the Dominican American diaspora in the United States, and for Latino readers, it provides a familiar landscape with which to relate. For readers who are not a part of the Latino community, the novel is sometimes more familiar as a bildungsroman – a coming-of-age novel – which, in this case, is about an overweight, nerdy, Dominican American kid named Oscar who aspires to be a hero and find love.

The novel weaves the history of a nation into the story of Oscar's life. Oscar's family comes to America when he is young and he grows up in Patterson, NJ. Oscar does not have a lot of friend and prefers the solitary pursuit of immersing himself in fantasy, science fiction, and comic books. The novel *is* a story of his coming-of-age, a bildungsroman, but it is also a novel

that speaks directly to the psychological makeup of a kid who grows up to willingly sacrifice himself for his highest ideal – love. Oscar, after being beaten brutally for having an affair with the love of his life Ybón – a woman who is also the girlfriend of a Dominican policeman – returns to the Dominican Republic to pursue his relationship with Ybón, and ends up passively allowing himself to be walked into the canefield to be shot and killed. To understand the motivations behind this final deadly act, one has to understand what makes Oscar think the way he thinks. The best way to understand Oscar’s motivations is to understand the kinds of literature and American popular culture he was exposed to that influenced his personal value system and the choices he makes during his lifetime.

The world created in *The Brief Wondrous Life of Oscar Wao* is a world that references science fiction, comic books and religious imagery to explain the affects of the Trujillo dictatorship on the Dominican American identity. In using these kinds of themes to help the reader understand Oscar’s experience, the mainstream reader is able to engage in a meaningful way with the text without having had to live through the immigrant experience, or be a part of the Dominican American subculture. The underpinnings of Oscar’s mindset correlate to the ways in which the reader engages with this novel. Rather than a straight forward discussion of identity and ethnicity, this novel has created a number of ways for the reader to interact with Oscar’s life and through processes. Once the reader understands Oscar’s way of processing the world around him, Oscar becomes a familiar character to many readers outside the Latino community. In addition to seeing the world the way Oscar sees it, the mainstream reader begins to recognize the different ways in which to cross over into the text through a study of the way in which this novel is written.

A thematic discussion of *The Brief Wondrous Life of Oscar Wao* cannot ensue without a brief discussion about how this kind of literature is categorized. Generally, this kind of literature – literature written by an author of some kind of ethnic-American minority descent – is collectively dumped into the “multicultural” literature category. However, the problem with lumping all ethnic minority pieces of literature into one category is that it automatically “others” the literature from the mainstream, thereby making it difficult for the mainstream reader to understand the true import of the message trying to be conveyed. One solution to the problem of categorizing is to utilize Laurie Grobman’s concept of “multicultural hybridity” as discussed in her book *Multicultural Hybridity: Transforming American Literary Scholarship & Pedagogy* (18). In discussing “multicultural hybridity,” Laurie Grobman explains that even though “unities and common understandings are prerequisites to cross-cultural communication and global understanding,” there is a further “need to bring critical judgment to bear on all cultural norms, beliefs, values, and practices” (18). Although it may be easy to fall back on common stereotypes, being able to understand a piece of literature requires the reader to find new ways of critiquing the text, while gaining understanding of cultural differences.

In reading Díaz’s novel, readers need to find a way to engage with the character of Oscar in order to understand the issues of identity and sacrifice that the text is discussing. Although it makes sense to relate this novel to the issues of identity surrounding the Dominican American experience, there are other ways for the mainstream reader to relate and interact with the text, particularly if they have difficulty in really understanding the affects of the Trujillo dictatorship on the Dominican American experience. Grobman further explains in her theory of multicultural hybridity literature, that there is a “space of in-betweeness...[where] convention and reality break down, and new realities must be (re)constructed” (41). Within this gap of “reality,”

between the mainstream reader's experience and the Dominican American experience, there exists what Grobman calls "crossings," which consist of "cultural, linguistic, economic, political, and aesthetic" crossings (33). These "crossings" serve as bridges over which the reader can enter into the world of the fictional text in order to gain clearer understanding of the text and the message the author may be trying to send. Certainly, within *The Brief Wondrous Life of Oscar Wao*, there are numerous ways the reader can relate to the text. However, the focus of this paper will be on crossings, or bridges of understanding, that fall under the "aesthetic" category. This novel lends itself to being able to explore this category more fully by a discussion of the many genre styles that Díaz utilizes and weaves into the novel to tell the story.

For the purposes of this research project, three different ways for a mainstream reader to relate to this text will be used, that fall under Grobman's "aesthetic crossings." First, the reader, if familiar with the genres of science fiction and fantasy, can understand the feelings that Oscar experiences as a non-typical Dominican American kid growing up in the United States as an outsider or an alien. Secondly, religious themes woven into the text help explain how the sacrifice of identity, through a literal loss of physical life, reflects the horrible circumstances of living under the Trujillo regime and the intense assimilation that immigrants have to undergo in order to survive and succeed in the United States. Finally, references to cartoon superheroes in American popular culture draw the reader into the issues surrounding identity and the dualistic nature of self-image and identity.

### **Science Fiction & Fantasy**

The Science Fiction and Fantasy genres do not rank as "high art" within academic circles, which is why it is surprising to have a novel receive such praise, and as much literary criticism,

as has *The Brief Wondrous Life of Oscar Wao*. However, it is through the use of these genres, that a new way of discussing history and dictatorships has been created in order to describe the Trujillo regime. The genres of science fiction and fantasy can be defined as follows: “[F]antasy is fiction that depends on magical or supernatural elements not specifically meant to scare you...[i]f the magical elements are replaced with imagined technologies, it’s *science* fiction” (Athans 14). In science fiction and fantasy, the main character typically is on a quest and needs to go through an arduous journey of self discovery in order to attain the final goal of saving something or someone – usually the world in which they live. Since there are many references within *The Brief Wondrous Life of Oscar Wao* to several novels and writers within these genres, only a few examples will be used to discuss how Science Fiction and Fantasy relate to the Dominican American experience under the Trujillo dictatorship and why this kind of literature is important to the character Oscar.

One of the most familiar books in the fantasy genre utilized in *The Brief Wondrous Life of Oscar Wao* to describe Trujillo and his military supporters is J.R.R. Tolkien’s *The Lord of the Rings*. This novel is an epic story about the battle of good versus evil. Tolkien created a universe peopled with multiple races and beings with different languages, origins and customs. It is a story about a ring that gives power to whoever wears it, but in the hands of someone evil, it gives the power to dominate and destroy. The main hero in *The Lord of the Rings* is Frodo Baggins, a hobbit, who receives the ring from his uncle as part of his inheritance. Hobbits are “an unobtrusive but very ancient people, ...[who] love peace and quiet and good tilled earth” (1). They are “merry folk” who wear “bright colors,” have curly hair and “tough leathery soles” on their feet (2). They were also called “Little Folk” and lived in a woodsy pleasant place called The Shire (146).

In direct contrast to humble Frodo sits Sauron, the main antagonist in *The Lord of the Rings*. He is the Great Eye who wants the One Ring of Power and breeds a species called Orcs, who are disgusting foul beings that serve as his military to wage war against the rest of Middle Earth. Sauron wants to dominate everybody and everything. Within *The Brief Wondrous Life of Oscar Wao*, Sauron becomes a symbol representing the ultimate dictator who rules with terror and evil intent. In one scene in *The Lord of the Rings*, where Frodo's companion Sam is looking into the Elf Queen Galadrial's magic mirror, he sees The Shire's trees being chopped down and replaced with "black smoke" (353). It is a vision of what the future could become if Sauron and his minions are able to dominate the people and the landscape.

The destruction of a way of life and the trust of a community is reflected in *The Brief Wondrous Life of Oscar Wao*. When describing Trujillo's dictatorship, the narrator Yunior states in the first footnote that Trujillo was "our Sauron..., our Once and Future Dictator, a personaje so outlandish, so perverse, so dreadful that not even a sci-fi writer could have made his ass up" (2). Yunior goes on to explain that Trujillo's dictatorship was fueled by "violence, intimidation, massacre, rape, co-optation, and terror" (2). By using a well known character to mainstream America, such as Sauron in *The Lord of the Rings*, the novel is able to be analyzed in a new way. Mainstream readers understand, after reading *The Lord of the Rings*, and seeing the trilogy of movies that began to come out in 2001, that Trujillo's dictatorship reflects the same kind of terrorizing issues played out by Sauron in *The Lord of the Rings*. It is through understanding this connection that a mainstream reader can cross over from sympathizing to empathizing with the plight of people living under a dictatorship. No longer is Trujillo just "some" cruel Dominican dictator – the reader understands the implications of a dictator capable of killing with impunity

because they “know” how the character Sauron functions in *The Lord of the Rings* because they have experienced an emotional reaction while reading the book or watching the movies.

The science fiction genre differs from fantasy in that it usually includes a critique of society’s reliance upon machines and technology; however, similar to the fantasy genre, it too has a savior-type main character that must undergo an arduous journey in order to save himself and/or his world. This idea of a savior archetype is important to understanding the underpinnings of *The Brief Wondrous Life of Oscar Wao* and Oscar’s motivations for the book finale. This idea of saving the world speaks directly to Oscar’s need to counteract the mysterious *fukú* curse that is mentioned over and over again in the text that Oscar ultimately tries to counteract. The *fukú* curse has plagued Oscar’s family and all of the New World since the time of Christopher Columbus’s “discovery” of it (Díaz 1). It is the drive to end the curse and save his family that makes Oscar’s character a savior archetype.

In Yunior’s description of Oscar’s nerdiness, he discusses that Oscar immerses himself in the science fiction genre and rattles off several science fiction authors including “Lovecraft, Wells, Burroughs, Howard , Alexander, Herbert, Asimov, Bova and Heinlein” (Díaz 21). For the purposes of this paper, only one of these authors is going to be used to help explain the relevance of the Science Fiction “crossing” with the literature. Frank Herbert published the novel *Dune* in 1965 in what would become the first in a series about the barren, desert planet of Arrakis. Arrakis is important to the created world in this novel because it is the source of the “spice,” a drug that is used for fuel and health. A “three-point civilization” must be balanced between “the Imperial Household,” “the Federated Great Houses of the Landsraad”, and the Spacing Guild, which has a “monopoly on interstellar transport”, and there are legends about a Savior that will come and be able to bring all these elements into balance (Herbert loc. 472).

This novel relates to *The Brief Wondrous Life of Oscar Wao*, in that, the main character is also a teenage boy who is on a journey or quest of identity and personal sacrifice on behalf of the people on his new planet Arrakis. Paul Atreides is the Duke's son and heir, but his enemies want to prevent his family from controlling the spice. Paul's role within the story is a journey to his becoming the savior of his planet based on the religious belief system that his mother and the majority of the empire consciously believes in and follows. The Bene Gesserit, a sort of religious hierarchy, similar to the Catholic Church, is headed by a Reverend Mother who serves as counselor to the Emperor. Part of the Reverend Mother's duties is "as a Proctor of the Bene Gesserit, [to] seek the Kwisatz Haderach" – the name of the Savior who will bring peace to Arrakis and the empire by controlling the spice production (Herbert loc. 525). Paul is eventually able to succeed in being the Savior after undergoing a painful test that allows him to know the past and the future and gives him the knowledge to control the desert worms that create the spice.

Oscar, like Paul's characters, reflects bravery and a willingness to face fear and engage in self-sacrifice. Paul says to the Reverend Mother Bene Gesserit "I must not fear. Fear is the mind-killer. ...I will face my fear. ...Where the fear has gone there will be nothing. Only I will remain" (location 182). Oscar emulates this concept of fearlessness because, he "didn't cry when they drove him back to the canefields...he tried to stand bravely," while knowing that this time he was really going to be killed (Díaz 320-1). Oscar acknowledges that his killers will feel nothing over murdering him, but that they can no longer stop his desire and ability to be a hero because he has come to believe that "anything you can dream...you can be" (Díaz 322). Oscar, being familiar with this kind of writing, can identify with the message in the novel *Dune* –

self-sacrifice is sometimes necessary in order to protect one's family. For the mainstream reader, this also makes sense; because, as mentioned previously, American culture is obsessed with the hero archetype and by listing various authors in these genres; the mainstream reader finds another way to engage with this piece of literature.

Oscar also identifies with Paul because they both are on a journey of self-discovery. Oscar calls himself a hero, and although his character is very similar in intention as Paul's character, Paul represents the Christ figure more blatantly than Oscar (Díaz 322). However, Oscar also becomes a Christ figure within the text by virtue of his sacrificing his own life in order to save his family from the curse and to die for his highest ideal – true love. Again, in understanding the kind of literature that Oscar immerses himself in, feeding his mind as he grows up, provides the mainstream reader another way to understand why this kind of sacrifice is important.

### **Religious Themes**

Science Fiction, Fantasy, and comic book superheroes overlap as “crossings” in *The Brief Wondrous Life of Oscar Wao*. They each share characters who are engaged in the battle of fighting evil influences and peoples. The battle between good and evil is a universal theme and in American culture is a reflection of the Christian roots that American culture has been built upon. Although the weaving of this kind of a “crossing” in *The Brief Wondrous Life of Oscar Wao* is done in a subtle manner, the religious themes are nonetheless relevant to understanding this text and should be included as a way for mainstream readers to relate to the novel. As the discussion below will show, the reader can make multiple connections with the text from a religious perspective. Although, many of the religious references within the text are based in

Catholicism, and it is from this tradition that much of the discussion will stem from, other connections to varying forms of Christian Protestantism will also be referred to without any distinction for denominations.

The reader knows that Catholicism plays a part in the narrative because La Inca, Oscar's grandmother, is Catholic. La Inca acts as a sort of mediator on behalf of Oscar's mother Beli and later for Oscar too. When Beli is taken by her lover's wife's goons, La Inca "did what many women of her background" did – she "posted herself by her portrait of La Virgen de Altagracia and prayed" and was soon joined by many other women who prayed "to exhaustion and beyond (Díaz 144-5). The act of praying could be interpreted to be just what it is – an act that alleviates the worrier in times of despair.

However, in this story, during the horrific beating that Beli is undergoing, she sees "for a brief instance La Inca praying in her room" (Díaz 148). Beli then sees "an amiable mongoose...[with] golden lion eyes" and a "black pelt," that tells her she has to get up and keep moving (149). La Inca is able to transform herself into a mongoose as Beli's motivation to keep moving – a mediator of sorts between life and death. The National Geographic website explains that "some species of mongoose will boldly attack venomous snakes." In a religious context, the mongoose could represent some kind of a savior symbol in that it is stronger and more able to defeat snakes – the serpent mentioned in the Garden of Eden in the Bible is generally considered to be a representation of the Devil. La Inca could represent a Christ figure, or she could symbolize La Virgen herself, either way, she represents a way to defeat evil. The reader is able to see the religious overtones of this particular scene and relate to the text regardless of personal religious belief systems or worldviews.

Yunior becomes much like the gospel writers who recount Jesus Christ's life, experiences and teachings in the Bible. He explains to the reader how Oscar's mind worked through the literature he read, his life experiences growing up on the outside of his own community in the U.S., and his reasons for taking the actions he takes. Yunior stands outside the situation and relates everybody else's feelings, motivations and internal thoughts. He is a scribe, a psychologist, a mystic and – he is haunted. He is haunted by the dreams of Oscar, who waves around a book, and whose “hands are seamless...and [sometimes] he has no face” (325). It is this image of Oscar that haunts Yunior until he gives in and writes the story in order to escape being haunted. This “haunting” could be interpreted as a form of inspiration or at least the catalyst that inspires his writing Oscar's story.

Although Oscar is never referred to specifically as any kind of a Christ-archetype character within the story, he can be seen as the sacrificial Christ lamb that conquers the *fukú* curse. The novel discusses the supernatural *fukú* or curse at the very beginning as a potential explanation and answer for *why* Oscar's family ends up killed off by the Trujillo regime. Yunior, refers to a *zafa* as a way to counteract the curse, and the reader is led to assume that the only way to bring Oscar's life, and the greater Dominican American community, back into a homeostatic existence is by means of a supernatural solution. In this case, the solution or *zafa* is the actual writing and existence of this story as it is told by Yunior (Díaz 7). A foundation in supernatural causes and effects creates the circumstances for the reader to interact with the text

on yet another plane of reality, except in this case, it is a reality that many readers find very real – religion and religious experience.<sup>1</sup>

The novel explains the *fukú* as a curse that goes back to the time of Christopher Columbus and that the arrival of his entourage to “Hispaniola unleashed the *fukú* on the world” (Díaz 1). The *fukú* is used to explain everything that goes wrong from small things in day to day life to tremendous things like Trujillo’s oppression and reign of terror. Yunion explains that it doesn’t matter if an individual is superstitious, “because no matter what you believe, *fukú* believes in you” (5). Although the narrator in the novel discusses the *fukú* as a kind of superstition, it could also be said that a belief in the *fukú* requires a certain level of faith because it is seen as a curse.<sup>2</sup>

---

<sup>1</sup> Other literary critics see the usage of these superstitions in a supernatural context. Ignacio Lopez-Calvo discusses these references in the context of magical realism in “A Postmodern Plátano’s Trujillo: Junot Díaz’s *The Brief Wondrous Life of Oscar Wao*, more Macondo than McOndo” where he explains that the usage of certain words or phrases serve as signals of magical realism. Lopez-Calvo argues that even bringing up the *fukú* and defining it as “a curse or a doom of some kind” (1), or saying that Trujillo has “almost *supernatural* powers” (3), and that Trujillo “is...a cosmic force...” (204) sets the novel apart as a novel that is a part of the magical realism genre. If utilizing Grobman’s theory of multicultural hybridity literature, it would make better sense to interpret these quotes as a “crossing” for the reader to make a leap into the unknown.

<sup>2</sup> There is some question as to what the original curse or *fukú* really symbolizes. The curse or *fukú* has been explained by different literary critics to mean different things. Daynali Flores-Rodriguez explains in the essay “Addressing the *Fukú* In Us: Junot Díaz and the New Novel of Dictatorship,” that the *fukú* is a “metaphor for the historical and cultural bind in which Caribbean writers find themselves” (94). Sandra Cox in her essay “The Trujillato and Testimonial Fiction: Collective Memory, Cultural Trauma and National Identity in Edwidge Danticat’s *The Farming of Bones* and Junot Díaz’s *The Brief Wondrous Life of Oscar Wao*” believes that the *fukú* “stands in for the difficulties of a diasporic existence, and ...is a symbol for Trujillo’s tainting of Dominican national identity” (Cox 108).

The belief in a curse that affects generations of families resembles the concept of the fall from grace as told in the Bible. The story of Adam and Eve's fall into imperfection and the need for salvation in order to counteract their spiritual distancing from God is very much like the necessity of a *zafa* to counteract the *fukú* depicted in *The Brief Wondrous Life of Oscar Wao*. In this manner, Oscar resembles a Christ-archetype character – his sacrificial death becomes a propitiatory exchange for the *fukú* his family has endured both as Dominicans under the Trujillo regime and as assimilated Dominican-Americans. By becoming the savior for his family, Oscar finds a way to *zafa* the curse. In addition, by becoming a savior for his family, Oscar has to be cognizant of his motivations in wanting to die for his ideals, and that kind of cognition creates a sort of dualistic identity for Oscar to have to live with internally. It is that internal struggle between personas – the nerd versus the hero – that Oscar has to balance leads the reader to think differently about why comic book characters and superheroes make such an impression on Oscar.

American culture is obsessed with heroes, and whether the hero is a television or movie character, a superstar sports player or the next-door-neighbor fireman, Americans look for and encounter hero archetypes in every facet of their lives. Identifying with the superhero complex is something many Americans strive for and perhaps mainstream America can connect with *The Brief Wondrous Life of Oscar Wao* precisely because of Oscar's transformation into a hero by sacrificing his life for an ideal.

### **Comic Book Characters & Superheroes**

Like the Science Fiction and Fantasy genres of literature, comic books and graphic novels are also, in general, relegated to the “low art” section of literary studies. However, again, by

utilizing a familiar American pop culture icon, such as a superhero from Saturday morning cartoons, *The Brief Wondrous Life of Oscar Wao* crosses the barrier from multicultural literature into a mainstream understanding of Oscar's motivations as a character. There are several references to different comic book series, cartoon superheroes, and graphic novels within this novel. A look at a few of the different series will help explain the relevance of this kind of literature for establishing a connection with a broader audience, but first the question of whether comic books and graphic novels even qualify as a form of literature needs to be acknowledged.

There has been much controversy in academic circles about whether comic books and graphic novels can even be included in the category of "literature" even though they have made their way into academic theory and criticism. Aaron Meskin discusses the pros and cons of considering comics as a form of literature in his essay "Comics as Literature?" He explains that it is "tempting to think that at least some comics are literature" because they do have text in them and can be studied academically as such (219). Meskin goes on in his essay to posit that comics are "a hybrid art form...[having] descended from literature...[and] from non-literary forms" (237). Meskin, in describing comics and graphic novels as a hybrid art form, is reminiscent to Grobman's hybridity literature theory of "crossing." They both utilize the concept differently, but recognize that literature takes on different meanings and can be approached in different ways, which makes sense when trying to get mainstream readers to engage with a text.

That comic books and graphic novels provide a bridge over which readers can find meaning in a text is further established when it is realized that comic book characters and superheroes serve a dual purpose in *The Brief Wondrous Life of Oscar Wao*. First, they help explain the duality of identity that Oscar experiences as a Dominican-American, and secondly, they help explain Oscar's moral code of ethics that exemplify his ideals. In the former, both

Yunior and Oscar express angst about living between two different worlds even though both of their individual life experiences are very different. Lyn Di Iorio discusses in her chapter entitled, “The Latino Scapegoat,” that despite their differences, Oscar and Yunior are, in fact, very similar in their interests “in that they both write stories...they both ardently pursue women...and they both fail with women” (28). She likens it to a comparison between them – Oscar’s “obesity, which is an exterior deformity, and Yunior, because he can’t be faithful, an interior deformity” (28). Utilizing comic book characters, and more particularly, superheroes who dress up to hide their true identities in order to hide their “deformities” – their lesser, more human sides – creates another manner through which to understand why these genres of American popular culture are able to influence both of these young men.

The comic book characters and superheroes influence Oscar and provide the impetus for his ultimately sacrificing himself on behalf of his love for Ybón. Similarly, Yunior also relates to characters in comic books. Yunior calls himself “your Watcher” several times throughout the novel (92). The Watchers are first introduced in the comic book *Fantastic Four #13* through the character Uatu. The Watchers are aliens who “passively observ[e] the phenomena of the universe,” and are “telepathic, able to scan the mind of virtually every known form of sentient life and to project their thoughts into any brain” (“Watchers”). Not surprisingly, Yunior identifies with this particular character because that is his role in Oscar’s life. He passively stands by and watches Oscar struggle to fit in to American society. Yunior has spent years thinking and “getting into” Oscar’s mind so that he can understand his motivations and thoughts. Like the Watcher Uatu, who is “brought on trial for his numerous violation of his peoples codes of ethics, he ...allowed himself to identify with the action and emotion that he observed...[and] aided his favorite heroes,” Yunior violates the macho Dominican-American male persona by

allowing his audience to see him as the vulnerable “nerd” that he really is. Yuniór regrets not being a better friend to Oscar and it is through writing the story of Oscar’s life that he shows that he “identifies” with the emotion and motivations Oscar emulated.

Oscar’s character relates to many different superheroes, but seems to reflect the storyline and motivations of the superheroes in the graphic novel *Watchmen*, the story of a group of superheroes who battle crime from the 1940s through the 1960s. The superheroes are regular men and women who have decided to dress up in costumes to hide their identities so that they can engage in vigilante activities. There is only one who has “super” hero powers. All the rest are average people who want to belong to a group and want a better life for America. The bulk of the graphic novel takes place during the Cold War in the 1980s when (for the fictional story) the fear of nuclear attack is imminent. The superheroes are forced into retirement during the 1970s by the government and begin to reconnect with one another when one of their Minutemen group is murdered in the mid-1980s. Yuniór mentions that this graphic novel is one of Oscar’s favorites (Díaz 331). The reader can assume that Oscar may have found the characters intriguing and relevant because they were, if nothing else, resourceful and motivated to create change. Oscar is motivated to create change too, as evidenced by his final return to the Dominican Republic to claim Ybón. Oscar has already lived through one brutal beating, but he is unwilling to give up on his ideal of finding true love.

Yuniór quotes *Watchmen* at the very end of the novel. In an exchange between Dr. Manhattan and Adrian Veidt, one of them a “super” hero and the other a common superhero, Dr. Manhattan responds to Adrian Veidt’s question of whether he did the right thing, he replies: “In the end? Nothing ends, Adrian. Nothing ever ends” (Díaz 331). This quote can be analyzed in a few different ways. It could be a way for Yuniór to express his feelings that even with Oscar’s

*zafa* to the *fukú* curse, Trujillo's influence will continue to resonate through time and space onto succeeding generations, or it could have a more insidious meaning – the oppression of humans by other humans in power is a part of the human experiences and there is no way to stop it no matter what small battles a single person or even a group of people succeed in winning. The reader is able to understand how ominous and heavy the experience of dictatorship is through the interaction with the comic book story, and can then grasp the experience of the Dominican American.

## Conclusion

Stephen Greenblatt said in 1982 that, “the study of genre is an exploration of the poetics of culture” (2254). The purpose for studying the literature of any group of people is so the reader can interact with that particular “culture” on the reader's own terms. If the reader is unable to make meaning and relevance based on personal experiences, it seems purposeless to study literature as a way to have a cross-cultural experience of understanding. For the student of literature, there will be a continued need to find new ways of understanding and interacting with multicultural literature. The question, however, is whether multicultural literature will remain a separate category unto itself, or if at some point it will be seen and read as a valid “American” literature in its own right. It remains to be seen how academia will treat literature outside the stereotypical British and American canons and whether multicultural literature and literatures that contain hybridity within their texts will gain the same prominence as the more common Anglo-European canons.

As discussed, works like *The Brief Wondrous Life of Oscar Wao* open doors to understanding other subcultures within America. Of course, it is helpful when authors like Díaz

are able to create stories that pull the mainstream reader into the fictional world being created through using other doorways to understanding – such as genre fiction and American popular culture. Díaz is able to get the reader to relate to his story whether they are a part of the Latino community or not because he has attempted to appeal to many different kinds of readers.

Although Díaz utilizes science fiction, fantasy, and comic books to accomplish his intention, there are many in the academic community who will see this kind of literature as “low art” and ineffective. This kind of attitude is unfortunate. Genre fiction and popular culture icons can fill in gaps of understanding and bridging between cultures. All Americans have this one thing in common – our popular culture that is emitted through the media, television and Hollywood. Those are things that all of us relate to regardless of our ethnic-American background. Perhaps if more writers take a chance on bringing those connections to the fore, they will continue to reach a broader audience.

The purpose of literary studies is to engage students in new ways of making meaning and understanding. This is the foundation and purpose of research in literature. It may seem to undermine the celebration of our multicultural America if all ethnic-American literatures are set on the same playing field as the Euro-American canon. However, that is not the message this research is trying to send. The search for identity is universal even if the foundation is based on different reader life experience. No matter the cultural background of an individual American, everyone has a different life experience and brings something different to the table when trying to understand another person’s life or way of thinking. It is a valuable tool to be able to find “crossings” into new kinds of literature so that understanding can grow and expand, and finding those crossings does not necessarily undermine the intent and form of the original text.

A continued discussion of how different kinds of readers can interact and “cross” over into other kinds of writing must continue to be a part of literary study and research. It is only through new ways of writing, and new ways of understanding one another’s cultures within the collective culture, that America can feel more united. Ultimately, “literature is conceived to mirror the period’s beliefs” (Greenblatt 2254). American literature is moving into a new era where our collective consciousness and awareness of our popular culture can be utilized to bridge gaps between members of different communities and backgrounds. Instead of the differences in our cultural, socio-economic, and political backgrounds serving as a way to divide the people of America, perhaps we can learn, through our personal stories, how to find a way to connect and understand one another.

Works Cited

- Athans, Philip. *The Guide to Writing Fantasy and Science Fiction*. Massachusetts: Adams Media, 2010. (iBook for iPad application)
- Caminero-Santangelo, Marta and Roy C. Boland Oseguada, eds. *Antípodas: Journal of Hispanic and Galician Studies No. XX*. “Trujillo, Trauma, Testimony: Mario Vargas Llosa, Julia Alvarez, Edwidge Danticat, Junot Díaz and other writers on Hispaniola.” Madrid: Editorial Voz, 2009.
- Cox, Sandra. “The Trujillato and Testimonial Fiction: Collective Memory, Cultural Trauma and National Identity in Edwidge Danticat’s *The Farming of Bones* and Junot Díaz’s *The Brief Wondrous Life of Oscar Wao*.” Caminero-Santangelo 107-126.
- Díaz, Junot. *The Brief Wondrous Life of Oscar Wao*. New York: Penguin Group, 2007.
- Flores-Rodríguez, Daynalí. “Addressing the *Fukú* In Us: Junot Díaz and the New Novel of Dictatorship.” Caminero-Santangelo 91-106.
- Gibbons, Dave, and Alan Moore. *Watchmen*. New York: DC Comics Inc, 1987. Print.
- Greenblatt, Stephen. “Introduction to *The Power of Forms*.” *The Norton Anthology of Theory and Criticism*. Vincent B. Leitch, Gen. Ed. New York: W.W. Norton & Co., 2001. 2250-2254.
- Grobman, Laurie. *Multicultural Hybridity: Transforming American Literary Scholarship & Pedagogy*. Illinois: NCTE, 2007.
- Herbert, Frank. *Dune*. New York: Penguin Group, 1965. Amazon Kindle for Apple iPad (location 1-10577).
- López-Calvo, Ignacio. “A Postmodern Plátano’s Trujillo: Junot Díaz’s *The Brief Wondrous Life of Oscar Wao*, more Macodo than McOndo.” Caminero-Santangelo 75-90.

Blanchard, Deb

“Mongoose.” *National Geographic*. 2010. National Geographic Society. 19 Dec 2010.

<<http://animals.nationalgeographic.com/animals/mammals/mongoose/>>.

Meskin, Aaron. “Comics as Literature?” *British Journal of Aesthetics*. 49.3 (July 2009): 219-

239. Montana State University, Bozeman. 24 June 2010.

<<http://bjaesthetics.oxfordjournals.org> >.

Sandín, Lyn Di Iorio, and Richard Perez, eds. *Contemporary U.S. Latino/a Literary Criticism*.

New York, NY: Palgrave Macmillan, 2007. American Literature Readings in the 21st

Century. *MLA International Bibliography*. Web. 14 May 2010.

Tolkien, J.R.R. *The Lord of the Rings*. One-Volume Ed. New York: Houghton Mifflin

Company, 1994.

“Watchers.” *Marveldirectory.com*. 2001. Marvel Characters, Inc. 2 Aug. 2010.

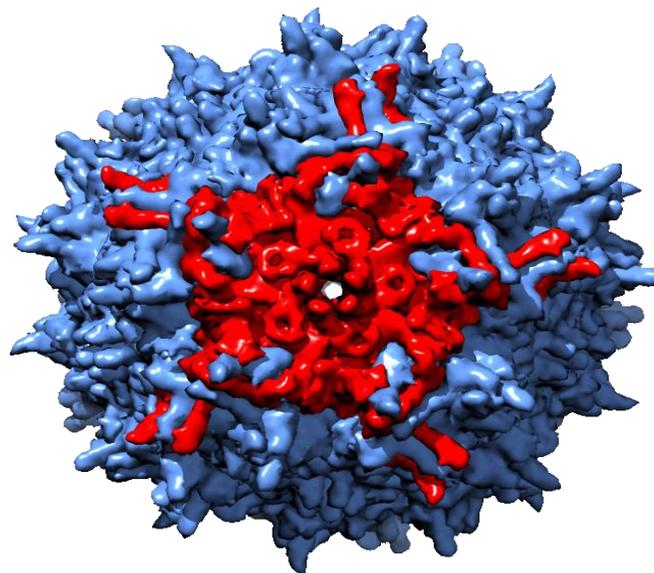
<<http://www.marveldirectory.com/alienraces/watchers.htm>>

## Introduction

Adeno-associated viruses (AAV) are non-pathogenic viruses that require a helper virus to complete replication in human cells. Because they are non-pathogenic and each serotype has a unique tropism, there is great interest in their use as a vector for gene therapy. It has already been shown to be effective in treating genetic diseases such as Leber's congenital amaurosis, where individuals suffer from retinal degeneration<sup>2</sup>. Currently, the determinants of the observed tissue specificity are not well understood. This is preventing researchers from creating chimeric virions with specifically tailored properties. The goal of my research is to elucidate the role of phospholipase activity in viral entry.

Parvoviruses are non-enveloped, isosahedral viruses with T=1 symmetry.<sup>3</sup> The AAV group is characterized into eight serotypes (AAV 1-8).<sup>5</sup> The single-stranded genome codes for four non-structural proteins and three structural proteins, VP1, VP2, and VP3 which make up the capsid with a 1:1:10 ratio.<sup>1</sup> The viral capsid is composed of 60 subunits, made up from three proteins (VP1-VP3) with a majority of the capsid being composed of VP3.<sup>1</sup> VP1 and VP2 are present in fewer copies, but have additional sequences on their amino-termini that have specific functional domains.<sup>4 5 6</sup>

AAV-2 infects a cell by first binding to heparan-sulfate proteoglycan and subsequent entry to the cell by endocytosis.<sup>7 8 9</sup> The virus particle exits the endosome and enters the cytoplasm to deposit its genetic material in the nucleus.<sup>10</sup> Structural studies of AAV found that infectivity was completely lost in capsids with mutations in the N-terminus of VP1, which shares sequence similarity to a secreted phospholipase A2<sup>4</sup>. This domain of VP1 is initially internalized in the capsid and virions are not infectious until externalized, and studies have shown VP1 domains being externalized by heat treatment<sup>11</sup>. However, little is known of the mechanism of externalization. Although there is structural information supporting the phospholipase domain on the VP1 protein as the essential domain for virus infectivity<sup>4</sup>, there is little known of the mechanism of how VP1 is externalized and aids in the departure of the virus particle from the endosome.



**Figure 1. Adeno-Associated Virus.** Located on the five-fold axis (Red) is a channel that is thought to be the pathway for the VP1<sub>up</sub> externalization.

In the interest of monitoring phospholipase activity, we have developed a fast liquid-chromatography mass-spectrometry (LCMS) based lipase assay with high accuracy and precision. From the development of this assay, the phospholipase domain has been characterized to have a clear calcium-dependent. Furthermore, the AAV lipase domain has shown to have higher activity at lower pH, which could attribute to the domains ability to escape from the endosomal pathway.

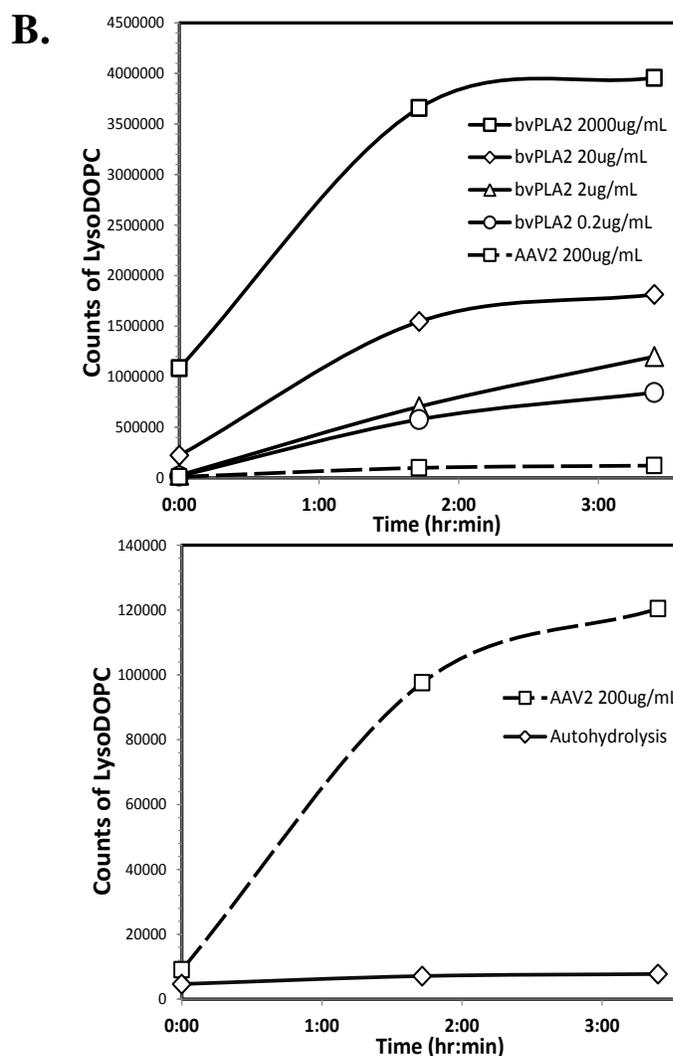
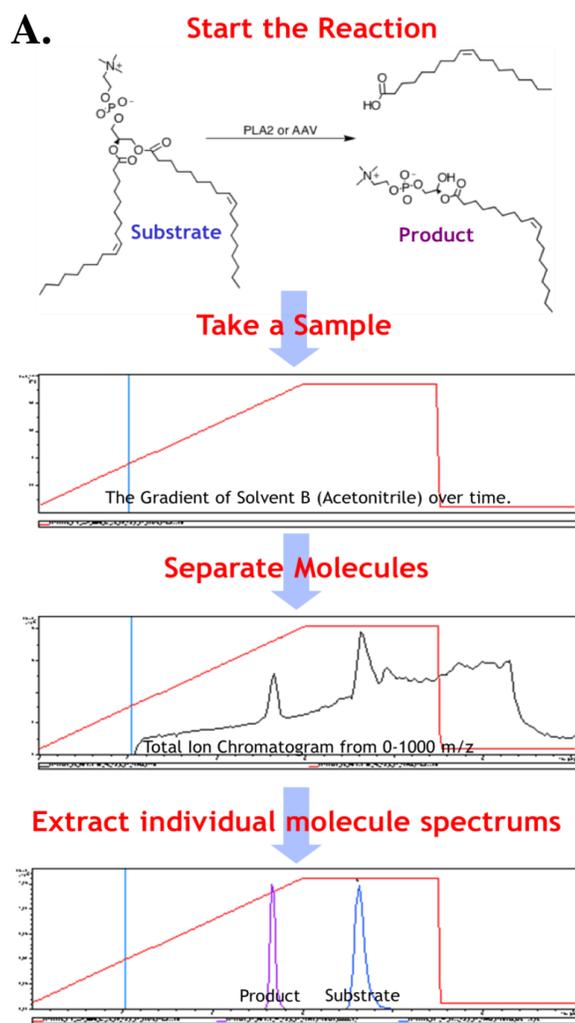
## Methods

### *Lipase Reaction*

The phospholipid used for the reaction is 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC). The lipase activity of AAV is induced by heating the virus at 65°C for 3-minutes [4]. The reaction is then initiated by adding 10 µL of 150 nM AAV (heat-treated) to 50µL of phospholipid/buffer (200 nM DOPC, 40mM Tris-HCl (pH 7.5), 80mM NaCl, 1.6mM NaN<sub>3</sub>, 5mM CaCl<sub>2</sub>) for a final reaction volume of 60 µL. Honey-Bee PLA2 is used as a positive control, because previous studies have shown its lipase activity with DOPC.<sup>12</sup> Auto hydrolysis of DOPC is monitored in a vial without enzyme as the negative control.

### *LC-MS*

The reaction of AAV with phospholipid is monitored with a high performance liquid chromatography (HPLC) coupled to the Bruker MicroTOF mass spectrometer. The HPLC allows



**Figure 2- A.** The LCMS method allows for the product and substrate to be separated efficiently with high resolution of the eluted peaks. **B.** Although AAV2's lipase activity is much lower than bvPLA2, AAV2 PLA2 activity can be monitored with high accuracy and reproducibility.

for a clean separation of the DOPC from the cleaved product allowing us to see the formation of the cleaved product over time. The HPLC is the Agilent 1100 series composed of a degasser, a binary pump system, an autosampler, and a thermostat column compartment.

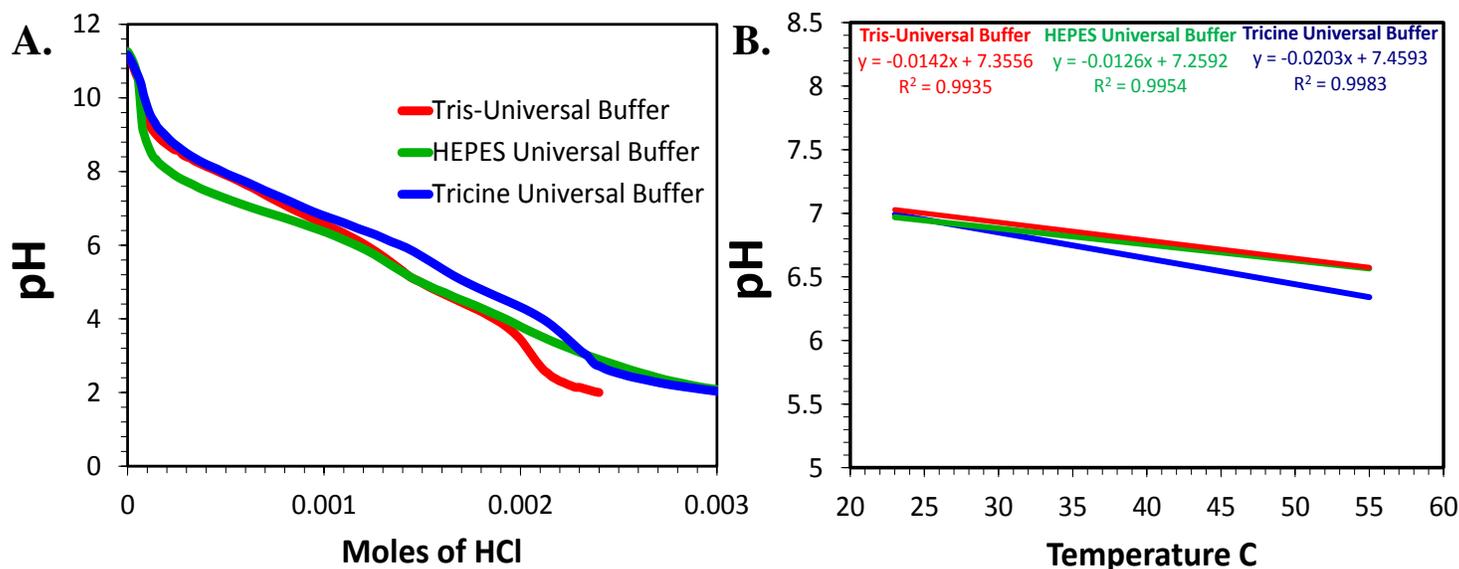
The elution used to separate DOPC from the cleaved product is a gradient elution with a binary solvent system (A =H<sub>2</sub>O, B =ACN). There is a 3-minute gradient from 5%B to 95% B to separate the lipid components, followed by 2-minutes of 95% B to clean the column, and finished with 5% B for 1-minute to equilibrate the LC.

The cleaved product appears at 2.7-min and DOPC appears at 3.6-min. The stationary phase used to separate the product from DOPC is a Jupiter C5 300 Å reverse-phase column. The autosampler monitors

the reaction at 37° and takes an injection from the reactions every 12 minutes. The Bruker MicroTOF is set to monitor the 0-1000 m/z range to watch the consumption of DOPC (786.21 m/z) and the cleaved product (522.36 m/z).

#### *Bioinformatics of the AAV2 VP1up*

The VP1up of AAV2 was modeled using iterative threading assembly refinement (I-TASSER) from the Center for Computation Medicine and Bioinformatics at the University of Michigan<sup>13</sup>. The top five models predicted by I-TASSER are reported and the accuracy is estimated using TM-score and a C-score. The TM-score greater than 0.5 indicates that the structure has correct topology and a score of less than 0.17 indicates a random similarity.<sup>13</sup> C-scores are reported in a range of [-5, 2] which indicate structures with higher C-scores



**Figure 3. Super Buffer.** Each super exhibits buffering capabilities from pH 8 to pH 3. The HEPES, Bis-Tris, NaAc buffers from pH 8 to pH 3. The temperature dependence for each buffer was calculated at pH 7.

indicate a greater structure with higher confidence.<sup>13</sup>

Furthermore, ligand binding sites are predicted using the I-TASSER COFACTOR algorithm, and the structures reported with a BS-score as well as a TM-score. A BS-score greater than 1.1 signifies a structure with high confidence.<sup>13</sup>

#### *Super Buffer Methodology*

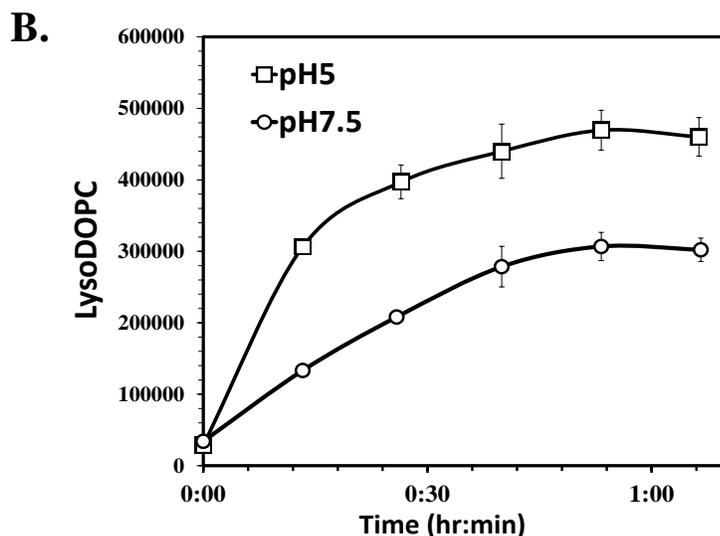
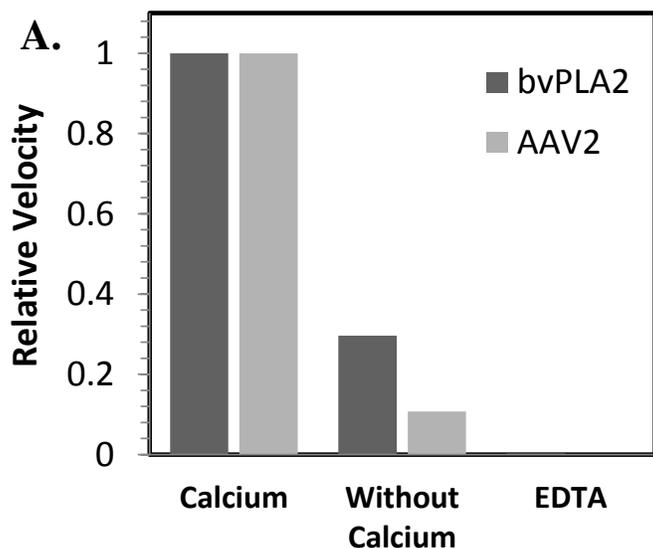
First, the range the buffer needs to be used for is determined. There is no need to make a multi-component buffer for anything less than  $\Delta\text{pH}$  of 2.5. From here, pick the buffer components that will buffer the edges of the range. For example, the pH range for the lipase assay used HEPES, Tris, or Tricine for the upper pH range, and used NaAc for the lower range. It is also important to consider if the components bind any metal ions in solution. For instance, calcium is necessary for most lipases, and calcium binding buffering agents were avoided for the lipase buffer. Now, it is important to run a quick titration to determine the actual buffering range of the buffering agent. Although the buffering ranges are pretty established, the published ranges are scaled back from the actual to give a safe zone. When combining buffers, these safe zones can be somewhat ignored. However, this depends on the degree of overlap between the buffering agents. Therefore, it is important to titrate the individual buffering agents as well as the combined buffering agents. For picking intermediate buffering agents, the best results for a smooth overlap are when the two buffering agents differ by 1-1.5 pKa units.

Once the buffering agents have been chosen for the appropriate range, titrate the combined buffer to see its capacity.

## **Results**

### *Calcium Dependence*

Calcium dependence was determined by adding calcium to one reaction and completely removing calcium in another. If activity is stopped after removing calcium, the domain is calcium dependent.<sup>14</sup> Sequence similarity between of the N-terminal VP1 region suggests that the phospholipase most closely resembles secreted PLA2 (sPLA2) type enzyme.<sup>4</sup> This class of PLA2s has a strict calcium dependence.<sup>14</sup> The role of calcium in PLA2 catalysis is to aid in coordination of the phospholipid in the active site and stabilization of the transition state complex.<sup>15</sup> Testing this was an important experiment for supporting this hypothesis. Figure 1A demonstrates that removing calcium from the system effectively prevents the hydrolysis of DOPC, which supports that the AAV PLA2 must use a similar mechanism for the hydrolysis of the phospholipid.



**Figure 4. AAV2 Lipase Activity.** Using the highly sensitive LCMS assay, the calcium (A) and pH (B) was determined. By adding EDTA to the reaction, the lipase activity was effectively inhibited. Furthermore, the lipase activity of AAV2 was increases dramatically at lower pH.

### *pH Dependence*

Since AAV uses the endosomal pathway as an entry to the cell<sup>10</sup>, the next important step was to determine the effect of pH on lipase activity. Previous lipase studies showed that monomeric VP1up had optimal activity at pH7 and would lose activity at low pH<sup>16</sup>. Although AAV shares calcium dependence with sPLA2 enzymes, the lipase domain of AAV operates within the low pH of the endosome<sup>17</sup>. However, sPLA2 enzymes would have no activity in the pH range of the endosome, because low pH deactivates the amino acids associated with the active site<sup>18</sup>. The effect of low pH on the capsid's lipase activity was monitored by adding heat-treated virus to a pH 5.0 buffer to see if lipase activity increases. Although the capsid has PLA2 activity, figure 1B shows that lipase activity in AAV is increased with decreasing pH.

### *Super Buffer*

For a lipase pH profile, the pH range needs to extend from pH 8 to pH 3. In the lipase assay, HEPES, MES, and NaAC were used because their pKa's are 1.5 units away from each. Thus, there was a smooth transition from one buffer to another.

Buffer agents tend to have an associated temperature dependence on their pKa (dpKa/dT), which is unfavorable for experiments that test the effect of temperature. This temperature dependence on their pKa is a result of increasing the solubility of the ion as temperature increased. Thus, the

strength the ion is solvated is proportional to the dpKa/dT. For example, Tris has twice the solubility of HEPES and therefore has twice the dpKa/dT. However, this is a little phenomenon is a little more complicated than just solubility, but this property has a major contribution.



about pH7 and will also have a contribution on  $dpK_a/dT$  at this range. Bis-Tris has a lower  $dpK_a/dT$ , which lowers the overall  $dpK_a/dT$  at pH7, and as the pH decreases so does the  $dpK_a/dT$ . This is a result of Tris's buffering activity decreasing and Bis-Tris's activity increasing. As the pH decreases further, Acetate begins to become more active, and its lower  $dpK_a/dT$  further decreases the overall  $dpK_a/dT$  at that pH. Therefore, a multi-stage buffer's  $dpK_a/dT$  is dependent on its composition and the pH at which it is set, and the temperature dependence for the buffer should be monitored at each pH or at the range in which it is the weakest. For example, when using multi-component buffer using acetate, it is important to not measure the  $dpK_a/dT$  at the buffering range of acetate. The result of the  $dpK_a/dT$  for the buffer will be recorded much less than it actually is.

The best possible solution for a temperature dependent buffer would be a combination of succinic acid ( $pK_{a1}=4.2$   $pK_{a2}=5.6$ ) and PIPES ( $pK_a=6.76$ ). The range would be from approximately from 7.5-3.5 and would have the lowest possible  $dpK_a/dT$ , because PIPES and succinic acid have almost no  $dpK_a/dT$ . However, both components have a relatively low solubility and will not work lower than pH 3.5, because PIPES is insoluble at a pH less than 3.2.

Because a virus capsid's conformation can change dramatically in different buffers, there was a need to create a buffer that could buffer completely from pH8 to pH 3 with the same components. By having the same molecules, the effect of the buffer on the capsid conformation can be ignored. A new methodology for studying enzymes in differing pH ranges by using multiple components to make a super buffer.

### *Bioinformatics of the AAV2 VP1up*

Since the AAV's VP1up had significantly higher activity in low pH, models were generated to analyze if there were any possible differences between AAV's VP1up and standard sPLA2 enzymes. The models were generated using iterative threading assembly refinement (I-TASSER) from the Center for Computation Medicine and Bioinformatics at the University of Michigan.<sup>13</sup> The first generated model in figure 5c had significant TM-score ( $0.58\pm 0.14$ ) with a C-score of -1.08. This

suggests that this model represents the AAV2 VP1up with a high level of confidence.<sup>13</sup>

From the model, the His-75, Asp-87, and Tyr-79 catalytic triad is completely conserved from the crystal structure of cvPLA2 and the VP1up. Mutational studies have shown that histidine is essential for PLA2 activity, which is the histidine found in this structure.<sup>4</sup> Furthermore, the Asp-76 has also been shown to be essential for PLA2 activity.<sup>4</sup> In the predicted structure, this Asp-76 has been shown to be one of the four calcium binding sites, previously shown to be essential for activity. The other three calcium binding sites are towards the N-terminus and are located on a random coil that hovers above the His-75. Other models that modified this random coil region had a significantly smaller TM-score and C-score, which indicates this particular structure must be conserved to bind calcium.

The Asp-87 has not been shown to be essential for activity, because mutational studies of the PLA2 have not extended much past His-75. In other sPLA2 studies, the catalytic aspartic acid (cAsp) has shown this residues role on the enzymes catalysis.<sup>19</sup> In the mechanism, cAsp has shown to stabilize the amide ion generated on the histidine during catalysis.<sup>15</sup> However, sPLA2s with mutations on cAsp have been shown to have normal catalysis. However, the  $pK_a$  of histidine was reduced one half  $pK_a$  unit.<sup>19</sup> This cAsp is also hydrogen bonded to a catalytic tyrosine (cTyr), which has also been shown unnecessary for catalysis.<sup>19</sup> Mutation of cTyr has also shown to increase the  $pK_a$  of histidine by one half a  $pK_a$  unit.<sup>19</sup> These results indicated the role of the hydrogen bond network between cHis, cAsp, and cTyr to be more essential for the protein's stability rather than its catalysis.<sup>20</sup> However, the stability gained from this hydrogen bond network goes unnoticed in sPLA2 enzymes, because they are rigidly stabilized by an extensive degree of disulfide bonds.<sup>21</sup> In the case of VP1up, the hydrogen bond network would have a larger role for stabilizing the PLA2 domain, because AAV lacks disulfide bonds, which is the major difference between AAV's VP1up and sPLA2s.

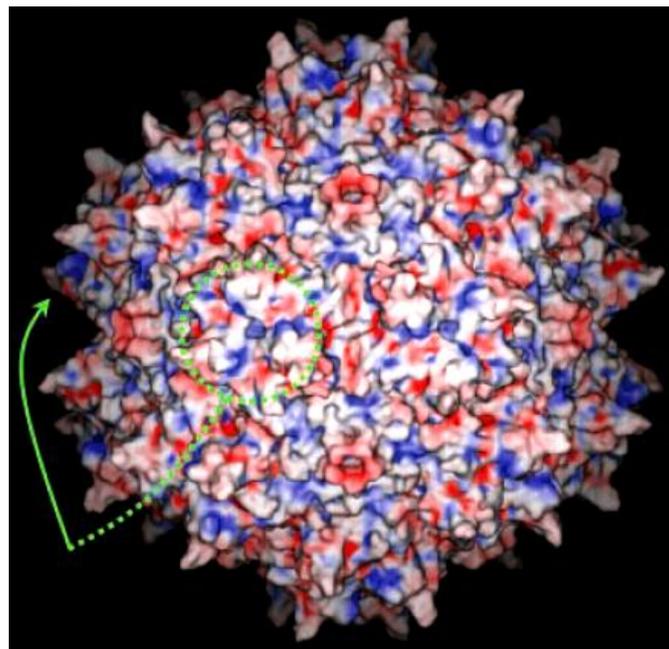
The predicted binding sites for AAV's VP1up in figure 5a,b had a TM-score of 0.745 and a BS-score of 1.63, which signifies this ligand binding site is

predicted with a high degree of confidence. The residues predicted are from the hydroxyl off Tyr-52, the amide hydrogen from the backbone of Gly-54, and from the amide hydrogen from Arg-58. From the structural predictions, small modifications in the regions results in a rapid decrease in the significance of the overall predicted structure.

The main purpose of the predicted structure of AAV2 VP1up was to possible elucidating the reason for AAV's increase in lipase activity. The prediction was useful in showing that there is essentially no major difference between AAV's VP1up and sPLA2 enzymes. The first major difference between the sPLA2 structure of cvPLA2 and VP1up is the decrease in the loop between the first and second helix, which is common to see in viruses. When viruses pick up a functional domain, they often decrease the distances of random coils for gene conservation. The second major difference between sPLA2s and VP1up is the lack of disulfide bonds found on VP1up. Disulfides bonds give sPLA2 enzymes immense rigidity and stability, but the VP1up probably lacks these in order to unfold from the interior of the viral capsid to the exterior upon where it can fold into its functional conformation.

The first assumption for the resulting higher activity in low pH could be from the pKa of the His-75. However, the environment around the His-75 is entirely similar to all other sPLA2 enzymes, and the His-75 is predicted to have a low solvent accessibility. Furthermore, monomeric VP1up did not show higher activity at low pH<sup>16</sup>, which indicates that the capsid has a role for this increase in activity.

For sPLA2 enzymes, catalysis could not be initiated until the enzyme could bind to the interface of the lipid membrane referred to as interfacial catalysis.<sup>20</sup> Upon binding to the lipid membrane, the sPLA2 pulls the lipid substrate from the membrane through a hydrophobic channel into the active site.<sup>20</sup> Modifications to the hydrophobic channel that decrease its hydrophobicity has shown to have a significant impact on the lipase activity.<sup>20</sup> Removing a lipid from the membrane into the solvent is a highly negentropic event, and the protein has to simulate the hydrophobic environment of the membrane. Furthermore, the structure of the protein that binds to the membrane



**Figure 6. Electrostatics of AAV2.** The electrostatics of AAV2 were calculated from the crystal structure. [red (-10) to blue (+10)]<sup>1</sup>

is referred to as the I-face and is essential for lipase activity<sup>22</sup>.

Structural analysis of the I-face has shown that it contains a high degree of polar residues which interact with the relatively negative lipid membrane.<sup>22</sup> Mutation of these residues to negative residues has shown to have dramatic effects on lipase activity, because it is essential for the I-face to attach to the membrane to establish the hydrophobic channel.<sup>22</sup>

Furthermore, the I-face has shown to be the major component for substrate specificity sPLA2s.<sup>20</sup> Studies have shown that the head group of the phospholipid did not alter the specificity of the enzyme unless it was sterically hindered within the active site.<sup>23</sup> It was found that the charge distribution on the membrane surface had the largest impact on the substrate specificity for sPLA2. Since the I-face of sPLA2 enzymes has a high incidence of positive residues, liposomes with a highly negative membrane were seen to have the highest activity.<sup>22</sup> The substrates of mixed liposomes were processed essentially the same regardless of the head group, but the charge distribution of the lipid membrane would otherwise increase or decrease the overall lipase activity.<sup>23</sup> In terms of AAV, the I-face most likely has the largest impact on substrate specificity as well as the

externalization of the VP1up from interior of the viral capsid. However, the location of the externalization of VP1up is highly debated. The majority of scientists agree that the likely site of externalization is from the 5-fold axis<sup>24</sup>, because a channel from the interior of the capsid has been located here and has shown to be dynamic upon receptor binding<sup>11</sup>. However, there is some speculation that the VP1up could be externalized from the three fold axis. When looking at electrostatic models from the crystal structure of AAV2<sup>1</sup>, the I-face of the three fold axis would be a likely candidate for membrane binding because of the abundance of positive residues and the hydrophobic peaks that could probably insert into the membrane. However, the three-fold axis is the most likely site for receptor binding.<sup>6</sup> The 5-fold axis channel has been shown to widen after binding to a surface receptor, which could enable the VP1up to pass from the interior to the exterior<sup>9</sup>, but the I-face of this region is abundantly negative. This I-face would have a significant degree of repulsion between the lipid membrane and could not establish a stable hydrophobic channel. In low pH however, the electrostatic repulsion could be mitigated until eventually the I-face of the 5-fold was stable enough to maintain contact for the hydrophobic channel to be established. However, interfacial kinetics experiments with differing membrane compositions would have to be tested to compare this effect, and it would have to be tested side by side with monomeric VP1up to discern the effect of the capsid on low pH lipase activity.

## Discussion

The high sensitivity and reproducibility of the LCMS system has allowed for the lipase domain of AAV to be characterized in terms of sPLA2 activity with a high degree of confidence. Firstly, we have established that both sPLA2 and AAV lipase activity is calcium dependent. This suggests they

## References

1. Xie, Q.; Bu, W. S.; Bhatia, S.; Hare, J.; Somasundaram, T.; Azzi, A.; Chapman, M. S., The atomic structure of adeno-associated virus (AAV-2), a vector for human gene therapy. *Proceedings of the National Academy of Sciences of the United States of America* **2002**, *99* (16), 10405-10410.

both use a similar mechanism for hydrolysis. Secondly, I have discovered that AAV's optimum pH for lipase activity is lower than sPLA2, which is most likely a result of their different operating environments. Furthermore, we have discerned from bioinformatics the possible reasons for the increase lipase activity in low pH. However, this effect will have to be completely analyzed by doing a pH profile of VP1up's lipase activity.

For further studies, we will further characterize the lipase domain by determining which acyl chain is hydrolyzed by using a lipid with different tail lengths such as 1-oleoyl-2-palmitoyl-sn-glycero-3-phosphocholine. By measuring the difference in mass between the substrate and the cleaved product in mass spectrometer, the acyl chain that is cleaved can be determined. The assay can also be taken a step further to determine the pH dependence of ( $k_{cat}/K_m$ ) by running the reaction through different pHs. In mechanistic studies of sPLA2 enzymes, calculating pH dependence of ( $k_{cat}/K_m$ ) aided in determining the amino acid residues involved in the catalysis of phospholipid hydrolysis [7]. This would allow for the active site residues in the AAV lipase domain to be characterized. Furthermore, we will test other possible substrates to determine if AAV has substrate specificity. This lipase assay would be ideal for testing substrate specificity, because it could track the hydrolysis of multiple substrates in a single reaction. If substrate specificity can be found and it is different amongst the AAV serotypes, it could be a possible explanation for each serotype's tissue specificity. Furthermore, the effect of the interfacial kinetics on the lipase activity will be determined. Thus, these results could be used to make more precise vectors for gene therapy that could have specific tissue tropism.

2. Miller, J. W., Preliminary results of gene therapy for retinal degeneration. *New England Journal of Medicine* **2008**, *358* (21), 2282-2284.
3. Hueffer, K.; Parrish, C. R., Parvovirus host range, cell tropism and evolution. *Current Opinion in Microbiology* **2003**, *6* (4), 392-398.
4. Girod, A.; Wobus, C. E.; Zadori, Z.; Ried, M.; Leike, K.; Tijssen, P.; Kleinschmidt, J. A.; Hallek, M., The VP1 capsid protein of adeno-associated virus type 2 is carrying a phospholipase

A2 domain required for virus infectivity. *Journal of General Virology* **2002**, *83*, 973-978.

5. Warrington, K. H.; Gorbatyuk, O. S.; Harrison, J. K.; Opie, S. R.; Zolotukhin, S.; Muzyczka, N., Adeno-associated virus type 2 VP2 capsid protein is nonessential and can tolerate large peptide insertions at its N terminus. *Journal of Virology* **2004**, *78* (12), 6595-6609.

6. Grieger, J. C.; Snowdy, S.; Samulski, R. J., Separate basic region motifs within the adeno-associated virus capsid proteins are essential for infectivity and assembly. *Journal of Virology* **2006**, *80* (11), 5199-5210.

7. Summerford, C.; Samulski, R. J., Membrane-associated heparan sulfate proteoglycan is a receptor for adeno-associated virus type 2 virions. *Journal of Virology* **1998**, *72* (2), 1438-1445.

8. Opie, S. R.; Warrington, K. H.; Agbandje-McKenna, M.; Zolotukhin, S.; Muzyczka, N., Identification of amino acid residues in the capsid proteins of adeno-associated virus type 2 that contribute to heparan sulfate proteoglycan binding. *Journal of Virology* **2003**, *77* (12), 6995-7006.

9. Levy, H. C.; Bowman, V. D.; Govindasamy, L.; McKenna, R.; Nash, K.; Warrington, K.; Chen, W.; Muzyczka, N.; Yan, X.; Baker, T. S.; Agbandje-McKenna, M., Heparin binding induces conformational changes in Adeno-associated virus serotype 2. *Journal of Structural Biology* **2009**, *165* (3), 146-156.

10. Bartlett, J. S.; Wilcher, R.; Samulski, R. J., Infectious entry pathway of adeno-associated virus and adeno-associated virus vectors. *Journal of Virology* **2000**, *74* (6), 2777-2785.

11. Kronenberg, S.; Bottcher, B.; von der Lieth, C. W.; Bleker, S.; Kleinschmidt, J. A., A conformational change in the adeno-associated virus type 2 capsid leads to the exposure of hidden VP1N termini. *Journal of Virology* **2005**, *79* (9), 5296-5303.

12. Huang, C. K.; Zhou, L.; Liu, Y.; Lai, L. G., A continuous fluorescence assay for phospholipase A(2) with nontagged lipid. *Analytical Biochemistry* **2006**, *351* (1), 11-17.

13. Roy, A.; Kucukural, A.; Zhang, Y., I-TASSER: a unified platform for automated protein structure and function prediction. *Nature Protocols* **2010**, *5* (4), 725-738.

14. Burke, J. E.; Dennis, E. A., Phospholipase A(2) structure/function, mechanism, and signaling. *Journal of Lipid Research* **2009**, *50* (Suppl. S), S237-S242.

15. Scott, D. L.; White, S. P.; Otwinowski, Z.; Yuan, W.; Gelb, M. H.; Sigler, P. B., INTERFACIAL CATALYSIS - THE MECHANISM OF PHOSPHOLIPASE-A2. *Science* **1990**, *250* (4987), 1541-1546.

16. Canaan, S.; Zadori, Z.; Ghomashchi, F.; Bollinger, J.; Sadilek, M.; Moreau, M. E.; Tijssen, P.; Gelb, M. H., Interfacial enzymology of parvovirus phospholipases A(2). *Journal of Biological Chemistry* **2004**, *279* (15), 14502-14508.

17. Stahnke, S.; Lux, K.; Uhrig, S.; Kreppel, F.; Hosel, M.; Coutelle, O.; Ogris, M.; Hallek, M.; Buning, H., Intrinsic phospholipase A2 activity of adeno-associated virus is involved in endosomal escape of incoming particles. *Virology* **2011**, *409* (1), 77-83.

18. Boyanovsky, B. B.; Webb, N. R., Biology of Secretory Phospholipase A(2). *Cardiovascular Drugs and Therapy* **2009**, *23* (1), 61-72.

19. Annand, R. R.; Kontoyianni, M.; Penzotti, J. E.; Dudler, T.; Lybrand, T. P.; Gelb, M. H., Active site of bee venom phospholipase A(2): The role of histidine-34, aspartate-64 and tyrosine-87. *Biochemistry* **1996**, *35* (14), 4591-4601.

20. Berg, O. G.; Gelb, M. H.; Tsai, M. D.; Jain, M. K., Interfacial enzymology: The secreted phospholipase A(2)-paradigm. *Chemical Reviews* **2001**, *101* (9), 2613-2653.

21. Lambeau, G.; Gelb, M. H., Biochemistry and physiology of mammalian secreted phospholipases A(2). *Annual Review of Biochemistry* **2008**, *77*, 495-520.

22. Ghomashchi, F.; Lin, Y.; Hixon, M. S.; Yu, B. Z.; Annand, R.; Jain, M. K.; Gelb, M. H., Interfacial recognition by bee venom phospholipase A(2): Insights into nonelectrostatic molecular determinants by charge reversal mutagenesis. *Biochemistry* **1998**, *37* (19), 6697-6710.

23. Wilton, D. C., Phospholipases A(2): structure and function. *European Journal of Lipid Science and Technology* **2005**, 107 (3), 193-205.
24. Bleker, S.; Sonntag, F.; Kleinschmidt, J. A., Mutational analysis of narrow pores at the fivefold symmetry axes of adeno-associated virus type 2 capsids reveals a dual role in genome packaging and activation of phospholipase A2 activity. *Journal of Virology* **2005**, 79 (4), 2528-2540.

Guffey, Kelsey

## FORAGING ECOLOGY OF BISON IN A MIXED GRASSLAND–STEEP ECOSYSTEM

Kelsey Guffey, Neto Garcia, Clayton Marlow, Phd.

*Department of Animal and Range Sciences, Montana State University, Bozeman, MT 59717, USA*

### ABSTRACT

Reproductive rates of American bison cows (*Bison, bison*) at the National Bison Range (NBR) in Moiese, MT have declined in the last decade. Understanding habitat selection by bison could provide tools for distributing bison for effective management of herd productivity and ecological condition. Ocular observations and vegetation data indicate patterns of disproportionate habitat selection, high selection pressure on preferred forages, and behavioral patterns subject to temporal and/or spatial variation.

### INTRODUCTION

Understanding habitat selection and foraging strategies of herbivores is essential in developing predictive models to meet management and conservation needs. (Gordon, 1994) This study aims to advance understanding of habitat selection by bison and evaluate patterns in landscape utilization and behavior. Describing interactions between herbivores and vegetation communities is an integral part of wildlife and ecosystem management. Selection of diets, patches and habitat plays a fundamental role in these interactions.

Many studies of ruminant foraging strategies involve cataloging forage species. These results have limited application outside the circumstances and site of the study. (Van Dyne et al., 1980) A challenge faced by modern managers is integrating

animal behavior into predictive ecosystem models (Hobbs 1996). Glenn (1994) contends that nutritional deprivation in bison is influenced by climatic conditions, habitat quality and other environmental stressors. Understanding habitat selection by bison can provide tools for assessing habitat quality.

Selectivity by grazing animals is essential because it alters ecosystems by multiple pathways and affects plant communities on local and regional scales (Augustine and McNaughton 1998, Senft. et al. 1987) and it has a fast response to environmental changes (Bryant et al. 1991). Modern natural resource management aims to maintain the integrity of all ecosystem processes. Management of large herbivores, like bison, offers opportunities to control ecosystem processes by influencing herd abundance and distribution. (Hobbs 1996)

Bison herd size appears to be related to habitat structure with larger herds occupying more open habitat (Van Vuren 1983) and flatter ground (Rutberg 1984). Bison appear to be generalist foragers requiring large quantities of forage daily (Houston 1982). However, bison may also exhibit highly selective foraging behavior (Plumb and Dodd 1993). Bison primarily consume grasses and sedges, while forbs and browse generally contribute <10% of the diet (Coppedge and Shaw 1998, Plumb and Dodd 1993, Van Vuren 1984). Foraging strategies are influenced by nutrient demands, time budgets, forage availability and forage quality (Fortin 2003, Plumb and Dodd 1993). Bison diets quantified on a landscape level are mostly comprised

of a few species. (Fortin et al. 2003) Observed foraging strategies show maximization of a bison's short-term rate of energy intake (Fortin et al. 2002).

Bison density levels are expected to affect forage selectivity and plant tolerance. As bison densities increase, selectivity is expected to decline due to lack of preferred forage availability. Low densities of bison are expected to exhibit high selectivity but have minimal effects on forage due to low absolute animal numbers. Medium herd densities may result in selective foraging behavior and a high degree of defoliation, significantly affecting the tolerance of the plant community. (Augustine and McNaughton, 1998)

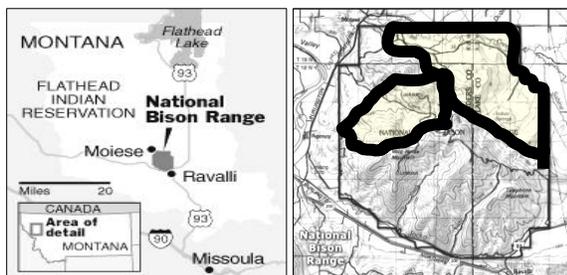
Ungulate effects on ecosystems include forage growth rate, nutrient uptake rate, and litter quality which has subsequent effects on ecosystem processes and trophic levels (Bryant et al. 1991). Feedbacks from the plant community will have long-term effects on ungulate populations. (McNaughton et al, 1997). The extent of these effects is determined by the degree of herbivore selectivity and by the recovery capacity of foraged species. Herbivores feed on plant species that are palatable to them and this defoliation reduces the fitness of plants in competition with unpalatable species. When herbivores avoid patches where unpalatable plants dominate the landscape, unpalatable plants can replace palatable plants which diminishes the carrying capacity of a range. (McNaughton, 1978. Augustine and McNaughton, 1998)

The semi-free ranging NBR herd has experienced a decline in annual net calf recruitment from historic levels of 87%, observed in 1999, to a 2008 value of 33% calves per reproductive age cow (Borgreen et al. 2008). In a review of 4 free ranging bison herds Van Vuren (1986) found production, as measured by pregnancy of cows  $\geq 2$  years old or calving rates of cows  $\geq 3$  years old, to be between 52% and 76% with a mean of 63%. While several confined herds showed significantly greater production between 67% and 86% with a mean of 79%.

Density in confined herds is often controlled through culling, or removal of excess animals resulting in higher possible productivity. Wild populations are regulated by migration, naturally occurring deaths, and lower levels of production when they are near carrying capacity of their habitat. (Meagher, 1989) Population biology of bison is greatly influenced by animal density, forage availability being the greatest limiting factor for population growth (Fuller et al., 2007, Van Vuren 1983).

Arnold (1985) demonstrated that animal distribution across the landscape can be highly discriminate on even seemingly homogenous plots. Annual management plans at the NBR adhere to traditional calculated stocking rates, but if habitat selectivity by bison is highly discriminate, disproportionate utilization of the landscape could lead to the over use of preferred areas and under use of less desirable areas. Overtime this pattern causes declines in both ecological condition and animal productivity. This pattern may partially explain the recent decline in calf recruitment at the NBR.

### *Study Area*



**Figure 1. Study area highlighted in the northern portion of the NBR near Moiese, MT.**

**Photo credits: nytimes.com and sangres.com**

Observations were collected at the NBR in Moiese, Montana (Fig. 1). The national wildlife refuge is 9000 ha (86 km<sup>2</sup>) of mixed steep and Palouse prairie topography, at elevations ranging from 820 to 1500 m. The NBR is home to a diversity of wildlife in addition to bison, including white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), elk (*Cervus elaphus*), pronghorn antelope (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), mountain lion (*Felis concolor*), coyote (*Canis latrans*), and black bear (*Ursus americanus*).

The herbage is composed of approximately 70% grasses, 20% forbs, and 10% woody vegetation by standing crop biomass (Belovsky & Slade 1986). Dominant native prairie vegetation includes bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and rough fescue (*F. scabrella*). Subdominant prairie species include junegrass (*Koeleria macrantha*), needle-and-thread (*Stipa comata*), needlegrass (*Stipa* sp.), slender and western wheat grass (*Agropyron trachycaulum*, *A. smithii*), Sandberg bluegrass (*Poa secunda*), and basin wildrye (*Elymus cinereus*). Non-native grasses present at NBR include cheatgrass (*Bromus tectorum*), Kentucky and bulbous bluegrass (*Poa pratensis*, *P. bulbosa*), crested and intermediate wheatgrass (*Agropyron cristatum*, *A. intermedium*), and wild oat (*Avena fatua*). Dominant forbs include Saint John's wort (*Hypericum perforatum*), lupine (*Lupinus* sp.), yarrow (*Achilliamillefolium*), Dalmatian toadflax (*Linariadalmatica*), salsify (*Tragopogon dubius*), and arrowleaf balsamroot (*Balsamorhiza hirsutissima*). In addition to the grassland communities, forest and shrub communities are found at higher elevations and along drainages. Woody species include fringed sagebrush (*Artemisia frigida*), western snowberry (*Symphoricarpos occidentalis*), prairie rose (*Rosa woodsii*), Douglas fir (*Pseudotsugamien ziesii*), and Ponderosa pine (*Pinus ponderosa*) (Mooring et al. 2005)

The bison herd observed contained approximately 250-300 bison that were moved into 3 pastures on a 6 week rotation during the summer of 2010. No artificial foods are provided to the herd, nor are any culling or animal removal practices currently in place. Pastures surveyed were the Upper Pauline (UP), Alexander Basin (AB) and Mission Creek (MC) pastures. Pastures varied in topography and contained many heterogenic patches of vegetation. The Upper Pauline is characterized by steep slopes surrounding a large drainage leading to Pauline Creek which exists as natural “potholes” in the summer. Alexander Basin is characterized by north and east facing slopes, open plains and 2 small drainages. The Mission Creek pasture parallels the creek and surrounding plains and contains some north facing slopes.

### *Project Description*

*Part A:* This investigation is part of a larger habitat assessment aimed at developing nutrient density mapping units that will provide managers a tool for effectively distributing and managing bison.

*Part B:* Field observations and selection data will augment the habitat assessment by adding habitat availability, utilization, and quality data. The following objectives will be met with aid of the current study discussed here: 1) Measure the amount of crude protein and digestible energy available within the preferred sites. 2) Calculate seasonal carrying capacity from the pooled nutrient availability for all preferred sites within pastures.

*Part C:* The following objectives are addressed by this manuscript: 1) Identify preferred grazing sites within pastures through comparisons of forage/landform selection to forage/landform availability. 2) Develop utilization indices by evaluating stubble heights of

grazed forages, 3) Interpret behavior patterns as an indication of habitat quality. Hypothesized outcomes of this investigation are as follows:

H<sub>1</sub>: Selection of landform types will be independent of their local availability and selection of some forage will be significantly greater than local availability.

H<sub>2</sub>: Utilization of preferred forages will exceed a utilization index of 0.50.

H<sub>3</sub>: The proportion of grazing and moving behaviors will increase while ruminating type behaviors will decrease in successive pastures.

## METHODOLOGY

Investigation took place during 5 observation periods of 3 days each from June 2 -August 24, 2010. A minimum of 10 observations were obtained per sampling period, and each pasture was sampled in 2 observation periods. During herd occupancy of a pasture, surveys were conducted during the following days: UP (n=18) June 2- 4 & 23- 25; AB (n= 18) July 12- 15 & Aug 3- 4; and MC (n=14) Aug 4- 5 & 23- 25. Ocular herd observations were taken sunrise-10:00 a.m. and again from 2:00 p.m.-sunset to allow surveillance during the diurnal activity peaks of bison. Although bison activity peaks are bimodal during the day, significant activity may exist during the night. (Plum and Dodd 1993)

Herds were located by traveling all maintenance, management, and tour roads and by further encroaching on foot. Topographical features may occasionally limit access and/or visibility of an area that bison occupy. Pastures were extensively surveyed in order to maximize

the possibility of encountering bison in all areas. When a herd of  $\geq 15$  bison was encountered, observations commenced.

By recommendation of Fortin and Andruskiw (2003) observations began at distances of approximately 260 meters from the herd's selected site when observing on foot. Herd movements resulting in increased proximity were not mitigated by observer retreat. Observations were also taken from a vehicle if encounters were at close range. Some studies suggest that bison permit vehicles 6 times closer than hikers without response (Mchugh, 1958). Presence of an observer has been shown to affect the behavior of animals of even tame animals. (Gordon, 1994) therefore maximum observable distance and minimum level of disturbance were maintained to abate behavioral changes.

Initial data included classification of landform type occupied. Distances to various landmarks were estimated and manual sketches or photographs were taken for accurate re-location of the central position. Initially, and at 15 minute intervals thereafter, a total herd count was obtained with aid of 10 by 52 binoculars.

Also at 15 minute intervals a single animal was systematically selected and their behavior was classified and recorded. Observation intervals and methodology are adapted from Plumb and Dodd (1993). Selection methodology was based on spatial position in attempts to minimize double sampling and to maximize the sampling distribution. Animals were selected from the herd perimeter at each cardinal direction, and from the center, in a clock-wise rotation.

Observations continued for up to 2 hours, or until departure of site. Valid observations required a minimum 30 minute herd occupancy of a single site. Gross movement and distribution of the herd was noted throughout the observation.

Circumstances of two small herds spatially separated but simultaneously visible permitted two replicate experimental units to be concurrently observed which diverges from Plumb and Dodd's methods. Topographical and vegetative features can prevent count and behavior sampling of some animals; this is enhanced by large herd size and wide distribution. This behavioral sampling method may be influenced by social interactions that dictate spatial position as in other large social herbivores (Mloszewski, 1983).

After herd departure of the site, reconnaissance location of the central position began. Cases of long term site occupancy delayed reconnaissance data collection. Once located, the central position of the herd was marked within 2 meters by a Garmin hand held GPS. On all herd selected sites, a 100 meter transect line was laid at a 90° or 180° angle originating at the observed central position mark. The transect direction was chosen to represent the gross observed movement and/or distribution of the herd. If movement and distribution was neutral, transect direction was chosen at random.

Following point-intercept methodology described by Cooperider et al. (1986), each meter mark was observed and the occurrence of interception by ( $\leq 1$  inch) herbage species, bare ground, rock, or litter material was identified and recorded. Incidences of grazed and ungrazed plant species were classified by morphology to the genus or species level. At each meter intercept, the height of standing biomass was measured to the nearest inch and recorded. Point-intercept transects are limited in their ability to sample scarce vegetation, but effective in quantifying large landscape patterns. Immature and closely grazed forages, seasonally varied morphology, and overall diversity challenge accurate species taxonomy. Unknown species were classified by herbage type (grass, forb, or woody species). Foraged species were assumed to be

grazed or browsed by bison during pasture occupancy; admittedly other herbivore species have continuous access.

### *Landform Selection and Availability*

Landform types selected by bison were classified by direct observation, as either a slope with a directional aspect, a riparian area or a flat to undulating plain. A slope is defined by continual and dramatic increases in elevation for  $\geq 100$  meters. Riparian areas are defined as areas surrounding a natural water source or drainage with apparent hyporehic flow; only areas with markedly different vegetation forming a “green line” were classified as riparian. Flat to undulating planes include rolling hills and gradual slopes.

Landform availability was determined by topographic and satellite photo mapping of pastures and landform types. The percent composition of landform types was determined for each pasture. Area was calculated in a linear manner and did not account for slope. Landform selection frequency was calculated as the proportion of bison occupying a landform in the total number of bison observed per pasture. Preferred landforms are defined as landform types selected with  $\geq 75\%$  frequency.

Selection frequencies of preferred landforms were compared to availability frequency of that landform type and a Chi-square tests for independence were done for the actual data range (selection frequency) and expected data range (availability frequency). When the probability ( $\alpha$ ) of seeing at least the measured degree of difference from actual and expected ranges by chance  $\leq 0.05$  landform selection was concluded to be independent of availability.

*Forage Selection and Availability*

Forage selection frequency was calculated as the ratio of grazed forage species to the total number of grazed forage observations per site survey (sample size variable). Forage availability frequency was calculated as the proportion of a forage species observed in the total intercept points (n=100). Preferred forages were defined as species selected with  $\geq 75\%$  frequency. Mean selection frequency and mean availability frequency were determined for each preferred forage species per pasture.

One-tailed paired T-tests probabilities were used to evaluate if selection frequency of preferred species are significantly greater than their availability frequency on selected sites. When the probability ( $\alpha$ ) that selection frequency values that high could appear by chance  $\leq 0.05$ , forage selection was concluded to be significantly greater than availability.

*Degree of Use*

Utilization was estimated by evaluating the height of grazed stubble in relation to adjacent ungrazed swards of identical species. Utilization indices were developed for preferred species in each pasture and calculated as the mean ratio of stubble height to sward height subtracted from 1. This method estimates the degree of defoliation and is adapted from the methodology of Johnson et al. (1994) Utilization classes and corresponding utilization indices are as follows: unused = 0, slight = 0-0.1, moderate = 0.2-0.4, full = 0.4-0.6, close = 0.6-0.8, and severe = 0.8-1.0.

*Behavior Patterns*

Behavior was classified as a grazing, ruminating, suckling, moving, or a breeding type behavior. Breeding behaviors are those social interactions exhibited by many large herbivores that are associated with the season of rut including tending, mounting, bellowing and aggressive territory defense (Mloszewski, 1983). Distant observations of prone ruminating animals resemble an animal at rest. Significant daylight time budgets may be allocated to resting (Plumb and Dodd, 1993). For the purpose of this study a ruminating animal is defined as those that are lying down. Frequency of observed behavior classes were grouped by pasture and calculated as the frequency of behavior occurrence in the total observation samples per pasture (sample size variable).

RESULTS AND DISCUSSION

*Landform Selection and Availability*

Selection frequency of landforms, as determined by observed herd occupancy, was found to be independent ( $\alpha \leq 0.05$ ) of landform availability in the 3 pastures sampled. Preferred landforms ( $\geq 75\%$  selection frequency) varied by pasture (Table 1; Graph 1). Flat-undulating and riparian areas were selected for in all pastures.

Landform selection in the UP pasture was moderately discriminate with 94% of selections being made for landforms that represent 55% of the available area. Variety of

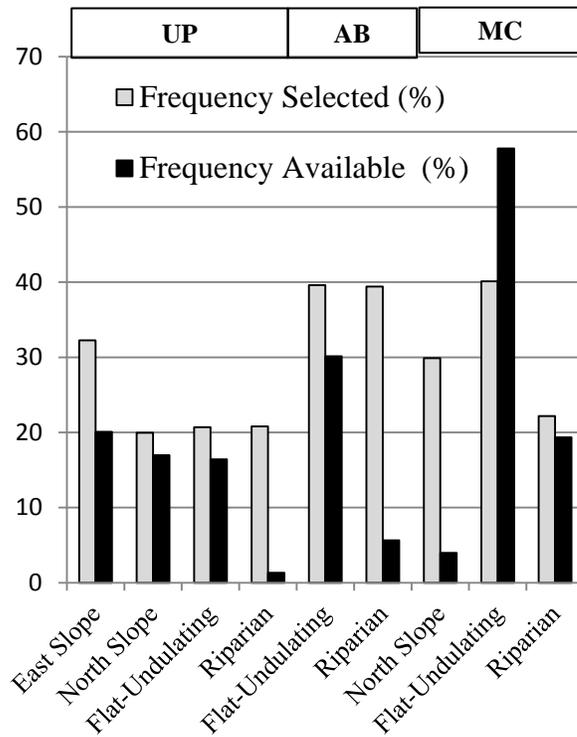
preferred landforms was highest here. Preferences were shown for 4 landform types, with east slopes, north slopes, flat-undulating and riparian areas constituting 94% of observed selections. Selection for riparian areas was much greater than local availability. Selections for north slopes and flat-undulating areas are slightly greater than, but comparable to their local availability

Herd occupancy of AB resulted in the most discriminate landform selection, with 79% of selections made for landforms that represent 36% of the available area. Variety of selected landforms was low here. Preferences for only 2 landform types were observed here, with flat-undulating and riparian areas constituting 79% of selections. Riparian areas were selected with much greater frequency than their local availability. Although selection frequency of flat-undulating areas was observed to be high, abundant local availability exists.

Landform selections in MC were least discriminate with 92% of selections made for landforms that represent 81% of the available area. Variety of selected landforms was moderate here. Preferences for 3 landform types were observed here, with north slopes, flat-undulating and riparian areas constituted 92% of observations. Greater selection frequency north facing slopes was observed here than in previous pastures. Selection for riparian areas was not elevated here increased availability. High selection frequency occurred for flat-undulating areas but was still lower than availability.

Pasture	Landform	Frequency Available (%)	Frequency Selected (%)
UP	East Slope	20	32
	North Slope	17	20
	Flat-Undulating	16	21
	Riparian	1	21
	<b>TOTAL</b>	<b>55</b>	<b>94</b>
AB	Flat-Undulating	30	40
	Riparian	6	39
	<b>TOTAL</b>	<b>36</b>	<b>79</b>
MC	North Slope	4	30
	Flat-Undulating	58	40
	Riparian	19	22
	<b>TOTAL</b>	<b>81</b>	<b>92</b>

Table 1. Selection and availability frequencies of preferred landform types.



Graph 1. Comparison of selection and availability frequencies for preferred landform types.

*Forage Selection and Availability*

Selection frequency of forage species varied by pasture (Table 2; Graph 2). Selection and availability frequencies for preferred forage species ( $\geq 75\%$  selection frequency) showed mixed results in a paired T-test. Selection for some species was shown to be significantly greater than ( $\alpha \leq 0.05$ ) local availability while selection for other preferred species were not significantly higher than availability. Foraged *Agropyron spicatum*, *Festuca scabrella*, and *Festuca idohensis* preferred in two or more consecutive pastures.

Forage selection in the UP pasture was the least discriminate with 85% of selections made for forages available on 42% of selected site. Variety of preferred forage species was low, with 4 forage species constituting 85% of selections. Selections for *Agropyron spicatum* and *Festuca idohensis* were found to be significantly greater than the availability of those species on selected sites. Selections for *Festuca scabrella* and *Bromus tectorum*, although high, were not found to be significantly greater than availability.

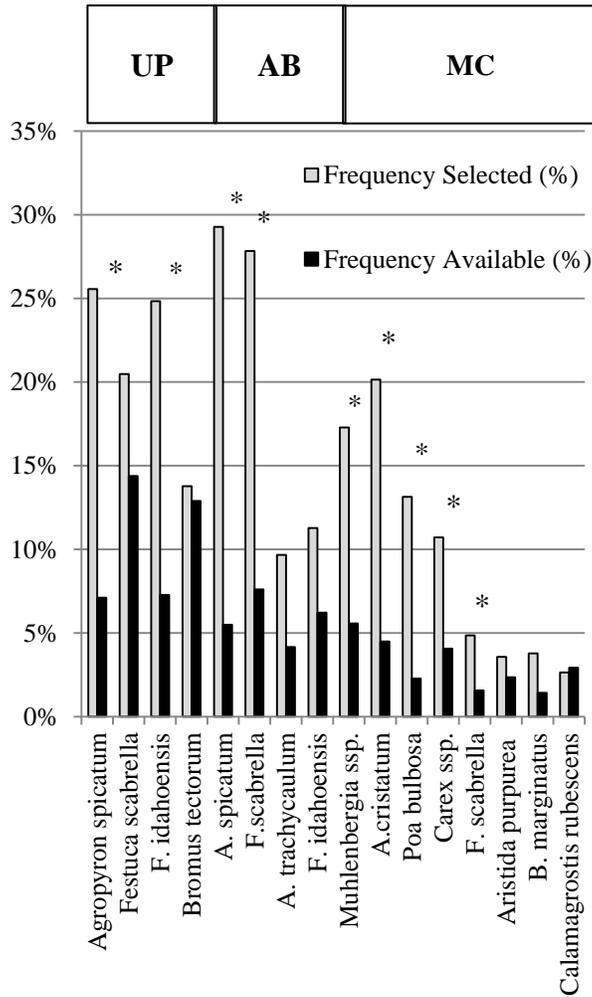
Forage selection in the AB was the most discriminate with 78% of selections made for forages available on 24% of selected site. Variety of preferred forage species was also low here, with 4 forage species constituting 78% of selections. Selections for *Agropyron spicatum* and *Festuca scabrella* were found to be significantly greater than the availability of those species on selected sites. Selections for *Festuca idohensis* and *Agropyron trachycaulum*, although moderate, were not significantly greater than availability.

Forage selection in MC were also highly discriminate with 76% of selections made for forages available on 25% of selected site. Variety of preferred forage species was high, with 8 forage species constituting 76% of observed selections. Selections for *Muhlenbergia ssp*,

*Agropyron cristatum*, *Poa bulbosa*, *Carex ssp.*, and *Festuca scabrella*, were found to be significantly greater than the availability of those species on selected sites. Selections for *Festuca Aristida purpurea*, *Bromus marginatus* and *Calamagrostis rubescens* were low and not found to be significantly greater than availability.

Pasture	Forage Species		Available (%)	Selected (%)	
	Latin	Common			
UP	<i>Agropyron spicatum</i>	bluebunch wheatgrass	7	26	
	<i>Festuca scabrella</i>	rough fescue	7	25	
	<i>F. idahoensis</i>	Idaho fescue	14	20	
	<i>Bromus tectorum</i>	cheatgrass	13	14	
	<b>TOTAL</b>		<b>42</b>	<b>85</b>	
	AB	<i>A. spicatum</i>	blue bunch wheatgrass	6	29
		<i>F. scabrella</i>	rough fescue	8	28
<i>A. trachycaulum</i>		slender wheatgrass	4	10	
<i>F. idahoensis</i>		Idaho fescue	6	11	
<b>TOTAL</b>			<b>24</b>	<b>78</b>	
MC	<i>Muhlenbergia ssp.</i>	muhly crested	5	20	
	<i>A. cristatum</i>	wheatgrass bulbus	6	17	
	<i>Poa bulbosa</i>	wheatgrass	2	13	
	<i>Carex ssp.</i>	sedge rough	4	11	
	<i>F. scabrella</i>	fescue	2	5	
	<i>Aristida purpurea</i>	red threeawn	2	4	
	<i>B. marginatus</i>	mountain brome	1	4	
	<i>Calamagrostis rubescens</i>	pinegrass	3	3	
	<b>TOTAL</b>		<b>25</b>	<b>76</b>	

**Table 2. Selection and availability frequencies of preferred forage species on selected sites.**



**Graph 2. Comparison of selection and availability frequencies for preferred forages.**

**Significant differences ( $\alpha \leq 0.05$ ) denoted with “\*”.**

*Forage Utilization*

Utilization for preferred forage species ranged from moderate (0.27) to severe (0.81) with a mean of full utilization (0.60) in all pastures sampled. *Agropyron cristatum*, *Poa bulbosa*, and *Calamagrostis rubescens* showed moderate utilization. *Agropyron trachycaulum* and

*Muhlenbergia ssp.* exhibited full utilization. Six different forage species: *Agropyron spicatum*, *Bromus tectorum*, *Festuca scabrella*, *Carex ssp.*, *Aristida purpurea*, and *Bromus marginatus* were classified as close utilization in one or more pasture. *Festuca idahoensis* was the only species classified as severe utilization.

In the UP pasture, utilization ranged from moderate (0.36) to close (0.78) with a mean of close utilization (0.62). In the AB, utilization ranged from full (0.43) to severe (0.81) with a mean of close utilization (0.68). In MC the range of utilization was found to be moderate (0.27) to close (0.78) with a mean of full utilization (0.54).

Pasture	Forage Species	Utilization	
		Index	Class
UP	<i>Agropyron spicatum</i>	0.78	Close
	<i>Festuca scabrella</i>	0.58	Full
	<i>Festuca idahoensis</i>	0.36	Moderate
	<i>Bromus tectorum</i>	0.78	Close
AB	<i>Agropyron spicatum</i>	0.80	Close
	<i>Festuca scabrella</i>	0.71	Close
	<i>Agropyron trachycaulum</i>	0.43	Full
	<i>Festuca idahoensis</i>	0.81	Severe
MC	<i>Muhlenbergia ssp.</i>	0.54	Full
	<i>Agropyron cristatum</i>	0.35	Moderate
	<i>Poa bulbosa</i>	0.36	Moderate
	<i>Carex ssp.</i>	0.67	Close
	<i>Festuca scabrella</i>	0.78	Close
	<i>Aristida purpurea</i>	0.62	Close
	<i>Bromus marginatus</i>	0.73	Close
<i>Calamagrostis rubescens</i>	0.27	Moderate	

**Table 3. Classification of utilization indices for preferred foraged per pasture. (Unused = 0, Slight= 0-0.1, Moderate = 0.2-0.4, Full 0.4-0.6, Close = 0.6-0.8, Severe = 0.8-1.0)**

*Behavior Patterns*

Behavior observations (Table 4) varied by pasture and patterns within a behavior class were not generally linear. Notable changes in the proportion of observed behaviors occurred within each behavior class as the herd moved from pasture to pasture throughout the summer. Recorded grazing behaviors ranged from 50% to 70% with a mean of 58%. Observations of ruminating type behaviors ranged from 8% to 42% with a mean of 25%. Suckling behaviors occurred between 0% and 10% of observations with a mean of 4%. The proportion of moving behaviors was recorded from 3% to 18% of total pasture observations with a mean of 10%. Breeding behaviors occurred between 0% and 5% of observations with an observed mean of 3%.

In the UP pasture behavior observations were nearly evenly distributed between grazing and ruminating type behaviors with very little suckling, moving, or breeding type behaviors observed. In the AB frequency of observed suckling, moving, and breeding type behaviors increased while observations of ruminating and grazing decreased from the previous pasture. In MC an increase in grazing and moving type behaviors was observed, while the lowest frequency of rumination observations occurred here. No suckling behavior was recorded and breeding behaviors decreased slightly from the previous pasture sampled.

	Grazing (%)	Ruminating (%)	Suckling (%)	Moving (%)	Breeding (%)
<b>UP</b>	53	42	2	3	0
<b>AB</b>	50	25	10	10	5
<b>MC</b>	70	8	0	18	4

**Table 4. Behaviors as a proportion of total behavior observations.**

## CONCLUSIONS

Landform selection was shown to be independent of landform availability in each pasture which is consistent with the original hypothesis. Results agree with VanVuren (1993) and Rutberg (1984) that open and level landscapes are selected by larger herds. Selectivity of landform types was most discriminate while the herd occupied AB.

Selection of several, but not all, preferred forages was significantly greater than their availability. Hypothesizing that all preferred forages would be selected in greater frequencies than their local availability was incorrect; selection pressure was far greater on some preferred species than on others. Observed foraging behaviors compared to the studies of Fortin (2003). Patterns indicate selective grazing of patches where preferred forages are abundant and succulent. Forage selectivity was most discriminate while the herd occupied AB.

Mean utilization indices of preferred forages were  $\geq 0.50$  in each pasture which supports the original hypothesis. All preferred forages were not used to this extent, while some were used to a much greater degree. Some high value forages experience close or severe utilization and this could affect their ability to reproduce. (Augustine and McNaughton 1998) Utilization of preferred forages was highest while the herd occupied AB .

Behavior patterns were supported by the original hypothesis with one slight deviation. Grazing and moving behaviors increased in successive pastures with the exception of grazing in AB where values were slightly lower than in the previous pasture. Ruminating behaviors decreased in each successive pasture. These patterns may indicate a degree of nutritional stress resulting in increased forage search time.

These results compare with Hobbs (1996) in that during the rut time spent grazing decreases to allow time to be allocated to various social activities. This decrease in grazing time is mitigated by increased habitat selectivity in bison. Habitat selection and behaviors of bison were dynamic in this study and changed with either temporal or spatial changes. These changes in behavior could be a function of forage quality and abundance as well as the energetic and time budget demands of the herd.

#### ACKNOWLEDGMENTS

This cooperative research was made possible in part by the Montana State University Animal & Range Science Department; and by the U.S. Fish Wildlife Service with the Confederated Salish & Kootenai Tribes of the Flathead Nation whom manage The NBR as part of the National Wildlife Refuge System. Special thanks to Amy Lisk and all NBR staff. This material is supported by the United States of America Department of Education – TRiO’s Ronald E. McNair Post-Baccalaureate Achievement Program under Grant No. P217A090198.

LITERATURE SITED

- Arnold, G.W.** 1985. Spatial Relations Between Sheep, Cattle and Horse Groups Grazing Together. *Appl. Anim. Behav. Sci.*, 13:7-17.
- Augustine, D.J. and S.J. McNaughton.** 1998. Ungulate Effects on the Functional Species Composition of Plant Communities: Herbivore Selectivity and Plant Tolerance. *J Wildl. Manage.* 62: 1165-1183.
- Belovsky, G.E., and J.B. Slade.** 1986. Time Budgets of Grassland Herbivores: Body Size Similarities. *Oecologia.* 70:53-62
- Borgreen, M. J., T. J. Roffe, E. Berry, R. McCosh, and J. G. Berardinelli.** 2010. Reproductive Rate of Semi-Free Ranging Bison (*Bison bison*) at the National Bison Range. *Proceedings, Western Section, American Society of Animal Science* Vol. 61
- Bryant, J.P., F. D. Provenza, J. Pastor, P. B. Reichert, T. P. Clausen, and J. T. Dutoit.** 1991. Interactions between woody plant and browsing mammals mediated by secondary metabolites. *Annual Review of Ecology and Systematics* 22:431-446.
- Cooper, A.Y., R.J. Boyd, and H.R. Stuart eds.** 1986. Inventory and Monitoring of Wildlife Habitat. U.S. Dept. Inter., Bur. Land Manage. Service Center. Denver, CO. xvii: 858
- Coppedge, B.R., and J.H. Shaw.** 1998. Bison Grazing Patterns on Seasonally burned Tallgrass Prairie. *J. Range Manage.* 51: 258-264.
- Fortin, D.** 2003. Searching Behavior and Use of Sampling information by Free-ranging Bison. *Behav. Ecol. Sociobiol.* 54: 194-2003.

Guffey, Kelsey

- Fortin, D. and M. Andruskiw.** 2003. Behavioral Responses of Free-Ranging Bison to Human Disturbance. *Wildl. Soc. Bul.* 31: 804-813.
- Fuller, J.A., R.A. Garrott, and P.J. White.** Emigration and Density Dependence in Yellowstone Bison. *J. Wildl. Manage.* 71: 1924-1933.
- Glenn, D.D., F.J Singer, U.S. Seal, and G. Bowser.** 1994. Physiological Responses of Yellowstone Bison to Winter Nutritional Deprivation. *J. Wildl. Manage.* 58:24-34.
- Gogan, J.P., KM Podruzny, E.M. Olexa, H.I. Pac, and K.L. Frey.** 2005. Yellowstone Bison Fetal Development and Phenology of Parturition. *The Journal of Wildlife Management* 69:1716-1730.
- Gordon, I.J.** 1994. Animal-based Measurement Techniques for Grazing Ecology research: a Review. *Sm. Rum. Research.* 16:203-214
- Hobbs, N.J.** 1996. Modification of Ecosystems by Ungulates. *J. Wildl. Manage.* 60: 695-713.
- Houston, D. B.** 1982. The northern Yellowstone elk, ecology and management. Macmillan Publ. Co., New York, NY 474-475 pp.
- Johnson, J.R., G.W. Reeves, D.W. Schmidt, and J.L. Skogberg.** 1994. Estimating Grass Utilization Using Photographic Guides. Cooperative Extension Service. South Dakota State University. USDA. EC 900.
- McHugh, T. 1958.** Social behavior of the American buffalo (*Bison bison bison*). *Zoologica*, 43:1-40.
- McNaughton, S. J.** 1978. Serengeti ungulates: feeding selectivity influences the effectiveness of plant defense guilds. *Science* 199:806-807.
- McNaughton, S.J., F. F. Banyikwa, And M. M. McNaughton.** 1997. Promotion of the cycling of diet-enhancing nutrients by African grazers. *Science* 278: 1798-1800.

Guffey, Kelsey

**Meagher, M.M.**1989. Range Expansion by Bison of Yellowstone National Park. *J. Mamm.*  
70:670-675

**Mloszewski, M.J.** 1983. .The Behavioral Ecology of the African Buffalo. Cambridge University  
Press, New York, NY. 75-78 pp.

**Mooring, M.S., D. D. Reisig, E.R. Osborn, A.L. Kanallakan, B.M. Hall, E.W. Schaad, D.S.  
Wiseman, R. R. Huber.**2005. Sexual Segregation in Bison: a Test of Multiple  
Hypotheses. *Behavior.* 142:897-927

**Plumb, G.E. and J.L. Dodd.** 1993. Foraging Ecology of Bison and Cattle on a Mixed Prairie:  
Implications for Natural Area Management. *Ecol Appl.* 3: 631-643.

**Rutberg, A.T.** 1984. Competition and Reproduction in American Bison Cows. Unpubl. Ph.D.  
dissert., Univ. Washington, Seattle, 174 pp.

**Senft, R. L., M. B. Coughenour, D. W. Bailey, L. R. Rittenhouse, O. E. Sala and D. M.  
Swift.** 1987. Large Herbivore Foraging and Ecological Hierarchies. *Bio Sci.* 37:789-799.

**Van Dyne, G.M., N.R. Brockington, Z. Szocs, J.Duek, C.A. Ribic.**1980. Large Herbivore  
Subsystem. In *Grasslands, Systems Analysis and Man.* International Biome Programme  
19. Breymeyer, A.I. and G.M. Van Dyne eds. Cambridge University Press, Cambridge,  
UK. 276-332 pp.

**Van Vuren, D.**1983: Group Dynamics and Summer Home Range of Bison in Southern Utah.  
*J.Mamm.* 64:329-332.

**Van Vuren, D.** 1984 Summer Diets of Bison and Cattle in Southern Utah. *J. Range Manage.* 37:  
260-261

**Van Vuren, D. and M.P. Bray.**1986. Population Dynamics of Bison in the Henry Mountains,  
UT. *J. Mamm.* 67: 503-511.

The holistic nature of the Native American model of wellness may serve as an example of how to more effectively treat symptoms of Posttraumatic Stress Disorder among combat veterans. When we explore treatment models from Western medicine and psychology, we find evidence that professionals involved in treatment of PTSD advocate a combination of treatments to help manage symptoms. As I researched the success of Traditional Native American cultures in assisting veterans in managing symptoms of Posttraumatic Stress Disorder, I was struck by the fact that, historically, Native Americans have served in the military in higher ratios compared to other ethnic groups in America. Even though a relatively high percentage of these Native American soldiers participate in heavy combat, remarkable success in treating symptoms of Posttraumatic Stress Disorder has been achieved through holistic traditional cultural methods.

The residents of the state of Montana are facing a disturbing dilemma. We are now seeing and will most likely continue to see an influx of veterans returning from overseas deployments. Many of these veterans are affected by symptoms of Posttraumatic Stress Disorder. It is likely that the existence and frequency of PTSD among Montanans will increase and have an impact on the lives of every resident in every community in the state in one way or another. According to a 2006 report from the U.S. Department of Veterans affairs, “Montana has the highest rate of military veterans of any state but its VA mental health facilities rank low in providing veterans benefits”. (U.S. Department of, 2006) The report shows that Montana has 106 veterans for every one thousand residents. In Montana, only six percent of all health spending was on specialized mental health services at VA medical centers. In addition, only fifty-six percent of Montana veterans with diagnosed mental illness received any treatment from mental health specialists. As Montanans, we must ask ourselves: Are we successful in addressing the needs of our disabled

veterans by providing treatment options, within our communities, especially those who are affected by symptoms of PTSD? (U.S. Department of, 2006)

It is most likely that the disorder of PTSD has affected human beings throughout our history. Western practitioners have only recently acknowledged the seriousness of PTSD. After the Viet Nam War, PTSD was known as combat fatigue. In the years following WW I and WW II, symptoms of PTSD were referred to as shell shock. After the Civil War, soldiers displaying symptoms of PTSD were said to suffer from soldier's heart. There are few more timely issues than addressing the needs of our warriors who suffer the invisible wounds of PTSD.

In order to develop holistic mental health care management programs to assist veterans with symptoms of PTSD in Montana, it is first necessary to initiate a focused conversation among health care providers, university scholars and researchers, and community leaders. Much empirical evidence exists on the efficacy of different forms of treatment. In light of the fact that our country is currently at war, and it is undeniable that a great number of our soldiers will be returning home with symptoms of PTSD, it is crucial that even more research be devoted to the subject of effective treatment options. It is important to understand that PTSD is a very real psychological disorder, but also one that can be effectively managed.

Ronald J. Comer is the director of Clinical Psychology Studies at Princeton University's Department of Psychology and a respected authority in the field of abnormal psychology. Comer states "The subject of abnormal psychology is people-very often people in great pain..." (Comer, p xx)

In regard to holistic models of treatment for PTSD, an important facet to Comer's pedagogy as it relates to a holistic model of treatment is the fact that he continually poses the question of "...whether competing models can work together in a more integrated approach." (Comer, p xxi)

Comer asserts that experts in the field of Western psychology maintain that it is unlikely that one form of treatment will be adequate to relieve or help manage symptoms, and it is evident that a balanced or holistic approach to manage an individual's symptoms contributes to more effective treatment results. Additionally, "The field of multicultural psychology has begun to have a powerful effect on our understanding and treatment of abnormal behavior." (Comer, pp xxi, 17)

In researching the subject of treatment models for symptoms of PTSD, I found evidence that a key element of effective and sustainable treatment may be missing from most Western treatment models when compared to the holistic manner of treatment utilized by traditional Native American Cultures. This omission is the lack of community involvement in assisting re-integration of veterans.

Research on traditional cultural methods of assisting warriors to overcome symptoms of PTSD shows a belief that a balance must be achieved at an individual level and also that the individual suffering must be regarded as a 'whole' person in order to achieve a balance between that individual's body, spirit, heart and mind. This individual balance or imbalance in turn affects the wellbeing of the community. This is the overreaching concept of holism as it applies to managing and individual's symptoms of PTSD.

It is important, of course, to first understand the concept of holism, and how this concept may be applied to formulating treatment models to effectively manage individual cases of PTSD. In order to gain an understanding of what is meant by the term "holistic", we may turn to explanations provided by Allan Savory, who may well be considered the modern guru of holistic management.

Savory notes that it was reknowned South African "statesman-scholar Jan Christian Smuts (1870-1950) who first introduced the theoretical worldview known as holism (from the Greek-

holos). Smuts, in *Holism and Evolution*, published in 1926, fostered the notion that “the world is not made up of substance, but of flexible, changing patterns.” From Smuts’ theoretical concepts, Savory reports “If you take patterns as the ultimate structure of the world, if it is arrangements and not stuff that make up the world, the new concept leads you to the concept of wholes. Wholes have no stuff, they are arrangements. Science has come round to the view that the world consists of patterns, and I construe that to be that the world consists of wholes.” Savory emphasizes that since “Individual parts do not exist in nature, only wholes... these form and shape each other” and cites Smut’s argument that “... all organisms feel the force and molding effect of the environment as a whole are indeed one with Nature. Her genetic fibers run through all our being; our physical organs connect us with millions of years of her history; our minds are full of immemorial paths of pre-human experience.” (Savory, pp 19-20)

Savory states, “In our culture it is mainly philosophers who concern themselves with this larger issue because it is hard to see how individuals caught up in daily life can take responsibility for the long-term consequences of their actions.” However, Savory argues that any entity or condition may be managed by “looking inward to the lesser wholes that combine to form it, and outward to the greater wholes of which it is a member.” By understanding this concept, we may begin to see how holistic management of symptoms of PTSD will not only assist the sufferer but begin to affect the community in a positive manner. (Savory, p 20)

Savory proposes that “...no whole, be it a family, a business, a community, or a nation, can be managed effectively by the isolation of any single ‘part’.” To warrant this claim, Savory uses a well known example from the natural sciences. Savory reveals that “without realizing it, American biologist Robert Paine provided dramatic evidence of the holistic nature of communities in a study he did in a seashore environment.” (Savory, pp 17, 19) Paine removed a

predatory species of starfish from a population of fifteen observable species, and the balance of the ecosystem quickly deteriorated. Savory surmises, “You do not see yourself, or your parents, or your children as communities of interconnected cells, you see them as whole persons.”

Removing one element in the whole, as Paine did, severely disrupted the whole marine community (Savory, p 17, 19, 20). If, in our communities, we ignore the suffering and inability of a single member to manage the symptoms of PTSD, it inevitably affects the wellbeing of the community as a whole.

Savory admitted that he had “tremendous difficulty” in understanding the true nature of holism. He acknowledged that “until I actually could work it out with my own hands as a young child might,” he could not fully fathom this concept. The following excerpt explains how Savory worked out a solution to his inability to understand Smut’s holistic theory: “I took four balls of kindergarten-type modeling clay in red, green, yellow and blue, and began kneading them together until they slowly blended into a fifth color, gray. Mentally I let gray represent the world we originally set out to understand. Close inspection of my gray ball revealed traces of the four colors I had begun with. So to understand this world of gray I would study the colors I knew to be in some way involved in it, in much the same way our earliest scientists broke our natural world into what they perceived a parts for study.” Savory then came to the realization that all management decisions, from the management of an ecosystem, a business, or even an individual’s personal life, had to be made from the perspective of the “whole under management.” He asserts that if management decisions are based on any other perspective, “we could expect to experience results different from those intended because only the whole is reality.” He explains that “the whole (the gray) had to be defined, bearing in mind that it always influenced, and was influenced by, both greater and lesser wholes—and we had to know what we

wanted to do with it: we needed an all-encompassing, holistic goal. If we begin to understand that managing an individual case of PTSD must be considered from the perspective of the whole, including the individual's family and community, we may begin to achieve more success in assisting disabled veterans by taking measures to help them reintegrate into their civilian lives. (Savory, p 26-27)

Holism, in the context of a resultant healthy community that has acknowledged and integrated all of its members in a positive manner, can also easily be related to the concept of systems theory, an interdisciplinary theory that seeks to explain how complex patterns exist within nature as well as society. Deidre Combs, in *The Way of Conflict: Elemental Wisdom for Resolving Disputes and Transcending Differences*, explains that in the twentieth century, "new scientists" began to "focus on the whole", or what they called the system." Combs points out that these "new scientists described the universe as a living system made up of independent, interrelated systems..." and that "any group of people, be it a married couple, a family, or a community is a system. This concept illustrates how the actions of every member of a community system affect every other member of that system. By striving to understand this concept, we may begin to acknowledge how crucial it is for us to identify and acknowledge ways to assist members of our communities who are veterans with PTSD in achieving a sustained and balanced healing of their invisible wounds. (Combs, p 49-50)

Many indigenous people of America have long understood this principle and practiced ways of reintegrating their wounded warriors back into the community. Although the diverse clans of Native Americans hold many different traditional views, the general Native American worldview may be said to be holistic in nature, as may be shown by the following representation of the Anishinaabe Medicine Wheel (Figure 1).



Figure 1.

If we compare the Anishinaabe Medicine Wheel to a representation of a Western Holistic Model, we see correlations. (Figure 2).

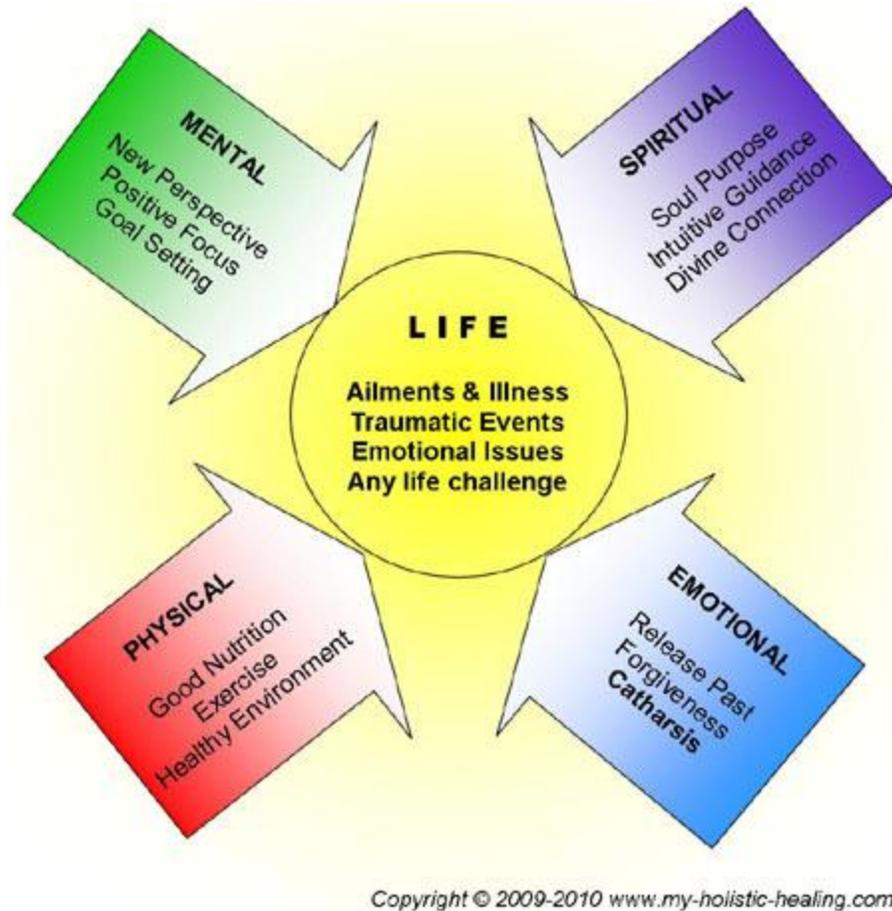


Figure 2.

In the Western Model, the body is represented by physiological aspects, including adequate nutrition and exercise, environmental stimuli, possibly drug therapy, and the way these factors ultimately contribute to healthy or unhealthy brain function. The spirit is represented by spiritual processes, including guidance and divine connection. The heart is represented by emotional processes which include forgiveness and catharsis. The mind is represented by cognitive processes including modification of perspective, focus, and behavior.

Note that central to the Western model is “Life,” indicating an emphasis on the individual, whereas the Native American Model holds a “Healthy Community” as central to wellbeing.

Here we see what may be missing in Western treatment models for PTSD--an emphasis on the community as a whole and the individual as an important and active member of that whole.

In the Native American worldview, a balance between aspects of the body, spirit, heart, and mind lead to a healthy being and a healthy community. We will look at ways in which Traditional Native American Cultures have achieved success in assisting their veterans with PTSD, but it is at this point in our discussion that we may be best served by attempting to understand the actual symptoms of Posttraumatic Stress Disorder. In this way, we may begin to see the serious affects that this disorder may have on not only an individual, but also on the family and community encompassing the individual.

The effects of symptoms of PTSD has a dramatic effect on the ability of an individual to function. According to the DSM-IV TR, PTSD is diagnosed when a person is exposed to an actual or perceived threat that results in a response involving “intense fear, helplessness, or horror” (Criteria A and B). This event is re-experienced in one or more experiences of recurrent and intrusive recollections, distressing dreams of the event, a sense of reliving the experience, including illusions, hallucinations, and dissociative flashbacks, intense psychological distress when exposed to cues that symbolize or resemble aspects of the trauma, and psychological reactivity when exposed to external or internal cues. Experiencing these symptoms of PTSD may lead an individual to avoid thoughts, feelings, or conversations associated with the trauma, as well as efforts to avoid activities, places, or people that arouse recollections of the trauma. An individual affected may show a markedly diminished interest or participation in significant activities, feelings of detachment or estrangement from others, and a sense of a foreshortened future, including expectations that they will not have a career, marriage, children or a normal lifespan. The individual may display a restricted range of affect, or be unable to have loving

feelings. Affected individuals also show persistent symptoms of increased arousal, not present before the trauma, including difficulty falling or staying asleep, irritability or outbursts of anger, difficulty concentrating, hypervigilance, and exaggerated startle response. In an individual diagnosed with PTSD, these disturbances cause clinically significant distress or impairment in social, occupational, or other important areas of functioning. There are several additional associated features and disorders associated with a diagnosis of PTSD that reveal reasons that it is crucial for communities to strive to help alleviate symptoms. Individuals with Posttraumatic Stress Disorder may describe painful guilt feelings about surviving when others did not survive or about the things they had to do to survive. Phobic avoidance of situations or activities that resemble or symbolize the original trauma may interfere with interpersonal relationships and lead to marital conflict, divorce, or loss of employment. The following associated constellation of symptoms may occur, more commonly seen in association with an interpersonal stressor (e.g., childhood sexual or physical abuse, domestic battering, being taken hostage, incarceration as a prisoner of war or in a concentration camp, torture): feelings of ineffectiveness, shame, despair, or hopelessness; feeling permanently damaged; a loss of previously sustained beliefs, hostility; social withdrawal; feeling constantly threatened; impaired relationships with others; or a change from the individual's previous personality characteristics. There may be increased risk of Panic Disorder, Agoraphobia, Obsessive-Compulsive Disorder, Social Phobia, Specific Phobia, Major Depressive Disorder, Somatization Disorder, and Substance-Related Disorders. If we consider veterans, their families, and their communities as an integrated system, it is clear that PTSD may affect not only an individual veteran, but the entire system. (Posttraumatic Stress Disorder, DSM-IV-TR)

Additionally, in one study, *Trait Aggression Among Veterans: An Examination of Personal Trauma Experiences, Combat Exposure, and Posttraumatic Stress Disorder*, Emily Kay Overbo concludes that “combat-exposed veterans had higher levels of physical aggression than did military members without combat exposure and an even greater difference with civilians...those within the combat-exposed group with PTSD had significantly higher levels of anger and hostility, which is consistent with the diagnosis of PTSD, and may be indicative of the individual reactions to trauma.” Overbo points out that “the mental health functioning of veterans has been a source of concern across the world” and that “previous research (conducted by Taft, Pless, et al., 2005) has examined adjustment difficulties with veterans, including posttraumatic stress disorder.” Overbo warns that her study “illustrates the continued need to address the psychological consequences of war. Independent research on the effects of war-related trauma to both service members and their family is needed. Research should be longitudinal and address a wide variety of difficulties that are faced by veterans and their families.” (Overbo, pp vi-viii)

Reflecting on the above information, it leads us to the conclusion that the wellbeing of communities and families may be seriously affected by the behavior of a person diagnosed with PTSD and that it is imperative for individuals with the disorder to have timely access to effective treatment for symptoms. In reservation and rural non-reservation communities across Montana, veterans with PTSD struggle to access appropriate care. Barriers to accessing care include the lack of facilities in proximity to the community and travel complications as well as perceived stigma.

Even if a veteran is able to access health care options in their community, are we certain that the treatments provided will be effective? It brings us to the subject of commonly used Western treatments for PTSD and to the subject of psychology and its practice in general. It is helpful to

explore briefly the historical evolution of the practices by which Western practitioners have attempted or neglected to provide management of symptoms of PTSD and other psychological disorders.

Comer provides an interesting chronological history of the evolution of Western treatment of psychological disorders, beginning in the Middle Ages. He reports that the “Middle Ages were a time of great stress and anxiety--a time of war, urban uprising, and plagues...abnormal behavior apparently increased greatly during this period.” Traumatic events such as these are known to cause symptoms of PTSD. Comer asserts that it is not surprising that “...some of the earlier demonological treatments for psychological abnormality reemerged during the Middle Ages” and that it was “...not until the Middle Ages drew to a close that demonology and its methods began to lose favor...Medical views of abnormality gained favor, and many people with psychological disturbances received treatment in medical hospitals....” (Comer, p 8)

Comer then advances to the Renaissance Period, “a period of flourishing cultural and scientific activity from about 1400 to 1700 [when] demonological views of abnormality continued to decline.” In fact, it was in the mid-fifteen-hundreds that the German doctor, Johann Weyer, became the “first physician to specialize in mental illness...he is now considered the founder of the modern study of psychopathology.” (Comer, p 8)

According to Comer, “The care of people with mental disorders continued to improve in this atmosphere. In England such individuals might be kept at home while their families were aided financially by the local parish...across Europe, religious shrines were devoted to the humane and loving treatment of people with mental disorders...Gheel [or Geel], Belgium [was] perhaps the best known of these shrines....” He explains that people from all over Europe flocked to this site for “psychic healing.” When we discuss the crucial import of the community in helping to

alleviate symptoms of PTSD, it is important to remember that Comer observes, “Local residents welcomed these pilgrims into their homes, and many stayed on to form the world’s first “colony” of mental patients.” Comer emphasizes that Gheel is considered “the forerunner of today’s community mental health programs, and it continues to demonstrate that people with psychological disorders can respond to loving care and respectful treatment.” (Comer, p 8)

Comer then reveals that “unfortunately, these improvements in care began to fade by the mid-sixteenth century.” This trend continued until about 1800, the advent of “Moral Treatment” in Europe and the United States. He attributes these methods to Pinel and Tuke. Their methods were deemed Moral Treatment, “because they emphasized moral guidance and humane and respectful techniques.” Comer explains that “patients with psychological problems were increasingly perceived as potentially productive human beings whose mental functioning had broken down under stress.” It is not unlikely that many of these patients suffered from symptoms of PTSD. (Comer, pp 8-9)

Comer cites *Bockoven, 1963*: “By the 1850’s, a number of mental hospitals throughout Europe and America reported success using moral approaches...by the end of that century, however, several factors led to a reversal of the moral treatment movement.” He suggests factors that may have contributed to this reversal, including “the speed with which the movement had spread; as mental hospitals multiplied, severe money and staffing shortages developed and recovery rates declined; the assumption behind moral treatment that all patients could be cured if treated with humanity and dignity; the emergence of a new wave of prejudice against people with mental disorders. As increasing numbers of patients disappeared into large, distant mental hospitals, the public came to view them as strange and dangerous. In turn, people were less open minded when it came to making donations or allocating government funds.” These observations

serve as ominous warnings to today's society regarding how an influx of soldiers returning from Iraq and Afghanistan with PTSD may be expected to be perceived and treated. (Comer, pp 9-10)

In the 1890's Viennese physicians Josef and Breuer gained recognition for their work with the newly developed technique, psychoanalysis, "...a form of discussion in which clinicians help troubled people gain insight into their unconscious psychological processes." Psychoanalytic treatment was offered to patients who did not require hospitalization and is considered the predecessor of today's outpatient treatment. (Comer, p 12)

In addition to mentioning the relatively positive development of Breuer's and Freud's psychoanalytic work, Comer identifies two "opposing perspectives" that emerged with the decline of the moral movement in the late 1800's and claims that the proponents of these perspectives competed rather than collaborated in their treatment of psychological disorders. These opposing ideologies were the somatogenic perspective and the psychogenic perspective. From the somatogenic perspective, physical causes were responsible for abnormal psychological function. Alternatively, the psychogenic view was that psychological disorders caused abnormal functioning." (Comer, p 10)

It is interesting to note, at this time, that Comer asserts that although the psychogenic perspective had "a long history," it "did not gain much of a following until studies of hypnotism demonstrated its potential." It is not mere coincidence that the decline of the Moral Movement and the inception of the opposing somatogenic and psychogenic perspectives coincided with the bleak period of human history in which the ideology of eugenics was in full force in Western societies. To illustrate some effects of the eugenic movement and to move us forward to the state of Western psychiatric treatment in middle of the twentieth century, Comer provides a

chilling timeline regarding relatively recent Western trends regarding treatment of those affected with psychological disorders:

1896: Connecticut became the first state in the United States to prohibit persons with mental disorders from marrying.

1896-1933: Every state in the United States passed a law prohibiting marriage by persons with mental disorders.

1907: Indiana became the first state to pass a bill calling for people with mental disorders, as well as criminals and other “defectives”, to undergo sterilization.

1927: The U.S. Supreme Court ruled that eugenic sterilization was constitutional.

1907-1945: About 45,000 Americans were sterilized under eugenic sterilization laws; 21,000 of them were patients in mental hospitals.

1929-1932: Denmark, Norway, Sweden, Finland, and Iceland passed eugenic sterilization laws.

1933: Germany passed a eugenic sterilization law, under which 375,000 people were sterilized by 1940.

1940: Nazi Germany began to use “proper gases” to kill people with mental disorders; 70,000 people were killed in less than two years. (Comer, pp 11-12)

Comer points out that in the years between 1950 and the present, we have seen “major changes in the ways clinicians understand and treat abnormal functioning.” One of the most revolutionary changes has been in regard to medications used to treat mental dysfunction beginning in the 1950’s. At this time, drug therapy was developed. Psychotropic drugs that act to reduce dysfunctional mental symptoms were developed, including anti-psychotic drugs to correct confused thinking, antidepressant medications, and anti-anxiety drugs. All these medications enabled relatively effective treatment of some symptoms of PTSD and other mental

dysfunction. Comer adds that, additionally, there has been a renewed interest in “community care,” a community based mental health approach resembling that of the historic Gheel community. (Comer, p 8)

Comer asserts “...the field of abnormal psychology has had a dramatic growth spurt over the past several years...” He attributes some of this growth to “...’new wave’ cognitive and cognitive-behavioral theories and therapies that help clients “accept” and objectify maladaptive thoughts that are resistant to change. ...mindfulness-based cognitive therapy and Acceptance and Commitment Therapy (ACT)...” and adds that “correspondingly, biological theories and treatments for abnormal behavior have taken unprecedented leaps forward during the past several years...” Current methods of treatment include medication, individual psychotherapy, group therapy, desensitization and flooding. (Comer, pp xvii, xviii)

Comer explains that there are now more theories and types of treatment as well as more information and research studies regarding abnormal psychology. Conversely, this abundance of new information has resulted in more disagreements in treatment methods. Comer maintains that although “in some ways the study and treatment of psychological disorders have come a long way... in other respects clinical scientists and practitioners are still struggling to make a difference.” (Comer, pp 13-14)

According to Comer, modern Western practitioners currently utilize a variety of behavioral techniques and combinations of techniques. In the cognitive-behavioral theoretical perspective, cognition (the abilities to think, remember and anticipate) is “learned behaviors,” and being learned, they may be “unlearned” with the assistance of a therapist. The cognitive model “emphasizes the process and content of thinking as the causes of psychological problems.” Cognitive therapy, developed by Aaron Beck, “helps people identify and change the maladaptive

assumptions and ways of thinking that help cause their psychological disorders.” Beck’s “Cognitive Triad” identifies the three forms of “negative thinking...that lead people to feel depressed. The triad consists of a negative view of one’s experiences, one’s self, and the future.” Another theoretical perspective in current usage is the psychodynamic model, in which all “human functioning” is seen as being shaped by dynamic (interacting) psychological forces and in which behavior is explained in reference to unconscious internal conflicts. The goals of the psychodynamic system of therapy are to “help clients uncover past traumatic events and the inner conflicts that have resulted from them, settle those conflicts, and resume personal development.” (Comer pp G-3, G-11)

Some Western practitioners utilize hypnosis in treatment of various disorders. Comer describes hypnosis as “a sleeplike suggestible state during which a person can be directed to act in unusual ways, to experience unusual sensations, to remember seemingly forgotten events, or to forget remembered events.” Hypnotherapy is a treatment in which “a person undergoes hypnosis and is then guided to recall forgotten events or perform other therapeutic activities...while in a “trancelike mental state during which they become extremely suggestible.” (Comer, pp 11-12)

At the same time as Western methods of treating psychological disorders such as PTSD were evolving, many cultures successfully utilized traditional methods of healing the invisible wounds of warriors. Still surviving are many methods used by the indigenous people of America. When we search for correlations between treatment of PTSD in Western practices and Native American Cultures, we may begin by looking to Comer’s definition of “treatment”. His view is that treatment “...typically includes a patient, a therapist, and a series of therapeutic contacts.” In

Native American cultures, the role of therapist is played by what we could refer to as trained healers. (Comer, p 6)

Studies have also shown that the use of ceremony, ritual and storytelling, combined in a manner that may be described as holistic, have had dramatic effects on the wellbeing of Native American veterans suffering from PTSD. History shows a very high proportion of Native Americans have seen heavy combat, yet those veterans who have been able to utilize tribal rituals and ceremonies have shown remarkable success in managing symptoms of post traumatic stress. Presently, it may be beneficial to veterans of war for researchers to examine lessons taught by the cultures of our indigenous people and attempt to find correlations among treatment methods that have proven successful. (Gross pp 375-76)

In 2007, Dr. Lawrence W. Gross, Ph.D., who currently serves as an assistant professor at Montana State University's Native American Studies Department, presented compelling research regarding Native American methods of treating Posttraumatic Stress Disorder among veterans of the Viet Nam era. In his award-winning article, *Assisting American Indian Veterans of Iraq and Afghanistan Cope with Posttraumatic Stress Disorder: Lessons from Vietnam Veterans and the Writings of Jim Northrup*, Gross calls for scholars in American Indian Studies and the Humanities to engage in a sustained, interdisciplinary conversation about practical suggestions for relieving the suffering of our American Indian Warriors." (Gross, p 373)

In his research on ground-breaking studies and important points regarding the extraordinary results obtained by traditional North American Indian cultures in helping veterans overcome symptoms of posttraumatic stress disorder, Gross uncovers evidence that many of these traditional manners of treatment are effective in managing symptoms of PTSD in Native American veterans of war. Gross provides evidence throughout the article to warrant the results

of traditional healing methods and the holistic manner in which these methods are applied. The one most poignant statement in this article that served to motivate my research is in regard to a group of non-Indian researchers led by Scurfield. Gross quotes Scurfield: “The bittersweet aspect was the recognition by non-native veterans (to include the author) that we never have had or would have this depth of mutual affinity with, let alone such support and recognition from, the communities in which we had been raised.” He adds, “Nothing more needs to be added to demonstrate the tremendous impact American Indian rituals and ceremonies can have in conjunction with standard psychological treatment for our warriors, both Indian and non-Indian alike.” (Gross, p 386)

Gross reports findings from Tom Holm’s study, *The National Survey of Indian Vietnam Veterans*. He asserts that although the study was “demographic in nature and not inferential,” it was indeed the first attempt to research and analyze data regarding American Indian Veterans, thus resulting in a “landmark investigation” that presents information invaluable to further research regarding treatment of PTSD. He also refers to the National Center for American Indian and Alaska Native Mental Health Research under the direction of Spero Manson, which provided the “first data that could be used to provide comparative analysis of American Indian Vietnam veterans with other groups.” He asserts that due to limited epidemiological data, “our picture is somewhat limited and obviously much work remains to be done in this area.” However, the data collected shows how these studies point to the fact that not only do American Indian veterans experience PTSD at a higher rate than other ethnic groups, but also these statistics can be directly attributed to the reality that in the wars of modern times, American Indians have had more exposure to combat in comparison to other ethnic groups. (Gross, pp 376-77)

Gross maintains that important cultural methods used to assist American Indian veterans with PTSD include traditional ceremonies and rituals. He states, “Given the important role they have played in helping veterans, they deserve closer examination.” (Gross, pp 377-78)

He reports Steven Silver and John Wilson conclude that “a key element in the healing of American Indian veterans from war-induced trauma was the involvement of the individual’s social-support system.” LaDue, Marcelley, and Van Brunt emphasize methods for treating veterans that utilize “medicine people, herbs, rituals, ceremonies, community events, and powwows.” Gross reports that “some veterans report that going through ceremonies upon their return literally saved their lives.” He also adds that ceremonies exist for sending soldiers off to battle and also for assisting soldiers’ reintegration into society when they return from battle. Gross claims these ceremonies reduce trauma by deconditioning “intense emotions associated with combat” and that Silver and Wilson, from the perspective of the field of psychology, believe the key is the “holistic nature of rituals.” From a cultural viewpoint, Gross cites Holm’s explanation of how rituals have powerful healing effects:

“...going through ceremonies helped the veterans establish a rapprochement with tribal elders, which, in turn, established the commitment the veterans had to their respective cultures. For some Native cultures, going through rituals was a way for veterans to purge the taint of war and so make possible their reintegration into society. Participating in rituals was also a way for communities to honor veterans for their service, thus helping to give meaning and purpose to their sacrifices. One of the more intriguing aspects of looking at healing from within American Indian cultures has to do with a process called ‘age acceleration’. Witnessing the death of people of a similar age forces soldiers to focus on their own mortality while still young. This, in effect, accelerates the maturation process... Having gone through combat, the veterans were granted

status in the community, received prestige for their wartime service, and were recognized as mature men. In effect, the ceremonies transformed the trauma suffered by these veterans and gave them meaning. No matter what type of horrors they may have experienced on the battlefield and how meaningless the sacrifices seemed to be at the time, the ceremonies enabled the veterans to reformulate their memories from being a source of anguish to being a wellspring of pride. Giving meaning to their time in the military helped them smooth the rough edges of their trauma, which in turn allowed them to better reintegrate into society. Thus, as Holm reported, many veterans saw their military service as a source of pride.” (Gross, p 378-79)

Additionally, Gross refers to investigations by Wilson and Silver that illustrate how the sweat lodge ceremony is used to assist in the healing of trauma in American Indian Veterans. Wilson asserts “the sweat lodge ceremony creates a positive change in the mental state of the individual, leading to a form of natural, organismically based healing.” Healing dimensions of the ceremony include cultural practices, psychological processes, and psychobiological effects. He also argues, “The sweat lodge resembles the dynamics of group therapy in that there are group and individual parts.” According to Gross, Silver and Wilson conclude that “...during the ritual there is a release of emotions and acceptance of others. This leads to a “sense of release, rebirth, and a personal renewal of spirit.” Also stated is that “... embedded within the cultural practices of the sweat lodge are activities and customs that allow for the dynamics of group and individual therapy to occur.” Gross emphasizes “the psychobiological aspects of the ritual only add to its power.” He also states that Wilson’s study shows “the net effect is that the sweat lodge ceremony can result in neurophysiological changes in the brain.” (Gross, p 380)

Gross reports the views of Holm and Silver and Wilson regarding how ceremonial powwows may have a positive effect in helping American Indian veterans rejoin their communities. Silver

and Wilson “focus more on the involvement of families and communities in the events,” and Holm “adds two additional observations. First, he acknowledges the role the powwows play in fulfilling tribal obligations to the Creator. Further, he stresses the importance of the powwows in cultural continuity.” (Gross, pp 381-82)

Gross warns that it is crucial for researchers to be mindful of important considerations. “First, Wilson, Walker, and Webster hypothesize that having the treatment program be conducted in a natural environment is important in order to remove the stigma of the clinical setting. Further, the program may not be suitable for every veteran, and careful selection of patients is of critical concern. Finally, and perhaps most importantly, they wrote that we do not recommend that anyone attempt to replicate our experience or adapt Native American rituals without the utmost care, respect, knowledge, consultation, and approval of experienced medicine persons. It is also imperative to respect the fact that these rituals are embedded in the culture and cannot be extricated for reasons of expediency or personal gain.” (Gross, pp 384-85)

Gross also reports that Native American cultural and psychological literature emphasizes the importance of ceremonies and rituals, such as the sweat lodge and honorary powwows, as well as the fact that family and community are important and successful methods of helping American Indian veterans with PTSD alleviate symptoms. He then turns to literary works in his view of an holistic healing process. He suggests it “would be good for scholars to take up the challenge of publishing more on the existing literature about American Indians and Vietnam” in order to help veterans of Iraq and Afghanistan. Here, he analyzes the importance of writings by Jim Northrup, a veteran who suffers from symptoms of PTSD. In Gross’ opinion, “The healing power of storytelling in regard to recovering from posttraumatic stress disorder can be understood in relation to the larger storytelling tradition of the Anishinaabe” and refers to Northrup’s *Walking*

*the Rez Road* and *The Rez Road Follies* as examples of such contemporary storytelling. (Gross, p 388)

Gross also addresses Gerald Vizenor's opinions regarding "trickster discourse" in tribal societies. Gross sums up Vizenor's observation by stating that "trickster discourse functions as a cultural whole, meaning that the whole of the culture is involved in the process. Without appreciating that wholeness, it is impossible to understand the trickster...By the same token, the dialogic process explains, to some degree, how Vizenor can see the trickster as a liberator and healer. Engaging in language games, as trickster discourse does, the 'tribal trickster is atavistic, a revenant holotrope in new and recurrent narratives...The trickster does not die; he comes back to life again in new guises, new narratives. As such, the trickster can face the onslaught of the European invasion, and rather than 'vanish,' as seems to have been the hope of earlier Euroamericans, the trickster mutates into something even greater. Maintaining the role of culture hero in new stories and new roles, the trickster liberates the Anishinaabe from the oppression of colonialism and opens healing vistas of the imagination." (Gross, pp 393-94)

Gross states, however, that Vizenor does not provide a great deal of evidence on how "trickster discourse can aid in recovery" and offers to try to "fill in that gap" himself by considering what he terms "the comic vision of the Anishinaabe." He utilizes John Morreall's book *Comedy, Tragedy, and Religion* in this endeavor, citing Morreall as arguing "some religions are more tragic in nature and some more comic." He provides an explanation regarding comic vision and its ability to enable some groups of people to cope with negative events. Elements of cognitive psychology emerge as recognized features of the concept of comic vision, including "complex conceptual schemes, a high tolerance for disorder, seeking out of the unfamiliar, a high tolerance for ambiguity, divergent thinking (i.e., developing more than one

solution to a problem), critical thinking, emotional disengagement from problems, willingness to change one's mind, pragmatism, a second chance, an embracing of physical existence, and non-seriousness." (Gross, pp 393-94)

These concepts are important in illustrating how the comic vision held by many Native American Cultures relates to maintenance of mental health, particularly recovery from symptoms of PTSD. Gross argues that the two most important features of the comic vision in this regard are the ability to forgive and to allow a second chance. (Gross, p 394)

Gross adds that "since the features of the comic vision are drawn from cognitive and social psychology, it may be possible to research the strengths of these features and how they relate to healing and recovery for American Indians, including Vietnam veterans." As a starting point, it would be interesting to see to what degree different cultural groups maintain the attitudes of the comic vision and its corollary, the tragic vision...I would hypothesize American Indian Vietnam veterans with higher agreement levels with the features of the comic vision would be more likely to seek and successfully complete treatment compared to those individuals with lower agreement levels. Also, it could be helpful to examine American Indian Vietnam veterans who did not develop posttraumatic stress disorder to see to what degree the attitudes engendered by the comic vision, if any, helped them avoid falling victim to the disorder. If this would be the case, the results might contribute to the literature on positive psychology and point to the ways the comic vision as expressed through storytelling can help prevent posttraumatic stress disorder from developing in the first place, which certainly would be a boon for American Indian veterans of Iraq and Afghanistan. (Gross, pp 396-97)

Gross points out that Silver observes "there is much resistance on the part of non-Indian professionals to learn from Native healing practices" and goes on to quote that "if we can

remain aware of our tendency to close our ears to the words of Native American healers, there is much we might learn from them.” He also states that “Wilson, Silver, Scurfield, and the National Center for American Indian and Alaska Native Mental Health Research have all explored this topic from the point of view of mental health professionals, yet to my knowledge, no work has been done to examine how lessons drawn from American Indian experiences can be applied in mainstream society beyond the realm of psychological treatment, particularly in regard to religion.” (Gross, pp 400-01)

Gross then raises the question of how religious institutions are assisting combat veterans. Acknowledging that “it is not only American Indian soldiers who are making sacrifices for our country and suffering from the stress of combat,” he asserts that religious institutions in this country outside of American Indian societies do not have any rituals or other mechanisms for sending young people to war, reintegrating them back into society, honoring their contributions to our freedom, or making use of their experiences...” He proposes that “it would be well for American Indians to work with various non-Indian religious groups to develop rituals and other practices appropriate to the non-Indian traditions to help non-Indian veterans recover from posttraumatic stress disorder and to honor them for their service... Perhaps, as a simple starting point, leaders from non-Indian religious groups could be invited to observe events intended to help American Indian veterans, such as the powwows and sweats...” He suggests that a better approach might be that American Indians “take the lead on this subject” and emphasizes that “working with non-Indian religious groups in this regard is one of the most important tasks facing Native peoples.” (Gross, p 401)

Gross puts forth a very important idea when he asserts that “American Indian Vietnam veterans have enough history with healing to help point out, practically speaking, what has

helped them recover and what mistakes should be avoided...” This statement may encourage research into the history of humankind’s ancient cultures and how warriors were assisted, perceived and either reintegrated or excluded from their communities and societies. Once again, the important concept of social integration emerges when analyzing Traditional Native American beliefs and practices in regard to assisting warriors wounded both physically and psychologically. (Gross, p 373)

Gross also opines that in order to change the pervasive negative attitude that American Indian Cultures “...are nothing and so nothing can come from them...it would be good for Native people to make clear to non-Indians the truly sophisticated nature of American Indian cultures and how much they still have to offer to the world. Starting with helping veterans would be particularly beneficial. The task is before us and the time is now”. (Gross, p 401)

If we attempt to assess the affect of cultural norms on treatment of PTSD, we may be well advised to acknowledge Comer’s statement, “A society that values competition and assertiveness may accept aggressive behavior, whereas one that emphasizes cooperation and gentleness may consider aggressive behavior unacceptable and even abnormal.” This statement clarifies one of the very important cultural differences between how warriors, veterans, and sufferers of PTSD are perceived by today’s modern American society and how they are perceived by Native American cultures in general. (Comer, p 2)

Not only is it important to realize that many North American Indian cultures have maintained their traditional healing strategies after centuries of European colonial attempts to eradicate them, but it is also crucial to acknowledge that this fact strengthens the importance of these cultural healing methods and how they continue to evolve in respect to modern day warfare. With a sense of gratitude, we must realize our great advantage in that we have effective living

examples of ancient treatment models at work in America and attempt to find correlations between these ancient methods and current Western methods of treating PTSD, as well as what components of treatment may be missing, so that researchers, clinicians, and scholars may partake in an interdisciplinary endeavor to create an effective holistic treatment model.

Scholars from every perspective may be able to address and identify issues regarding PTSD by looking back into the history of mankind and civilization. By embracing a chronological system of analyses, we can observe how the field of psychology has evolved over time and even identify periods of stark dysfunction contrasted with periods of illumination in the practice of treating anxiety disorders. Comer asserts that “every society, past and present, has witnessed psychological abnormality.” We may safely assume that every society has experienced warfare, and by looking to historical records, literature, and oral histories, we may be able to glean information on how our ancient civilizations treated warriors returning home, with differing degrees of success. Comer points out, “Unfortunately, throughout history each period of enlightened thinking about psychological functioning has been followed by a period of backward thinking...It would hardly be accurate to say that we now live in a period of great enlightenment about or dependable treatment of mental disorders. In fact, surveys have found that 43 percent of respondents believe that people bring mental disorders on themselves and that 35 percent consider such disorders to be caused by sinful behavior.” At this point in history, it is necessary to address a general ignorance of the intricacies of the disorder of PTSD and to explore ways, not only to effectively manage the symptoms, but also to alleviate stigma associated with it. (Comer, pp 6, 13)

In examining Native American traditional healing methods, ancient literature, and cultural accounts, we may find examples of how communities in the past engaged in assisting their

warriors reintegrate into the group after trauma inducing battle. We can also find instances in which society ignored and even sanctioned those who displayed symptoms of PTSD. Poet Robert Bly tells us that ancient literature and oral history of the Nordic and Celtic Cultures reveal that these societies provided particular individuals who assisted warriors returning from war in processes of “cooling down” from the state of “berserk”, thus enabling reintegration to the community. Our society today, in general, is lacking in sufficient and integrated treatment models that serve the heart, mind, body, and spirit of soldiers with PTSD and other anxiety disorders. Bly starkly observes that in the United States today, “we let our warriors go berserk, and then simply discharge them out into the streets.” Montanans, it is up to us to determine the importance of assisting our veterans affected by Posttraumatic Stress Disorder in a timely manner. (Bly, p 154)

#### References:

- Bly, R. (1990). *Iron john: a book about men*. Cambridge, MA: Addison-Wesley Publishing Company, Inc.
- Combs, D. (2004). *The way of conflict: elemental wisdom for resolving disputes and transcending differences*. Novato, CA: New World Library.
- Comer, R.J. (2010). *Fundamentals of abnormal psychology: sixth edition*. New York, N.Y.: Worth.
- Gross, L.W. (2007). Assisting American Indian veterans of Iraq and Afghanistan cope with posttraumatic stress disorder: lessons from Vietnam veterans and the writings of Jim Northrup. *American Indian Quarterly*, 31(3), Inclusive: 373-409.
- Overbo, E.K. (2008). Trait aggression among veterans: an examination of personal trauma experiences, combat exposure, and posttraumatic stress disorder. *Dissertation from the California School of Professional Psychology, Fresno Campus*, Inclusive: vi-viii.
- Posttraumatic Stress Disorder. (2000). *DSM-IV-tr*. Retrieved November 02, 2010, from <http://www.mental-health-today.com/ptsd/dsm.htm>
- Savory, A. (1999). *Holistic management: a new framework for decision making*. Washington, D.C.: Island Press.
- U.S. Department of Veterans Affairs, National Mental Health Program Performance Monitoring System. (2006). *2006 report* Retrieved from <http://media.mcclatchydc.com/smedia/2007/12/28/16/444-20071228-VETERANS-MONTANA>

**Analysis of Non-Motorized Use  
In  
Grand Teton National Park  
2010**

by

Eric Hansen  
Student

Western Transportation Institute  
College of Engineering  
Montana State University

A report prepared for the  
McNair Scholars Program  
And  
Fulfillment of CE470 Requirements  
Faculty Advisor Patrick McGowen

March 24, 2011

**ABSTRACT**

*An analysis of user survey, user count, and automated counter data collected in Grand Teton National Park in summer 2010*

## **DISCLAIMER**

The findings, opinions, and conclusions in this report are those of the author and not necessarily those of the McNair Scholars program, Montana State University, the Western Transportation Institute, or Grand Teton National Park.

## **ACKNOWLEDGEMENTS**

Thanks to Patrick McGowen for guidance on this report and especially for the one cell table trick. Thanks also to Rebecca Gleason and to Tiffany Allen for the pictures.

## TABLE OF CONTENTS

1. Introduction.....	1
2. Methodology .....	1
2.1. Road Tube Data.....	1
2.2. Non-Motorized User Count.....	1
2.3. Non-Motorized User Survey .....	1
3. Literature Review.....	3
3.1. Facilities .....	3
3.1.1. Shared roadway.....	3
3.1.2. Signed shared roadway. ....	3
3.1.3. Bike lane. ....	4
3.1.4. Shared use path. ....	4
3.1.5. Trails .....	5
3.2. Bicycle Facilities in National Parks .....	5
3.3. Bicycle Counting Methods.....	7
3.3.1. Traditional methods .....	7
3.3.2. Other methods.....	8
3.4. Bicycle Surveys.....	9
4. Road Tube Data .....	10
5. Summary of Non-Motorized Traveler Count Data.....	23
5.1. Non-motorized Count and Direction.....	24
5.2. Mode of Travel.....	26
6. Summary of Non-Motorized User Survey Data .....	28
6.1. Origins and Destinations of Non-Motorized Travelers.....	29
6.2. Non-motorized travel primary facility and distance .....	36
6.3. Purpose of Trip and Effect on Wildlife Viewing .....	42
6.4. Perception of Safety, User Satisfaction, and Suggested Improvements. ....	44
6.5. Information Sources .....	49
6.6. User Demographics .....	52
7. Conclusions.....	55
8. Appendix.....	57
8.1. Non-Motorized User Count Form.....	57

Hansen, Eric

8.2. Non-Motorized User Survey Form. ....	57
9. References.....	63

**LIST OF TABLES**

Table 1: Weekly Road Tube Bicycle Count at Station TPR-1 Below Windy Hill..... 11  
Table 2: Weekly Road Tube Bicycle Count at Station TPR-2 Taggart Lake Trailhead..... 13  
Table 3: Weekly Road Tube Bicycle Count at Station TPR-3 South of Highlands ..... 15  
Table 4: Weekly Road Tube Bicycle Count at Station TPR-4 N. Timbered Islands..... 17  
Table 5: Weekly Road Tube Bicycle Count at Station TPR-5 S. Jenny Lake Jct. .... 19  
Table 6: Weekly Road Tube Bicycle Count at Station Tpr-7 N. South Jenny Lake Jct..... 21  
Table 7: Moose Post Office Count..... 25  
Table 8: Taggart Lake Count ..... 25  
Table 9: Jenny Lake Count ..... 25

## LIST OF FIGURES

Figure 1: Moose Post Office Survey Site .....	2
Figure 2: Speed Distribution at Station TPR-1 Below Windy Hill .....	12
Figure 3: Weekly Count at Station TPR-1 Below Windy Hill .....	12
Figure 4: Speed Distribution at Station TPR-2 Taggart Lake Trailhead .....	14
Figure 5: Weekly Count at Station TPR-2 Taggart Lake Trailhead .....	14
Figure 6: Speed Distribution at Station TPR-3 South of Highlands .....	16
Figure 7: Weekly Count at Station TPR-3 South of Highlands .....	16
Figure 8: Speed Distribution at Station Tpr-4 N. Timbered Islands .....	18
Figure 9: Weekly Count at Station TPR-4 N. Timbered Islands .....	18
Figure 10: Speed Distribution at Station TPR-5 S. Jenny Lake Jct. ....	20
Figure 11: Weekly Speed Count at Station TPR-5 S. Jenny Lake Jct. ....	20
Figure 12: Speed Distribution at station TPR-7 N. South Jenny Lake Jct. ....	22
Figure 13: Weekly Count at Station Tpr-7 N. South Jenny Lake Jct. ....	22
Figure 14: Locations of Count Stations With Pathway Counts .....	23
Figure 15: Mode Choice From User Count .....	26
Figure 16: Mode Choice From User Survey Responce .....	27
Figure 17: Many Travelers Entered the Park by Bicycle .....	29
Figure 18: Mode of Entrance Into the Park .....	30
Figure 19: Parking Location .....	31
Figure 20: Parking Satisfaction .....	32
Figure 21: Bicyclist Entrance .....	33
Figure 22: Bicyclist Residency .....	34
Figure 23: The Climbers Ranch Loan A Bike Fleet .....	35
Figure 24: Choice of Facility .....	36
Figure 25: Primary Facility of Non-Motorized Use .....	37
Figure 26: Distance Ridden by Bicycle .....	38
Figure 27: Distance Ridden by Locals .....	39
Figure 28: Distance Ridden by Non-Locals .....	40
Figure 29: Road Use in Previous 12 Months .....	41
Figure 30: Exercise in Grand Teton National Park .....	42
Figure 31: Effect on Wildlife Viewing .....	43

Hansen, Eric

Figure 32: Perception of Safety is Reflected in Who is Riding the Pathway .....	44
Figure 33: Perception of Safety .....	45
Figure 34: Visitor Satisfaction .....	46
Figure 35: Local Non-Motorized User Dissatisfaction.....	47
Figure 36: Non-Local Non-Motorized User Dissatisfaction .....	48
Figure 37: Pathway Information Sources .....	49
Figure 38: Park Information Source .....	50
Figure 39: Future Information Sources.....	51
Figure 40: Respondent Age .....	52
Figure 41: Respondent Gender .....	53
Figure 42: Respondent Residency .....	54

## 1. INTRODUCTION

In 2008, work was completed on the Grand Teton National Park Shared Use Pathway. 2009 was the first year the shared use pathway was open during an entire season. Non-motorized user data was collected from August 20 to 22, 2010 in Grand Teton National Park, the weekend that was chosen to reflect an August weekend data gathering period in 2007. The weather was fair with cool mornings and warm afternoons. Working in two person teams, researchers collected two days of data at each of three sites along the shared use pathway. These data were in the form of user surveys and hand counts of user numbers.

In 2007, researchers conducted a user survey and conducted hand counts of non-motorized traffic in several locations along Teton Park Road. A series of automated pneumatic tube counters has also been in place on Teton Park Road from 2007 to present.

This report will summarize the road tube data, discuss data manually collected in 2010, and compare that data with 2007.



## **2. METHODOLOGY**

### **2.1. Road Tube Data**

Automated counters (road tubes) are located at seven locations on Teton Park Road between the Moose Visitor Center and North Jenney Lake Junction. The road tube counters were made by MetroCount and installed in a classifier configuration (two tubes) which allows them to record speed, direction of travel, and vehicle class. A test of the performance of these counters in comparison to human observation conducted in 2008 showed that the road tube will routinely undercount the bicycle traffic on the road. A classic case of precision versus accuracy, the counter cannot be relied upon to give an accurate cyclist head count but may be relied upon to predictably under-record speed and direction of slower short wheelbase vehicles. If enough hand count observations were taken at each installation a correction factor could be determined for each unit allowing for a greater degree of count accuracy. This, however, is not necessary as there is enough automated data recorded to be of use for part of this analysis.

### **2.2. Non-Motorized User Count**

A researcher at the same location as the user survey station conducted a hand count of the non-motorized travelers in the Park. Two of the locations (Moose and Taggart) allowed for easy observation of both the road and the shared use pathway. This count recorded the mode (bike or foot), facility (road or path), and direction (north or south) of travel as well as observation time, and whether the user was adult or child. There were 1,404 non-motorized users counted in total, 98.4% of them were bicyclists and 1.6% were on foot. One person on skates entered the pathway from Jenny Lake and skated out 30 minutes later. There were no observations of scooters or skate boarders during the research period.

### **2.3. Non-Motorized User Survey**

A voluntary user survey was used to collect data from persons on the shared use path. The survey station consisted of a folding table and chairs set up in a well seen wide section of pathway with an informative sign mounted on a portable A-frame traffic sign located an appropriate distance up the path so as to allow for safe stopping distance. Volunteers were offered a snack as an enticement (Figure 1). A total of 180 surveys were completed during this period. This figure is 15.23% of the observed non-motorized travelers recorded during this time. 70 surveys were completed at the Jenny Lake Visitor Center, 61 were completed at the Taggart Lake Trailhead parking lot, and 49 were completed at the Moose Post Office parking lot. These figures are 38.88%, 33.88%, and 27.22% of the total respectively. The survey questions asked pathway users about the origins and destination of the non-motorized portion of their trips, as well as trip mileage, parking location, mode of Park entry, and purpose of trip (see Appendix A for example of form). Visitors were also asked to convey their opinions about wildlife viewing experience, non-motorized facility conditions, safety, and ideas for improvement.



**Figure 1: Moose Post Office Survey Site**

### 3. LITERATURE REVIEW

#### 3.1. Facilities

Bicycle Facilities can be divided into five categories:

- Trail. Shared roadway.
- Signed shared roadway.
- Bike lane.
- Shared use path (AASHTO 1999)

##### 3.1.1. Shared roadway.

Shared roadway is simply “the road”, any street or highway without bikeway designation and signage where bicycling is allowed is considered a shared roadway. A majority of the bicycle travel in the United States takes place on this type of facility and unless special consideration has been given to bicyclists’ needs by local authority, it can be expected that no bicycle friendly improvements have been made.

##### 3.1.2. Signed shared roadway.

Signed shared roadways are marked with bike route signs that include destination. This simple distinction implies advantage as a preferred bike route. The road is usually a common through route for bicycle use that connects to other bicycle facilities and has been improved with respect to lane width, drainage grate type, rumble strip placement, and pavement surface maintenance.

A signed shared roadway will usually:

- Have a smooth surface,
- Have utility covers that are installed flush,
- Be free of debris,
- Be equipped with bicycle safe drainage inlet grates,
- Have, at minimum, a 4 foot wide paved road shoulder,
- Have rumble strips that do not extend to the edge of the road shoulder.

### 3.1.3. Bike lane.

This is a lane dedicated to bicycle use that should have the following characteristics:

- One way and with the direction of traffic.
- Smooth, free from potholes, large cracks, or abrupt edges.
- Regularly swept.
- Free from drainage inlets and utility covers if possible.
- Graded to avoid water puddling.
- Delineated from the motor vehicle lane by a 6 inch wide solid white line.
- Marked with the words “bike lane” or by the bicycle symbol.
- A minimum of 5 feet wide.

### 3.1.4. Shared use path.

A shared use or multi use path is a multiple purpose right of way built to accommodate a variety of non-motorized users. Used for both recreation and transportation, these paths can be located in many different settings including, but not limited to, abandoned rail lines (rails to trails), utility rights-of-way (under the power lines), or in parks. A shared use path is generally separated from a roadway to avoid the safety issues that arise from having someone riding a bike on the wrong side of the road into oncoming traffic. This type of path is meant to augment, not replace, existing roadway bicycle facilities. A shared use path is engineered and built based upon certain criteria such as:

- Using a design speed that accommodates faster bicyclists.
- Where able, the radius of curvature of a horizontal curve is calculated so that it will enable a rider traveling at a higher speed to negotiate the turn while leaning at an angle between 15 and 20 degrees.
- Horizontal curve lateral clearances should be determined based on the sum of the stopping sight distances of opposing riders.
- Vertical curve crests are chosen to allow maximum stopping sight distance for a bicycle rider of an average height.
- It is desirable that grades be less than 5 percent to prevent excessive downhill rates of speed for all wheeled users and to minimize the effort required to climb on a bicycle or in a wheelchair.
- The pathway should be cross sloped and include features such as ditches and catch basins to ensure proper drainage and landscaped to control erosion.

In situations where the optimum design criteria cannot be met standard warning signs and pavement markings should be installed. In general, signs and pavement markings should be installed according to the guidelines presented in the Manual on Uniform Traffic Control Devices (AASHTO 1999).

### 3.1.5. Trails

It is important to make a distinction between a trail and a shared use path. A shared use path is a designated non-motorized use facility that has been built to meet certain required standards. A trail is a mostly unimproved recreational facility. Trail improvements are usually limited to erosion control measures such as waterbars or crude steps and trail clearing efforts like the removal of downed trees and the trimming of encroaching brush. A trail that has been purposefully built to provide access to some place will usually be maintained by a controlling authority. A non-purpose built trail is kept passable by its use and will quickly deteriorate and disappear if not traveled. There are many shared use pathways that are referred to locally as a “trail” and are named accordingly as the “*such and such* trail”. In cases like this it must be noted that the “trail” is actually a shared use path.

Multiple studies have concluded that the single largest contributing factor to the level of use of a bicycle facility is connectivity. The most heavily used pathways are those that connect to where people want to go. There must also be multiple connections between pathways, bike lanes, transit systems, neighborhoods, shopping areas, and recreational facilities if the pathway is to be used as a convenient alternative to driving.

## 3.2. Bicycle Facilities in National Parks

The National Park System covers more than 84 million acres and is comprised of 392 areas called “units.” The units include 122 historical parks or sites, 74 monuments, 58 national parks, 24 battlefields or military parks, 18 preserves, 18 recreation areas, 10 seashores, four parkways, four lakeshores, and two reserves. The NPS also helps administer dozens of affiliated sites, the National Register of Historic Places, National Heritage Areas, National Wild and Scenic Rivers, National Historic Landmarks, and National Trails. Each of these units has its own distinct topography and character. The settings of these units range from urban to mountainous wilderness. The most common bicycle facility available in the National Park System units is the shared use roadway. With few exceptions, wherever a car can be driven, a bike can be ridden. Because of concerns for visitors’ safety, riding a bike on the road is discouraged in most of the National Parks because the roads are narrow, lack shoulders, and have high traffic volume. NPS units located near population centers seem more likely to have shared use paths and/or bike lanes. Bicycles are not allowed on hiking trails in National Parks however, many National Parks have bicycle trails. These improved dirt trails are designated for bicycle use and range in length from .5 miles to over 20 miles. There are also old roads that are closed to motor vehicle use where bicycling is allowed as well as lesser used sections of open roads where bicycling is encouraged (NPS 2010).

According to the National Park Service official website, the following National Parks have a shared use pathway and/or a bicycle trail:

- Acadia: Has 45 miles of paved carriage roads that are closed to motor vehicles but open to non-motorize use.
- Canyonlands: Is world famous for its hundreds of miles of four wheel drive dirt roads that are open to mountain biking.
- Cuyahoga Valley: The Ohio and Erie Canal Towpath Trail is a hard packed gravel shared use pathway that follows the Ohio and Erie Canal.
- Death Valley: Has a short bicycle trial at the visitor center as well as over 700 miles of backcountry roads that are open to bicycles.
- Everglades: Permits bicycling on several trails as well as on two old roads that are closed to motor vehicles.
- Grand Canyon: Has completed the first 2.8 mile section of the Hermit Road Greenway Trail which is part of a proposed 70 mile shared use pathway system.
- Great Smokey Mountains: Has two short bicycle trails but also closes the 11 mile long Cades Cove loop road to motorized traffic two days a week in order to provide a safe alternative to the parks other roads for bicycle riders.
- Hawai'i Volcanoes: The biggest biking attraction in this park is the 20 mile summit to sea downhill ride on the Chain of Craters road. There are also some very challenging single track mountain bike trails of varying lengths to be ridden.
- Mammoth Caves: A 9 mile long gravel bike trail on the bed of the former Mammoth Cave Railroad was completed in 2007. This trail has many entry points to allow users to select a preferred ride length.
- Olympic: Has an 8.2 mile single track bike trail on the now abandoned Spruce Railroad rail line which follows the shoreline around the west side of Crescent Lake.
- Redwood: has many, longer, single track bike trails that connect to dirt roads to form several loops.
- Grand Teton: A newly completed shared use pathway parallels Teton park road for over 8 miles.
- Yellowstone: Has many shorter bike trails located around the park as well as service roads that are closed to motor vehicles but open to bicycles.

- Yosemite: Is considered to have the best shared use pathway system of any National Park. 12 miles of paved path are located on the valley floor and provide access to all the famous Yosemite Valley sights.
- Zion: Because the Zion Canyon Scenic Drive is closed to automobile traffic from April to October (they have bus service) biking the road has become popular during this time. The Pa'rus trail is a paved shared use pathway that starts at the end of the Zion Canyon Scenic Drive and continues to the Zion Canyon Junction with a round trip distance of 3.5 miles. It has been proposed that the Pa'rus trail be extended alongside the road to provide safe access year round for non-motorized users.

Many NPS units have one medium length trail and/or several short trails, in several other locations the only bicycle trail is a short section of shared use trail that was built primarily to allow access for people using wheelchairs in accordance with the Americans with Disabilities Act.

### **3.3. Bicycle Counting Methods**

The data that is used to effectively plan for the future needs of motorized traffic is also used to plan for the future needs of non-motorized traffic. And while automated detection technology is successfully being used to gather motorized traffic information in real time such as volume, speed, and user classification; attempts to gather the same information about bicycle and pedestrian traffic have brought to light the short comings of existing technologies. A basic count of users of a particular non-motorized use facility is useful information and is currently being provided in most situations by the traditional methods of hand counting, pneumatic tube counter, or inductive loop counter. Other automated counting devices that have been used to count motorized traffic have not been effectively applied to non-motorized traffic (Dharmaraju 2002). There are many different ways to count the number of bicycles passing a position over a period of time. Each method has advantages and disadvantages for any given location.

#### **3.3.1. Traditional methods**

The following methods of counting bicycles are the most common.

- Hand count: Although labor intensive, a hand count is the most accurate method. The accuracy of all other methods of counting bicycles and pedestrians is determined by comparison to the hand count. A hand count can also capture information that is of a more complex nature than can any other method. No automatic sensor can determine the age, gender, or behavioral characteristics of an individual. A trained observer can record this type of information at a glance.
- Pneumatic tube: A pneumatic tube counter works by recording pressure pulses that are the result of the tube being run over by a wheeled vehicle. This device cannot count pedestrians but can be used for counting bicycles in mixed traffic. Bicycle count accuracy is questionable in mixed traffic situations. Pneumatic tube counters are not accurate but can be useful in estimating bicycle use (Schnieder 2005). Random error can be reduced

by tallying counts in time intervals of no less than 24 hours. Systematic error can be corrected by multiplying the count total by an experimentally determined adjustment factor. A tube counter is able to achieve a higher degree of accuracy if the manufacturer recommended softer rubber tubes are used and the tube length is kept under 10 meters. Direction, speed, and time of travel can be recorded. It is important that the counter not be placed on a grade as bicycles moving at a speed less than 10 km/hr may not be counted. A pneumatic tube counter may not be the best choice for data collection efforts on a shared use trail as the tubes are a trip hazard to walkers, roller skaters, and skateboarders (MacBeth 2002).

- Inductive loop: In an inductive loop traffic sensor, a magnetic field is generated by passing an electric current through a loop of wire built into the road surface. A conductive (metal) object entering this magnetic field causes a change in the effective inductance of the ground loop that is sensed by the control electronics of the unit. This type of sensor has been proven reliable in demand actuated traffic signals and can, if properly configured and calibrated, be relied upon to count bicycles provided they are made of metal. A disadvantage of this system is its lack of portability (Goodridge 2010).

### 3.3.2. Other methods

The following bicycle counting methods are in different stages of use and development.

- Passive infrared: A passive infrared sensor measures the changes in radiation emitted in a field of view. This type of device can be small in size and easily hidden. Passive infrared cannot distinguish between pedestrians and bicyclists, cannot distinguish close groups from individuals, and will often fail to count bicycles traveling faster than 15 mph (Turner 2007).
- Active infrared: An active infrared detection system emits low and high level radiation from 2 separate sources and measures the amount of light reflected back to an optical detector. This type of system is capable of recording speed, and can differentiate between pedestrians and bicyclists. This technology was developed for automobile traffic and when used for bike/ped can have trouble recording some data depending on direction of travel (Turner 2007).
- Infrared laser: This technology uses an invisible infrared laser beamed across a trail and reflected to a light sensor to measure the passage of a pedestrian or bicycle. When the beam of light is broken by a bicycle rider or a pedestrian the interruption is read by the sensor and recorded. This device cannot distinguish between user types and cannot distinguish between individuals and people who are traveling side by side (Schnieder 2005).
- Video Imaging: Video image processing has been used in automobile detection and can be used for bicycle and pedestrian detection.

### **3.4. Bicycle Surveys**

A voluntary survey is the most direct way to gather information about bicycle use. There has been an ongoing effort to gather data on shared use pathways in metropolitan areas of the United States for many years. Some municipalities have funded studies in an effort to provide better infrastructure for bicycles and pedestrians. In other areas where local government has been reluctant to get involved, grassroots organizations have been taking advantage of standardized survey forms and training available for free on the internet in order to conduct trailside surveys.

Many organizations have proved successful in securing funding for bicycle facilities based on their data gathering efforts. The more common scenario is a combination of local government effort augmented by grassroots involvement. The team effort has resulted in the construction of shared use pathways or rails to trails conversions in many cities. Working together, local governments and private groups have converted 13,150 miles of abandoned rail lines to long-distance trails and have constructed thousands of miles of trails through parks and along waterfronts (STPP 2006).

A perspective on the various uses of bicycle and pedestrian data is helpful in assessing needs and opportunities (USDOT 2000). However, data for nationwide bicycle use on NPS and USFS land units is not readily available. Some units have bicycle information based on permits or entrance fees but in general there is no data available (Gleason 2008). There have been no bicycle surveys conducted in a National Park other than Grand Teton National Park.

The US Department of Transportation stated that data about usage, trip, and user characteristics are of most importance for analysis of non-motorized travel while at the same time being most unavailable. There exists a need for the standardized collection of, as well as a national database for bicycle and pedestrian data (USDOT 2000).

Non-motorized use data is analyzed to estimate future demand in the same way as motorized data. A mode choice analysis would be performed in which inter-zonal volumes measured in person-trips would be distributed among different modes of transportation. In an urban setting there are many modes: drive, carpool, bus, rail, bike, etc. In a National Park the available modes are limited. Choice of mode is influenced by many factors such as personal characteristics, purpose of journey, travel time, and comfort of mode type.

The most used mode choice analysis tool is called multinomial logit. This is a probability model used to estimate individual choice of mode. In this model a utility function is computed for each available choice of transportation based on favorable aspects such as convenience, cost, reliability, or comfort. The utility function (U) is a measure of attractiveness that describes the likelihood of an individual choosing one particular mode over another.

#### **4. ROAD TUBE DATA**

Three years of automated counter data was analyzed in order to develop a clearer picture of bicycle use on Teton Park Road. The road tubes were installed in pairs, this configuration allows the counter to classify the type, speed, and direction of vehicles that cross the tubes. The software has built in algorithms that can distinguish vehicle type by the distance between axles. Motorcycles are class F1 based on an axle (wheel) spacing of less than 140 cm.

The counters are not accurate with bicycle traffic. Each road tube unit will undercount bicycles by a factor specific to the unit and the installation location. One can assume this error is somewhat consistent per unit such that road tube data can provide an indication of the level of bicycle use on Teton Park Road.

Motorcycles ride faster than bicyclists and the distribution of each type is bell shaped. The class F1 counts during the summer of 2008 were graphed by speed for counter stations designated TPR (Teton Park Road) units 1-7 and a distinct two humped curve is the result. Counter station TPR-6 was omitted because it was in a 15 mph zone. The low spot between the two speed distributions has been used as the dividing line to distinguish bicycles from motorcycles. The ideal bicycle cutoff speed was found to be 25 mph at all locations. Further observation and statistical analysis could provide a more accurate estimation of bicycle and motorcycle speed. For this analysis the method described above is adequate for the purpose of providing general trends in bicycle use.

The counter data for 2007, 2008, and 2009 from counter stations TPR-1 through TPR-7 was analyzed using 25 mph as a separator between bicycles and motorcycles and the results are clear. Bicycle use on Teton Park Road has dropped dramatically since the construction of the shared use pathway (See figures 2-13 and Tables 1-6). Presumably, this drop in bicycle traffic on the road is actually a shift to the pathway. The bicycle traffic recorded by counter unit TPR-7 which is located above the northern terminus of the pathway did not show a reduction in traffic.

**Table 1: Weekly Road Tube Bicycle Count at Station TPR-1 Below Windy Hill**

STATION: TPR-1 Below Windy Hill BEGINNING THIRD WEEKEND IN MAY ENDING SECOND WEEKEND IN SEPTEMBER	WEEKLY COUNT	WEEKLY COUNT	WEEKLY COUNT
WEEK #	2007	2008	2009
1	70	30	18
2	69	54	5
3	33	46	6
4	112	34	9
5	131	100	7
6	147	123	13
7	156	96	10
8	164	81	8
9	118	87	8
10	109	82	5
11	70	96	13
12	78	98	5
13	113	62	6
14	78	72	10
15	66	58	7
16	84	27	5
17	52	38	2

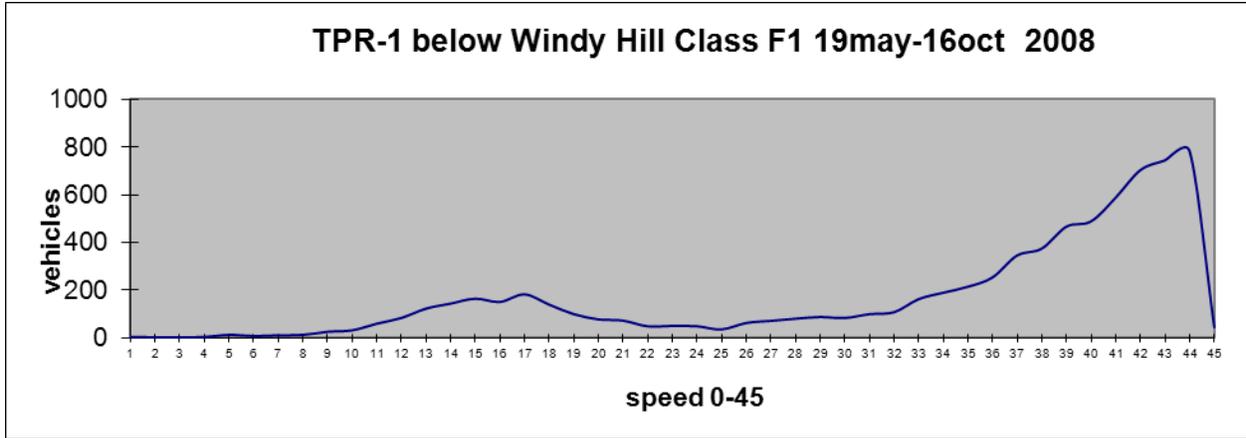


Figure 2: Speed Distribution at Station TPR-1 Below Windy Hill

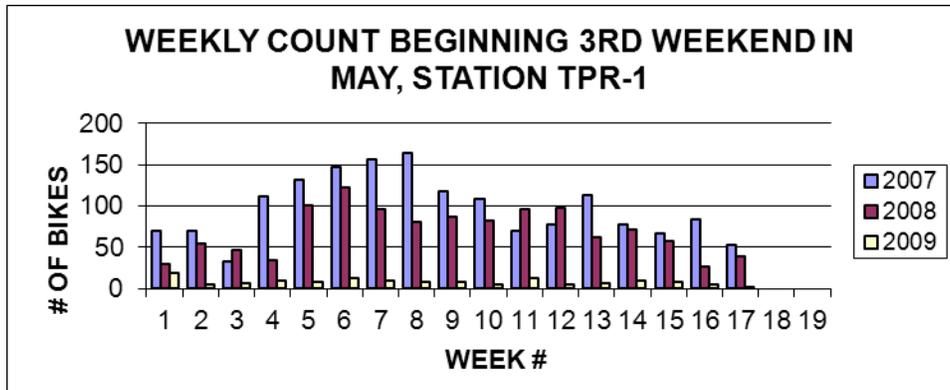
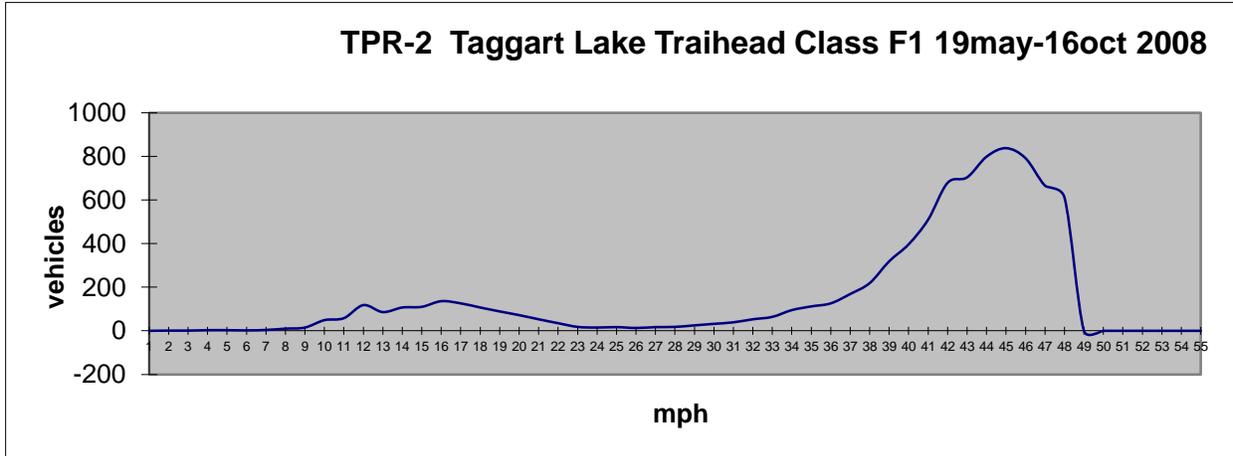


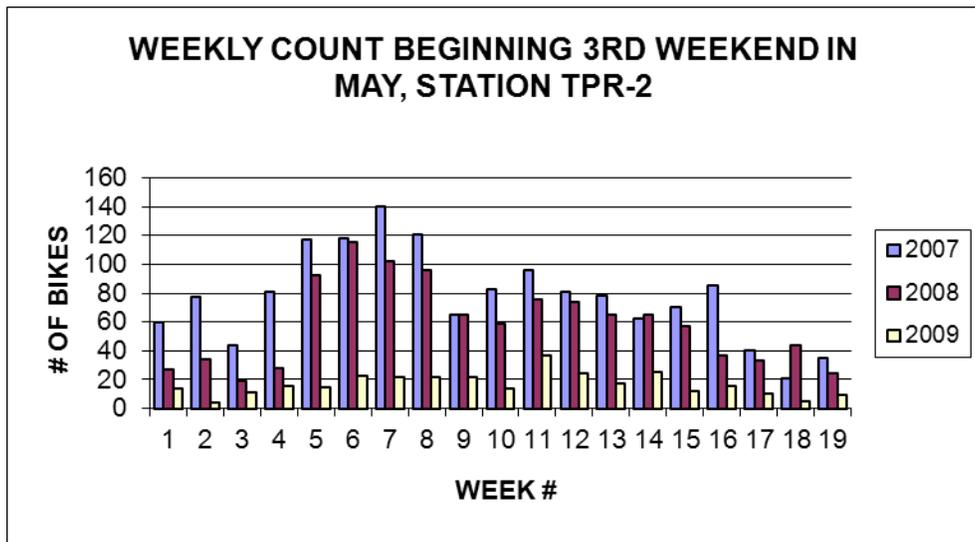
Figure 3: Weekly Count at Station TPR-1 Below Windy Hill

**Table 2: Weekly Road Tube Bicycle Count at Station TPR-2 Taggart Lake Trailhead**

STATION: TPR-2 Taggart Lake Trailhead BEGINNING THIRD WEEKEND IN MAY ENDING LAST WEEKEND IN SEPTEMBER	WEEKLY COUNT	WEEKLY COUNT	WEEKLY COUNT
WEEK #	2007	2008	2009
1	60	27	14
2	77	34	4
3	44	19	11
4	81	28	16
5	117	92	15
6	118	115	23
7	140	102	22
8	121	96	22
9	65	65	22
10	83	59	14
11	96	76	37
12	81	74	24
13	78	65	17
14	62	65	25
15	70	57	12
16	85	37	16
17	40	33	10
18	21	44	5
19	35	24	9



**Figure 4: Speed Distribution at Station TPR-2 Taggart Lake Trailhead**



**Figure 5: Weekly Count at Station TPR-2 Taggart Lake Trailhead**

**Table 3: Weekly Road Tube Bicycle Count at Station TPR-3 South of Highlands**

STATION: TPR-3 South of Highlands BEGINNING THIRD WEEKEND IN MAY ENDING LAST WEEKEND IN SEPTEMBER	WEEKLY COUNT	WEEKLY COUNT	WEEKLY COUNT
WEEK #	2007	2008	2009
1	56	17	7
2	78	31	6
3	48	54	5
4	86	30	4
5	135	85	14
6	127	93	6
7	167	92	9
8	126	84	5
9	83	74	5
10	81	65	8
11	89	75	12
12	65	73	10
13	71	66	10
14	51	72	13
15	79	56	13
16	80	35	8
17	44	35	2
18	21	58	2
19	34	31	5

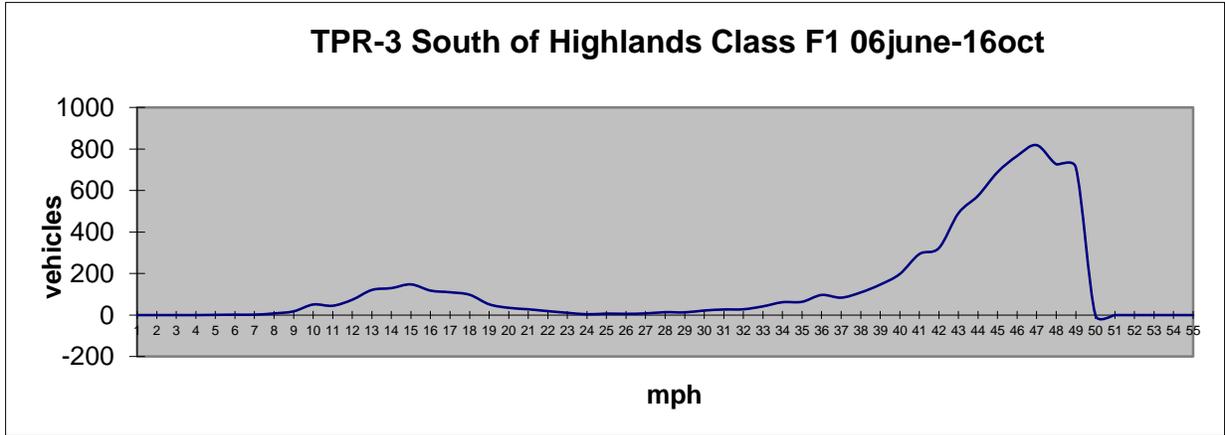


Figure 6: Speed Distribution at Station TPR-3 South of Highlands

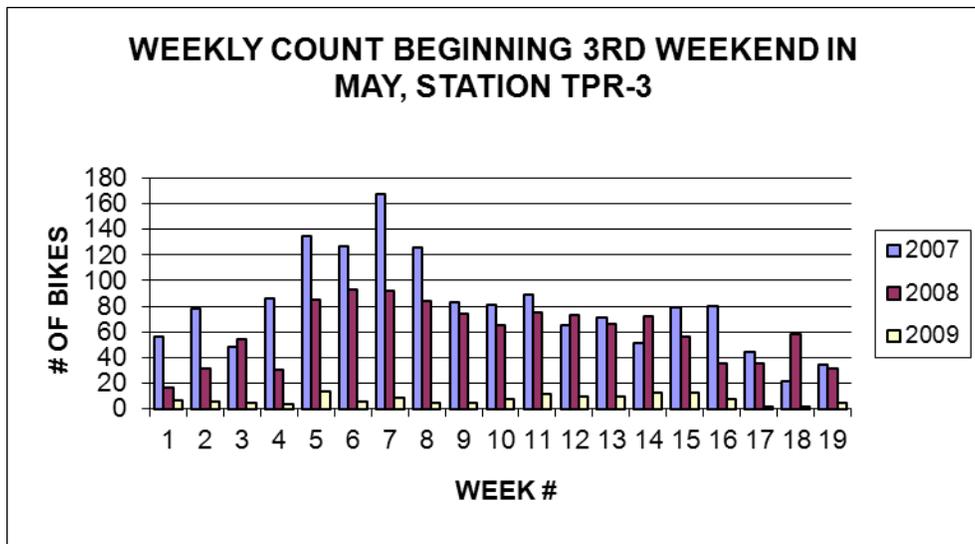


Figure 7: Weekly Count at Station TPR-3 South of Highlands

**Table 4: Weekly Road Tube Bicycle Count at Station TPR-4 N. Timbered Islands**

STATION: TPR-4 N. Timbered Islands BEGINNING THIRD WEEKEND IN MAY ENDING LAST WEEKEND IN SEPTEMBER	WEEKLY COUNT	WEEKLY COUNT	WEEKLY COUNT
WEEK #	2007	2008	2009
1	41	12	8
2	57	16	13
3	62	2	5
4	89	29	2
5	140	65	7
6	114	73	10
7	161	69	10
8	126	112	4
9	70	107	4
10	74	49	4
11	63	77	8
12	132	57	12
13	110	75	7
14	81	68	10
15	118	60	10
16	114	27	10
17	79	37	9
18	44	57	4
19	49	26	4

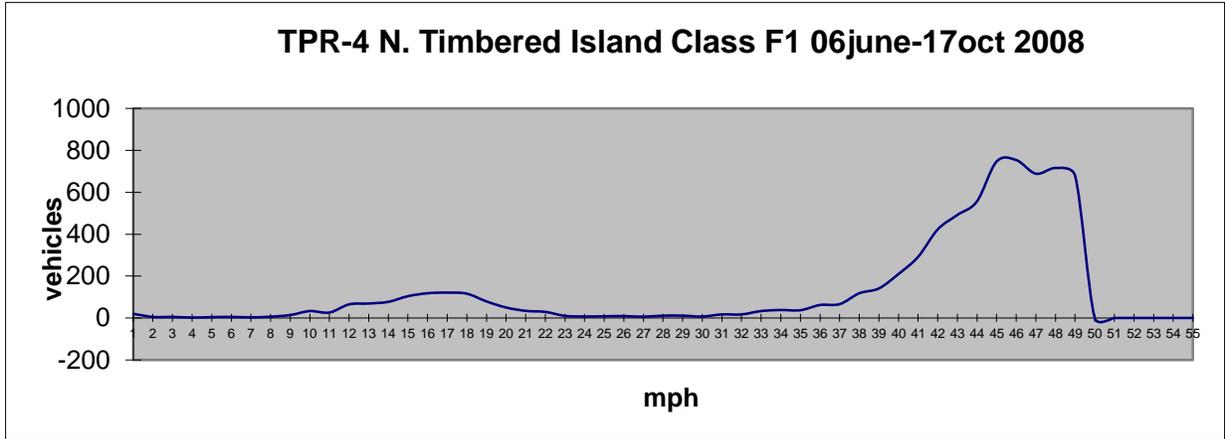


Figure 8: Speed Distribution at Station Tpr-4 N. Timbered Islands

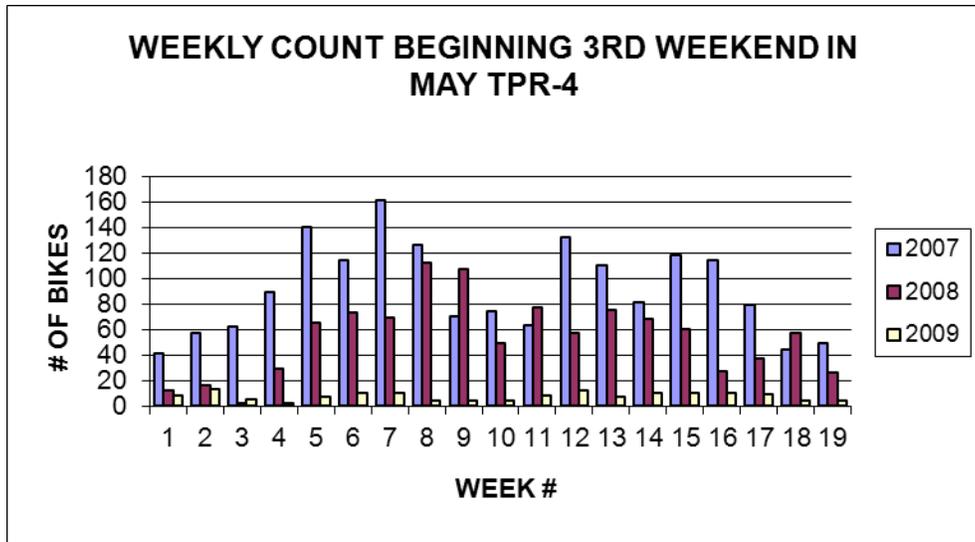


Figure 9: Weekly Count at Station TPR-4 N. Timbered Islands

**Table 5: Weekly Road Tube Bicycle Count at Station TPR-5 S. Jenny Lake Jct.**

STATION: TPR-5 S. Jenny Lake Jct. BEGINNING THIRD WEEKEND IN MAY ENDING LAST WEEKEND IN SEPTEMBER	WEEKLY COUNT	WEEKLY COUNT	WEEKLY COUNT
WEEK #	2007	2008	2009
1	33	12	9
2	54	29	15
3	60	45	13
4	73	29	11
5	111	65	16
6	93	73	32
7	135	27	22
8	94	91	20
9	57	107	20
10	63	57	22
11	75	77	32
12	54	57	35
13	61	75	7
14	44	68	0
15	58	48	7
16	72	28	22
17	37	37	9
18	35	57	19
19	25	26	17

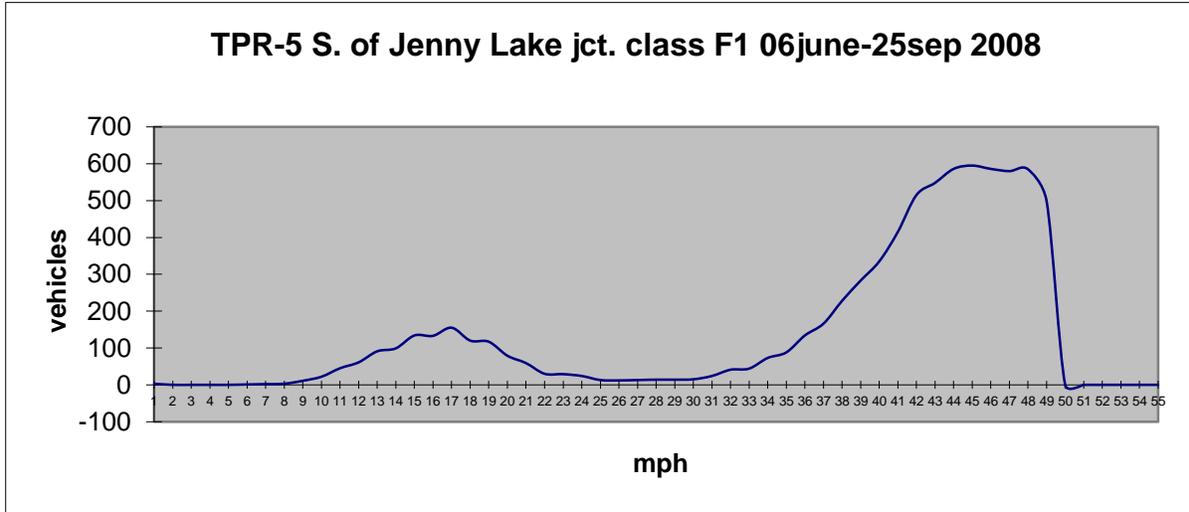


Figure 10: Speed Distribution at Station TPR-5 S. Jenny Lake Jct.

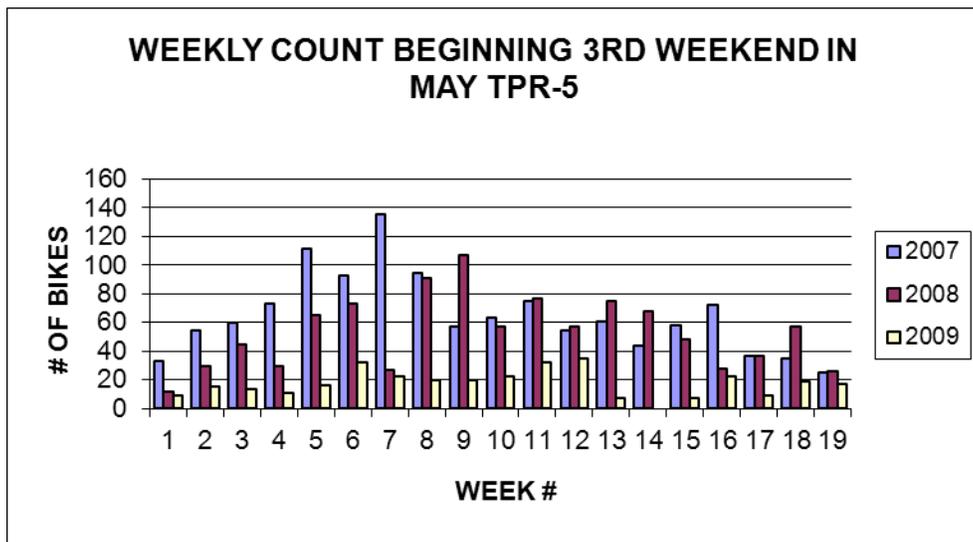


Figure 11: Weekly Speed Count at Station TPR-5 S. Jenny Lake Jct.

**Table 6: Weekly Road Tube Bicycle Count at Station Tpr-7 N. South Jenny Lake Jct.**

STATION TPR-7: N. South Jenny Lake Jct. BEGINNING THIRD WEEKEND IN MAY ENDING LAST WEEKEND IN SEPTEMBER	WEEKLY COUNT	WEEKLY COUNT	WEEKLY COUNT
WEEK #	2007	2008	2009
1	27	49	12
2	41	13	51
3	35	41	44
4	60	11	41
5	105	52	31
6	95	32	65
7	114	38	69
8	65	71	73
9	70	54	73
10	105	49	60
11	87	64	93
12	84	46	57
13	62	49	58
14	51	56	55
15	68	40	46
16	86	23	38
17	58	30	42
18	43	40	43
19			

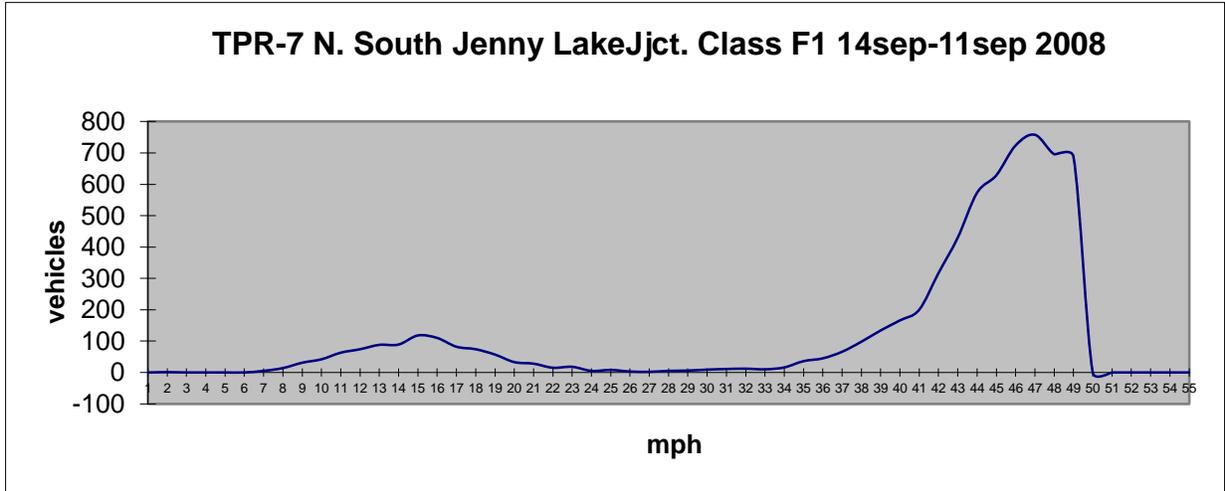


Figure 12: Speed Distribution at station TPR-7 N. South Jenny Lake Jct.

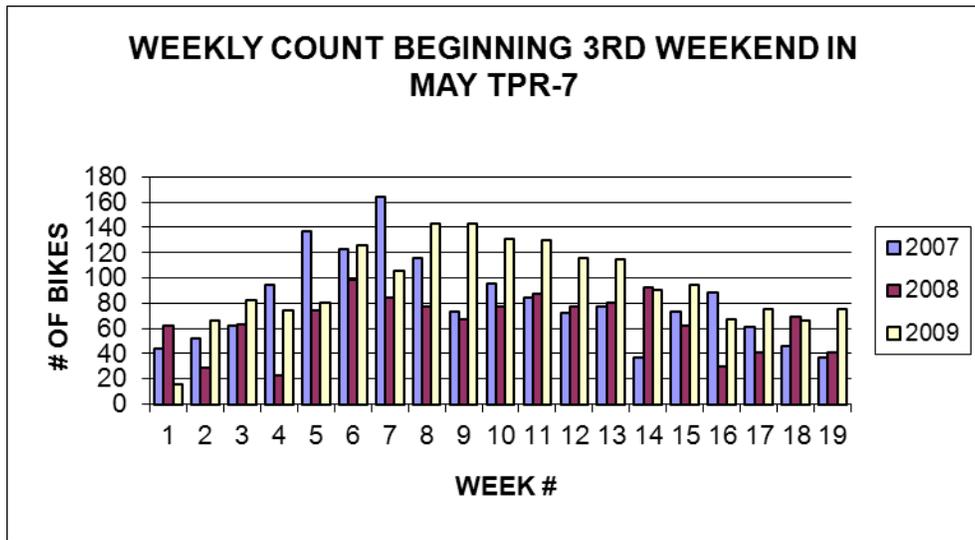
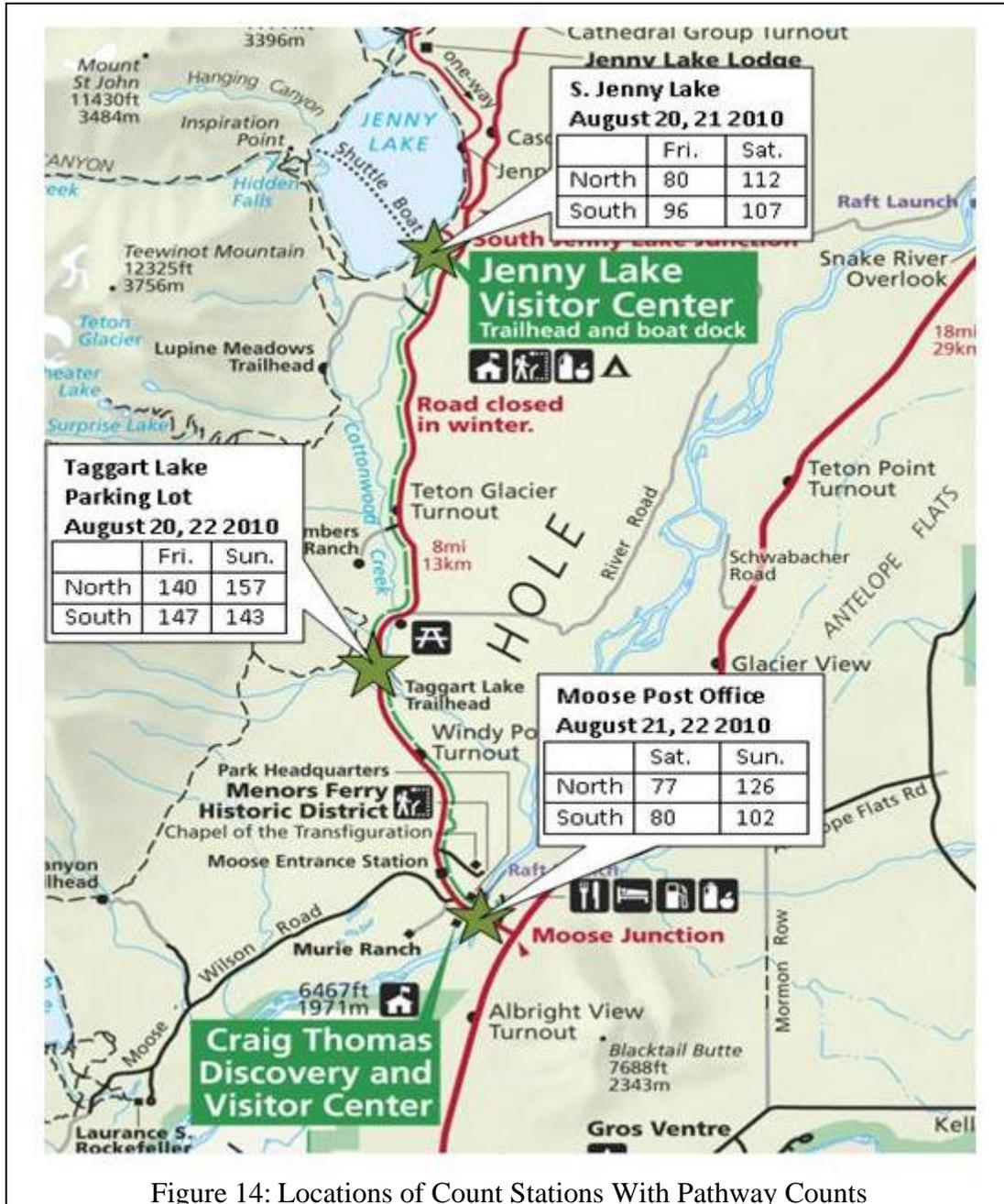


Figure 13: Weekly Count at Station Tpr-7 N. South Jenny Lake Jct.

## 5. SUMMARY OF NON-MOTORIZED TRAVELER COUNT DATA

This section is a summary and comparison of the non-motorized used count data collected at the Moose Post Office, the Taggart Lake Trailhead parking lot, and the Jenny lake visitor Center in on the 20<sup>th</sup>, 21<sup>st</sup>, and 22<sup>nd</sup> of August 2010 (Figure 14).



## **5.1. Non-motorized Count and Direction**

Data was not gathered at the Moose Post Office parking lot in 2007, however, it may be useful in the future to note that observed non-motorized traffic at Moose was 28.31% less than at Jenny Lake on Saturday and 24% less than at Taggart Lake on Sunday (Table 7). Non-motorized use was higher in 2010 at both Taggart Lake parking lot and Jenny Lake Visitor Center. Taggart Lake parking lot saw an overall increase of 91.99% in non-motorized traffic while Jenny Lake traffic was up by 83.54% (Tables 8 and 9).

Many riders made a round trip from one pathway terminus to the other and back so the number of individual users will be lower than the values presented in this part of the report as some individuals were counted a second time on the return trip. An educated guess based on researcher observation would put the real numbers at somewhere near 75% of the total count.

It is of interest that there were more bikes going south than north on the roadway. These were road bikers who had come in on Moose-Wilson road. Conversations with survey participants indicated that a number of riders will enter the area on Moose-Wilson Road from Teton Village, take advantage of the amenities at the Moose Visitor Center or at Dornans, and then continue north on the shared use pathway as part of a long loop ride that returns on highway 89 to Jackson. There is a difference between the riding habits and attitudes of serious road bike riders and those of mountain bikers or occasional pleasure cruise bikers. These differences become clearer as this analysis unfolds.

The ridership of the path included adults and children (no kids on the road) with many of the children in trailers or on tagalong peddlers. Several couples were on tandem road bikes outfitted for a long haul. This is why ridership count exceeds bicycle count in tables 1-3. In all, children made up 18.78% of total ridership. Many of these families took the survey and in conversation it was learned by the researchers that it was common to, after seeing the pathway from the car, stop at Dornans and rent bikes (and trailers and tagalongs) for the whole family and ride the pathway.

The user count collection form can be seen in appendix 8.1.

Moose Post Office	Friday 08/20/2010	Saturday 08/21/2010	Sunday 08/22/2010
North on Pathway	N/A	77	126
South on Pathway	N/A	80	102
North on Roadway	N/A	0	3
South on Roadway	N/A	0	10 (adult)

**Table 7: Moose Post Office Count**

Taggart Lake Parking Lot	Friday 08/20/2010	Saturday 08/21/2010	Sunday 08/22/2010
North on Pathway	140	N/A	157
South on Pathway	147	N/A	143
North on Roadway	1	N/A	0
South on Roadway	0	N/A	0
2007	Friday 08/24/2007	Saturday 08/25/2007	Sunday 08/26/2007
North on Roadway	8	15	17
South on Roadway	6	19	16

**Table 8: Taggart Lake Count**

Jenny Lake Visitor Center	Friday 08/20/2010	Saturday 08/21/2010	Sunday 08/22/2010
North on Pathway	80	112	N/A
South on Pathway	96	107	N/A
North on Roadway	0	0	N/A
South on Roadway	0	0	N/A
2007	Friday 08/24/2007	Saturday 08/25/2007	Sunday 08/26/2007
North on Roadway	12	22	14
South on Roadway	13	18	20

**Table 9: Jenny Lake Count**

## 5.2. Mode of Travel

Bicycling was the predominant mode of travel during the survey period. 98% of shared use pathway users were bicyclists, 1% were on foot, and 0.07% was one lone inline skater (see Figure 15). These figures are comparable to August 2007 where bicyclists accounted for 99% of non-motorized traffic. The results from question one of the survey (mode) showed that 93% of group respondents were riding bicycles. This figure is representative of 416 people making the bicycle the mode of choice by 96% (Figure 16).

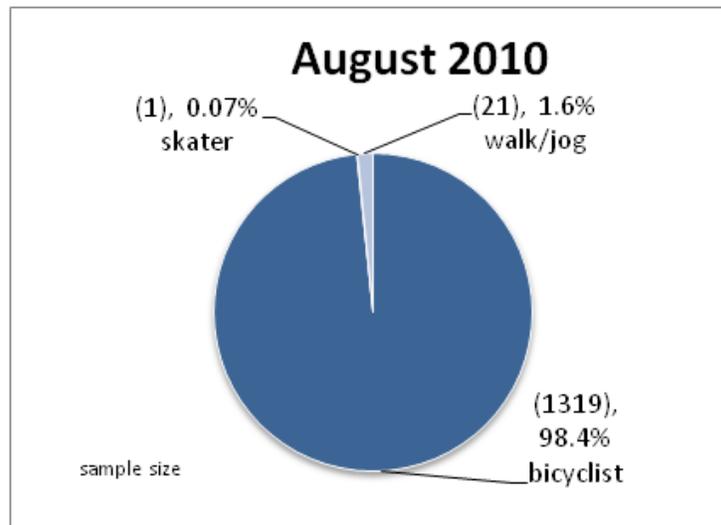
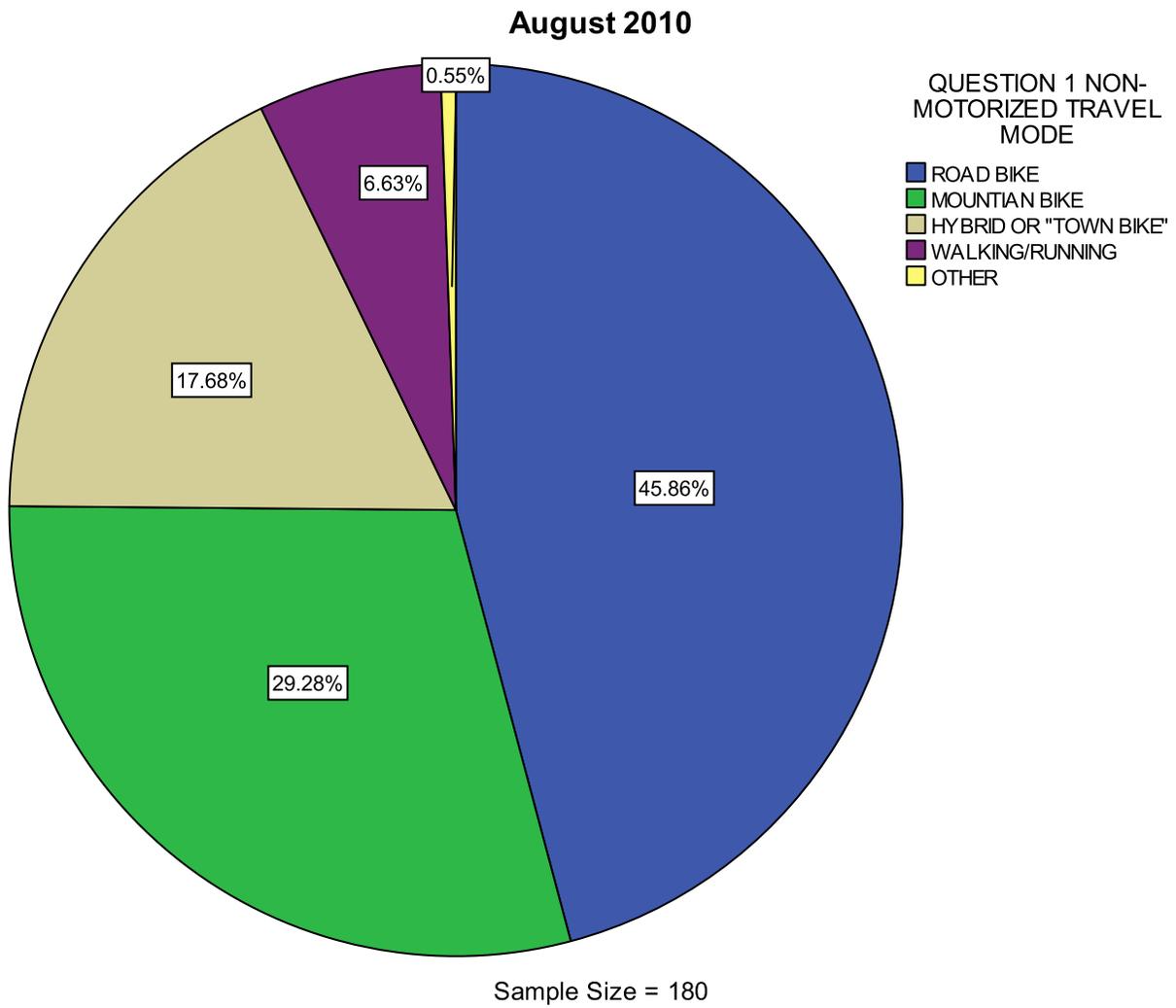


Figure 15: Mode Choice From User Count



**Figure 16: Mode Choice From User Survey Response**

## **6. SUMMARY OF NON-MOTORIZED TRAVELER SURVEY DATA**

This section is a summary of the survey data collected on the 20<sup>th</sup>, 21<sup>st</sup>, and 22<sup>nd</sup> of August, 2010. As stated in the *2007 Evaluation of Non-Motorized Use in Grand Teton National Park Phase I: Pre-Pathway*, the goals of the non-motorized user survey are the following:

Goal 1—Origins/destinations of current non-motorized users

Goal 2—Primary purpose of trip (exercise, commute, wildlife viewing, etc.)

Goal 3—Where non-motorized users are currently parking (if they have a vehicle)

Goal 4—Perceptions and attitudes about current non-motorized facilities/conditions in the park

Goal 5—What types of improvements non-motorized visitors would like to see in the park

Survey participants were limited to those over 18 years of age. Groups were asked to have the person with the next upcoming birthday complete the survey as group representative. A total of 180 surveys were completed. These 180 survey participants' are representative of 443 adult riders as indicated by the response values given for survey question number 15, group size. As indicated in figure 14 there were 1182 adult riders recorded in the hand count resulting in a response rate; 36% of pathway riders who stopped to be involved in the survey. This rate will be higher still if 25% of the pathway riders were counted twice as they rode round trip. In this case the representative response rate would rise to 48.84%. The non-motorized user survey form can be seen in appendix 8.2.

## 6.1. Origins and Destinations of Non-Motorized Travelers

Information regarding entrance to and non-motorized travel patterns within Grand Teton National Park are summarized in this section.

This data is from the following questions:

Q 2.1. What form of Transportation did you use to enter Grand Teton National Park?

Q2.2. On this visit, which entrance did you and your group first use to enter the park?

Q2.3. Where did you park your vehicle today?

Q2.4. What is the starting point, route, and destination for the non-motorized part of your trip today?

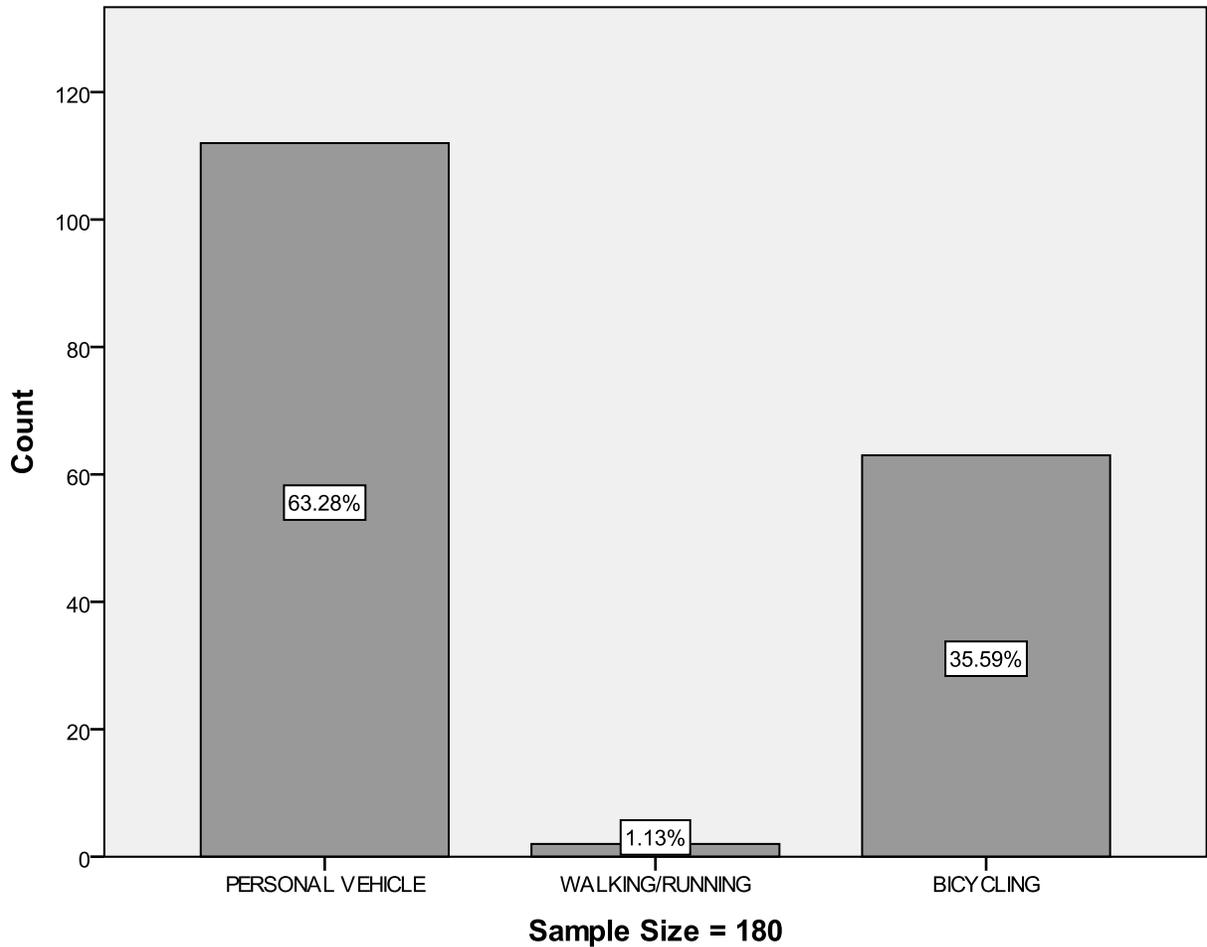
Q4. Were you satisfied with your parking location today?



**Figure 17: Many Travelers Entered the Park by Bicycle**

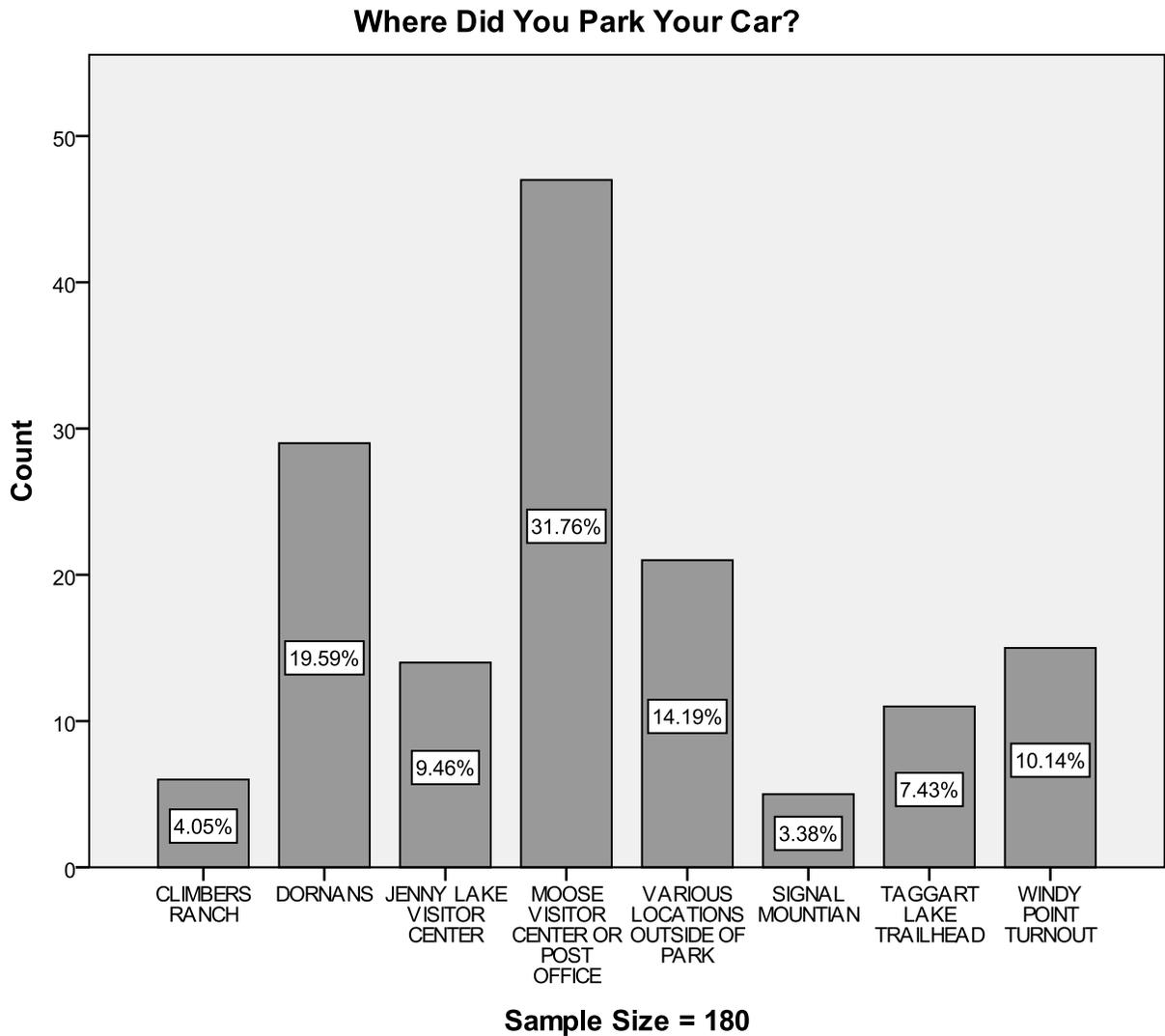
The majority of those surveyed entered the Park by automobile (Figure 18). Of the 63% of respondents that came by car, 55.56% first entered the park at the southern entrance and 51.35% of those also parked at the southern entrance. In 2007 63% entered by car 60% of whom came in through Moose.

**What Form of Transportation Did You Use to Enter Grand Teton National Park?**



**Figure 18: Mode of Entrance Into the Park**

61% of pathway riders are parking at the southern end of the pathway to begin their trip. A further 10.14% are parking at the Windy Point Turnout. Windy Point is the first parking area above the hill at the southern end of the park and it is possible that those wanting to avoid the climb but still wanting to ride the full length of the pathway are parking there. Smaller numbers of cyclists parked in various pullouts along Teton Park Road from Jackson Lake Overlook to the Taggart Lake parking lot (Figure 19). A majority of people were satisfied with their parking location (Figure 20).



**Figure 19: Parking Location**

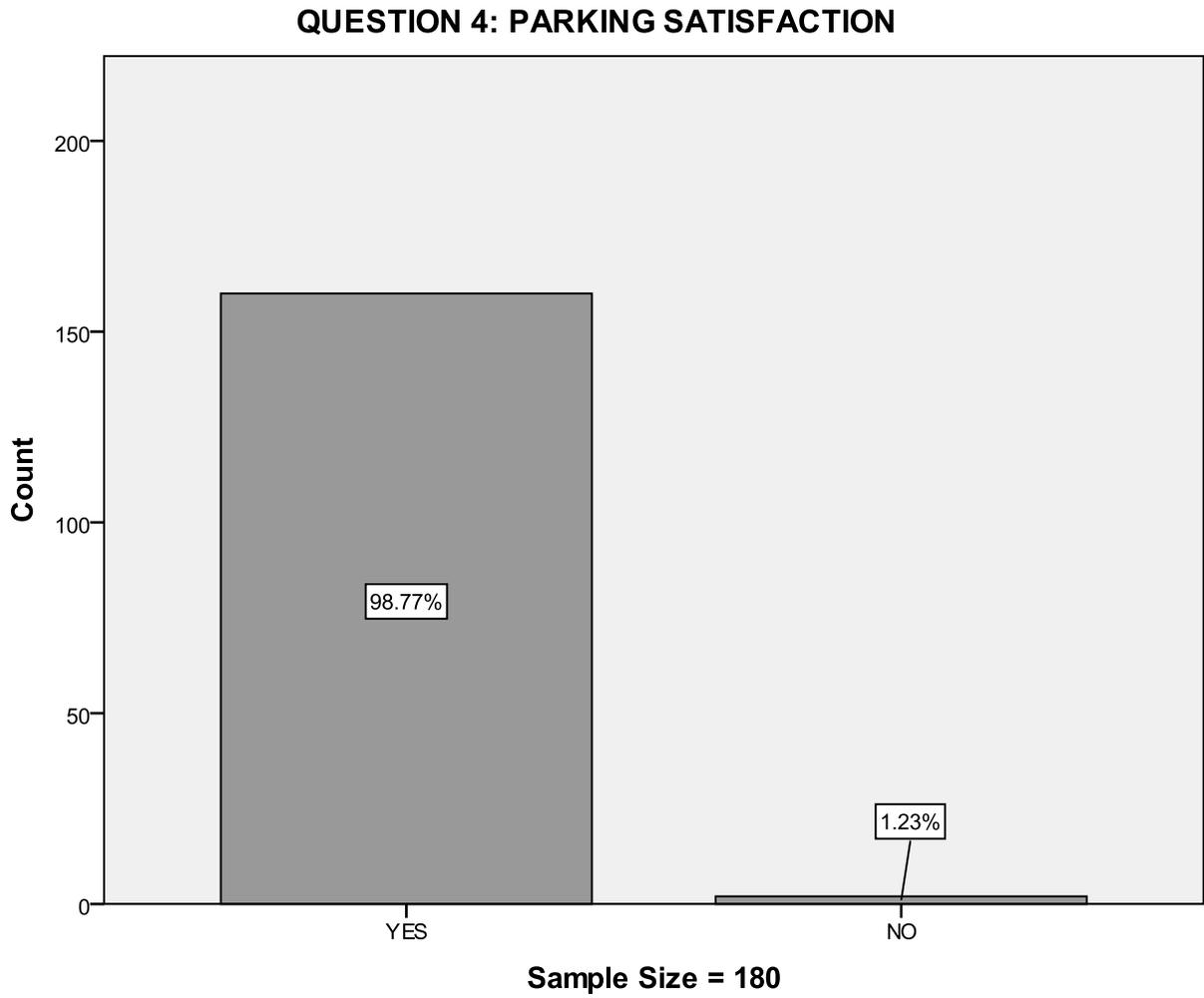
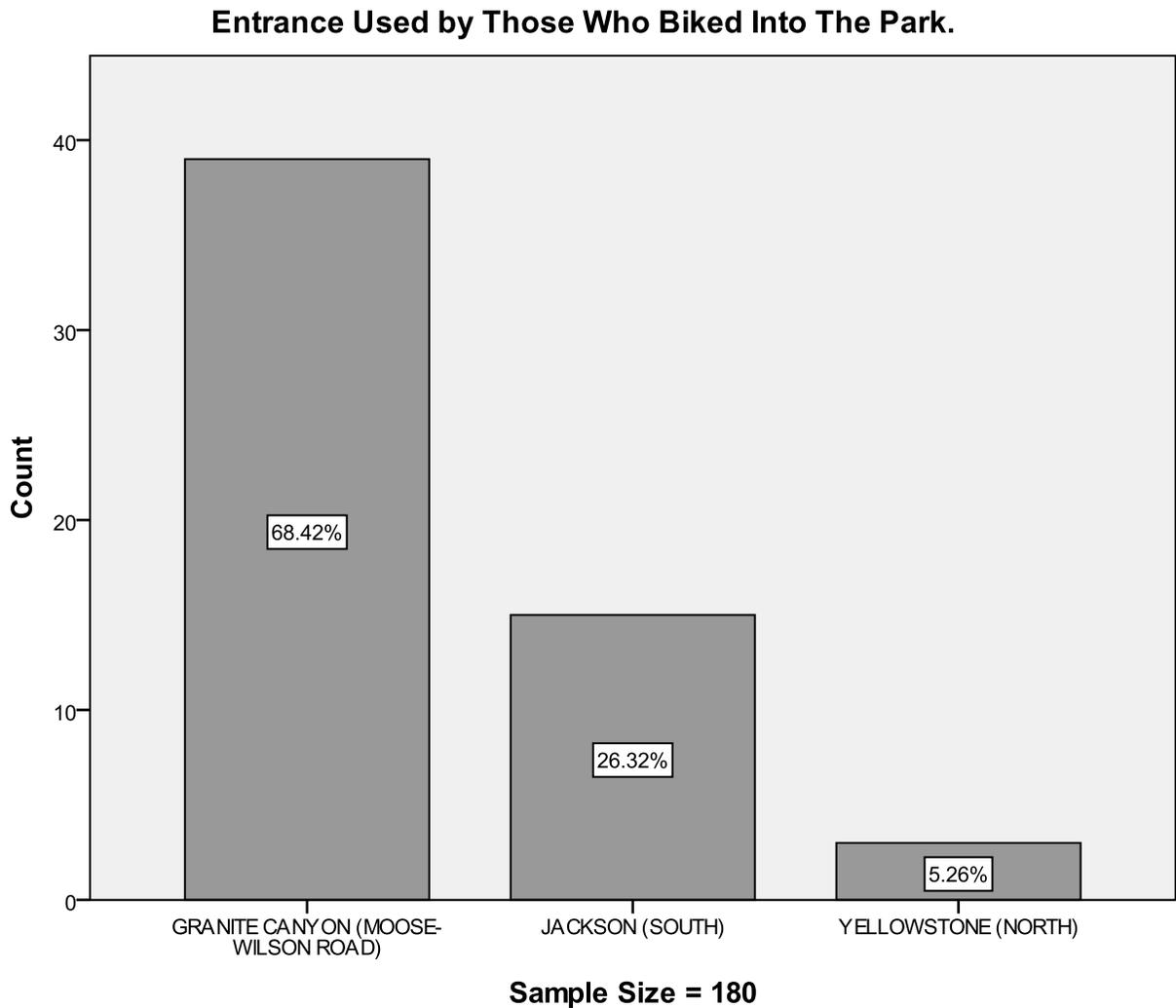
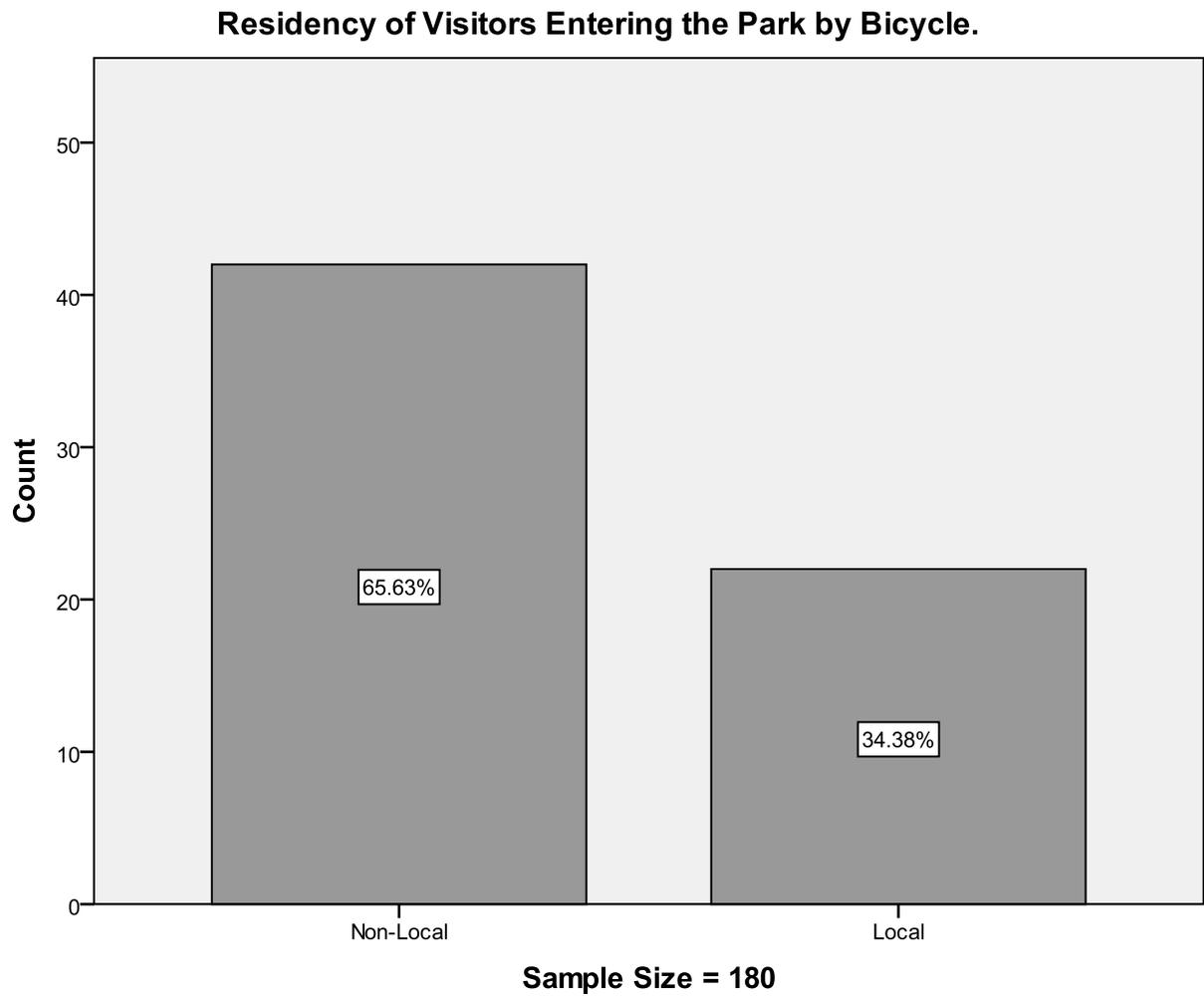


Figure 20: Parking Satisfaction



**Figure 21: Bicyclist Entrance**

Sixty-four respondents representative of 104 people entered the park by bicycle (Figure 21). This number is 32.2% of the total and is the same as in 2007. Of the people entering the park on a bicycle, 94.74% came through the Moose entrance. A majority of those bicycling into the park are non-locals riding in via Moose-Wilson road (Figure 22).



**Figure 22: Bicyclist Residency**



**Figure 23: The Climbers Ranch Loan A Bike Fleet**

The stated destination of 39.05% of respondents was the Jenny Lake vicinity, 27.81% were bound for Moose, and 33.14% were riding to one of over 20 various other locations both inside and outside the park. The round trip from one end of the pathway to the other and back was ridden by 48 respondents. In addition 41 rode one way from Moose to Jenny Lake, 6 rode one way from Jenny Lake to Moose. Some riders indicated that they were lodging at the Climbers Ranch and taking advantage of the loaner bike collection to ride to Dornans for supplies (Figure 23). The responses given for route information are varied and difficult to quantify.

## 6.2. Non-motorized travel primary facility and distance

This section summarizes the results of the following questions:

Q2.5. Which facility are you primarily using for your non-motorized travel today?

Q2.6. How far did you (or will you) travel today by non-motorized mode (bicycle, walk/run, roller blade, etc.) in and around Grand Teton National Park?

Q3. How many times in the last 12 months have you traveled by non-motorized modes on any portion of the road from Dornan's to South Jenny Lake?



Figure 24: Choice of Facility

The shared use pathway was the primary facility of choice for 83.8% of non-motorized travelers (Figure 25). The response “other” was chosen by mountain bikers who were riding Bar BC road. Of the respondents that listed roadway shoulder as primary facility, 100% also stated that they planned to or had already traveled greater than 15 miles in and around the park. Also, 100% of people riding less than 15 miles listed the shared use pathway as their primary facility of choice. It is 7.7 miles one way from one pathway terminus to the other, 15.4 miles round trip. The road is still being ridden by some road bikers on longer trips. Those who are riding a shorter distance somewhere between Moose and Jenny Lake prefer the pathway.

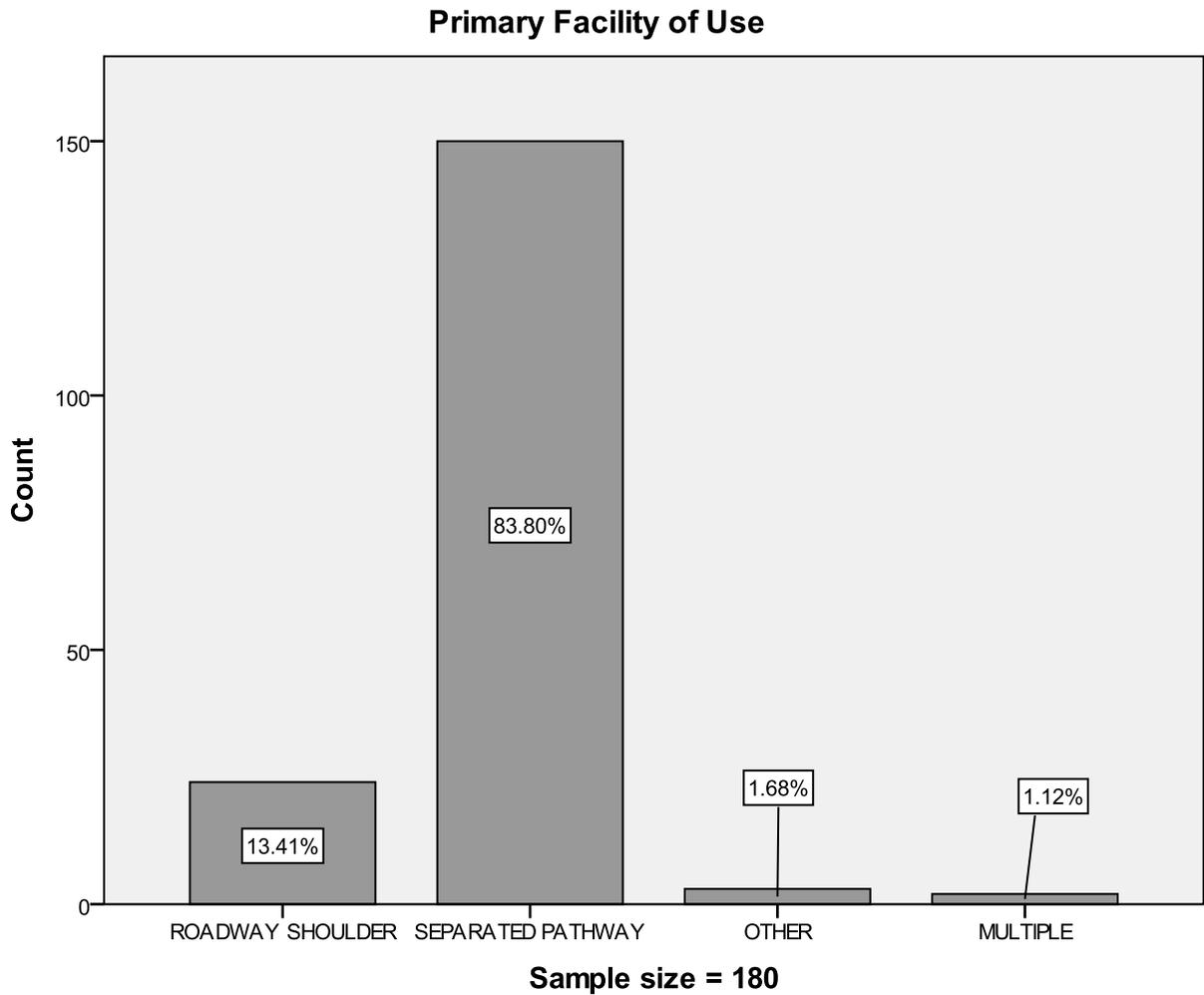


Figure 25: Primary Facility of Non-Motorized Use

Those cyclists who plan to ride to some destination serviced by the shared use pathway are all using the pathway as primary facility. There is further evidence to back this claim. No bicyclists were observed on the road by the Taggart Lake survey team. Some road bikers were seen at Moose. It is plausible that the more serious road biker will climb the grade at Windy Hill on the road to avoid slower riders on the pathway but are exiting the road at the Windy Hill Turnout or at the crossing before the Taggart Lake Trailhead and continuing north on the pathway all the way to Jenny Lake. 51% of cyclists' are riding farther than 15 miles (Figure 26).

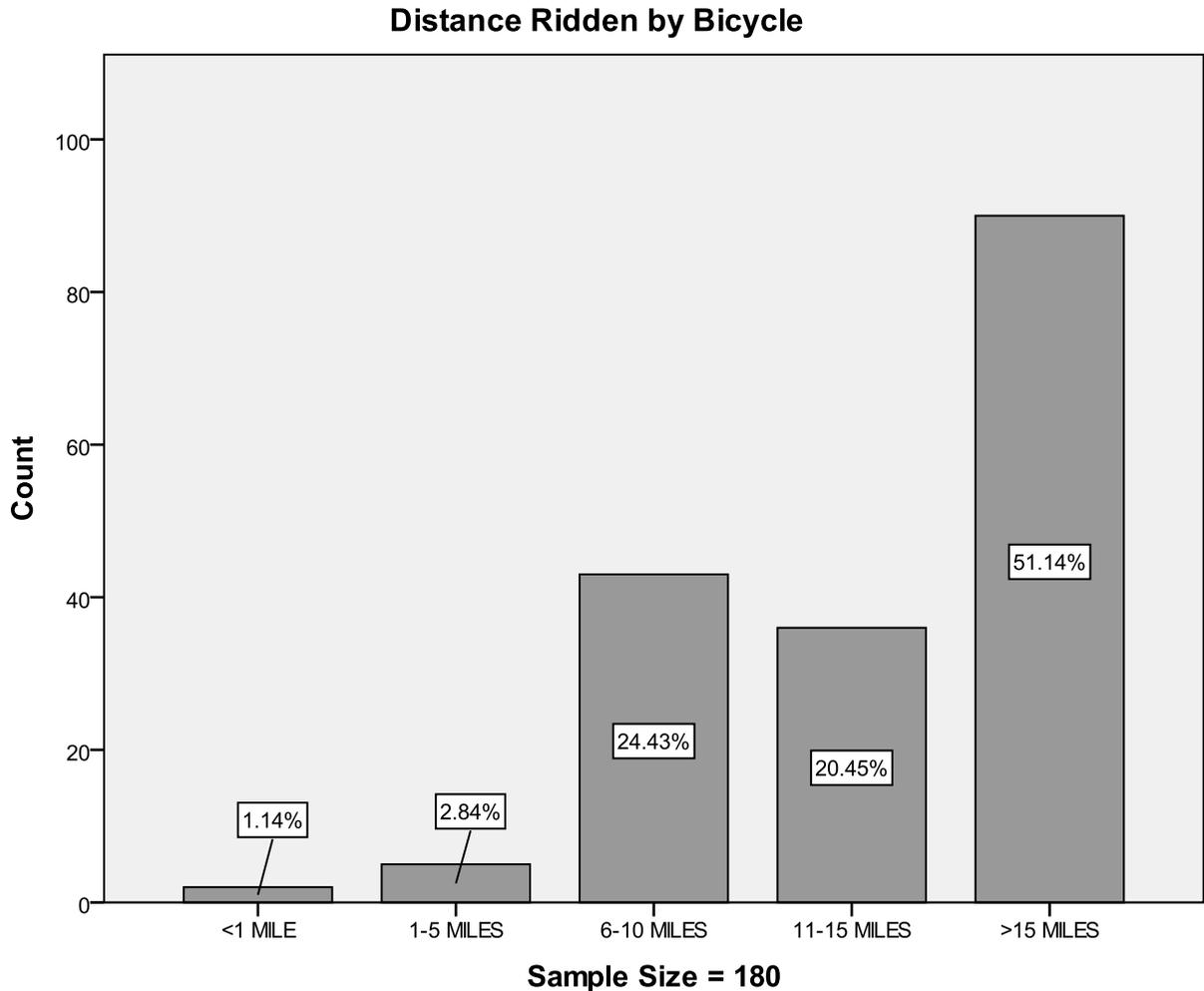
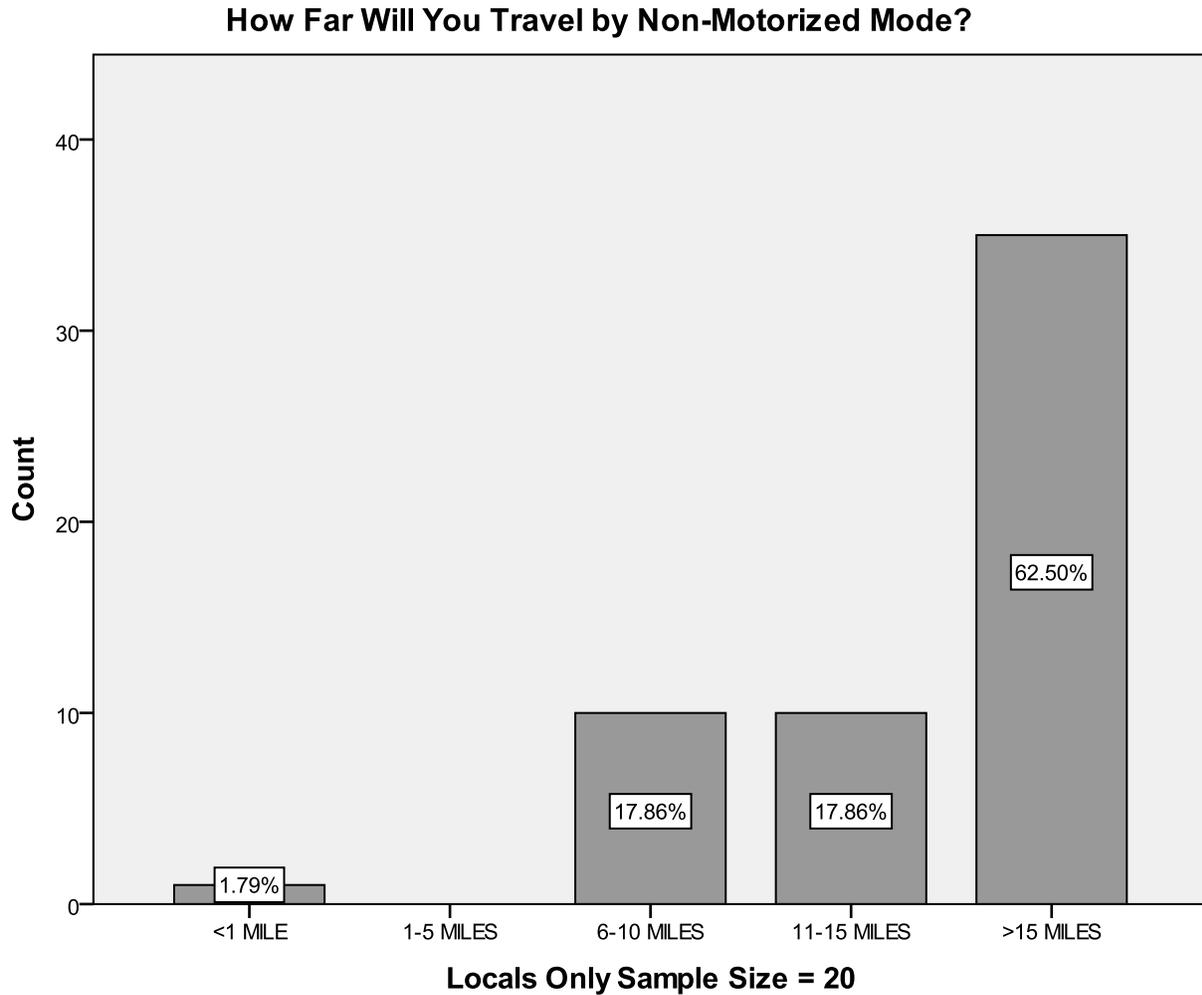


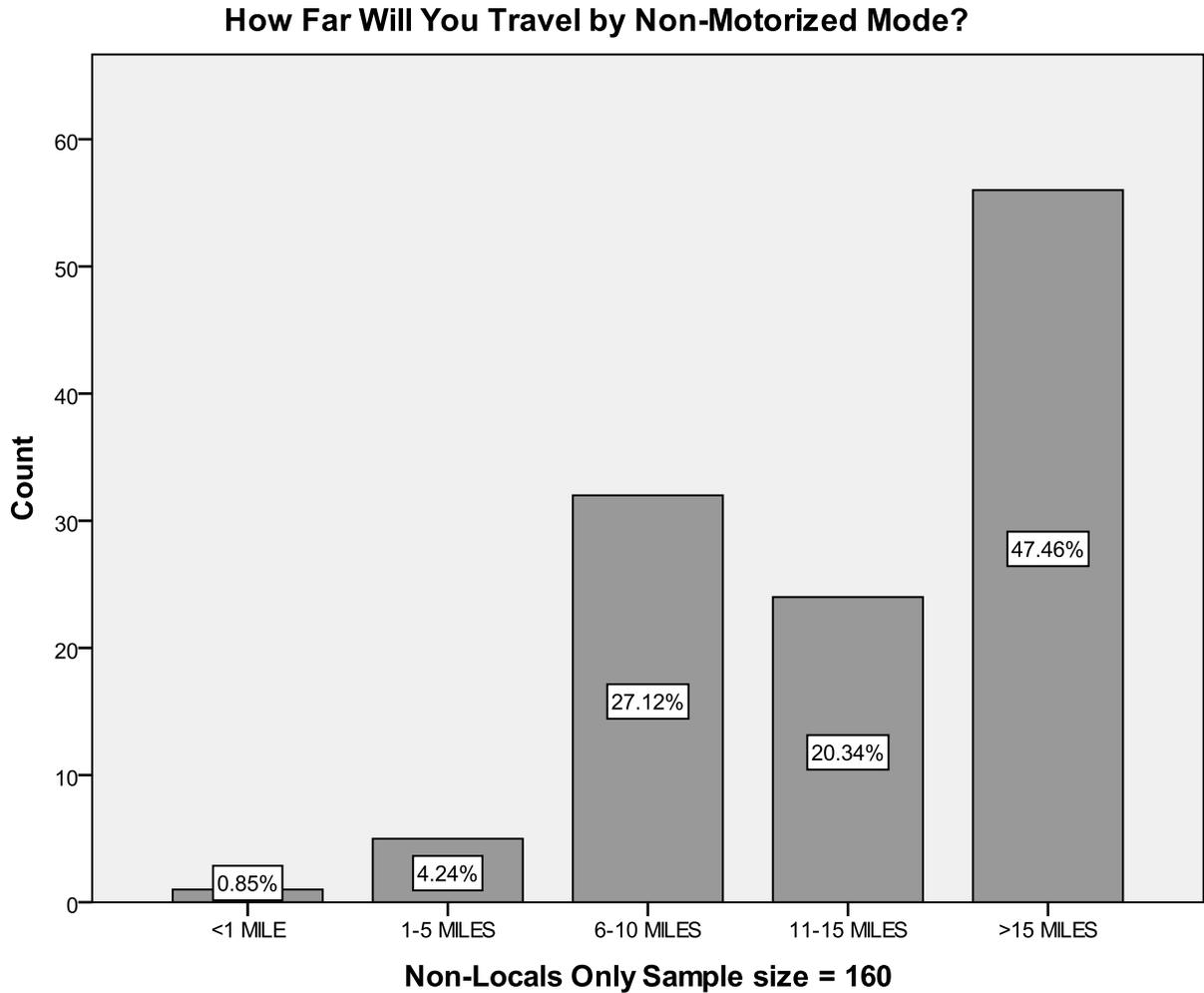
Figure 26: Distance Ridden by Bicycle

A majority of both local and non-local cyclists rode more than 15 miles (Figure 27-28). A popular route for the more serious road biker is to start at Moose or Taggart Lake and ride to Signal Mountain and back. A greater percentage of non-local riders rode one way from Moose to Jenny or vice versa while equal numbers of locals rode one way and round trip on the pathway.



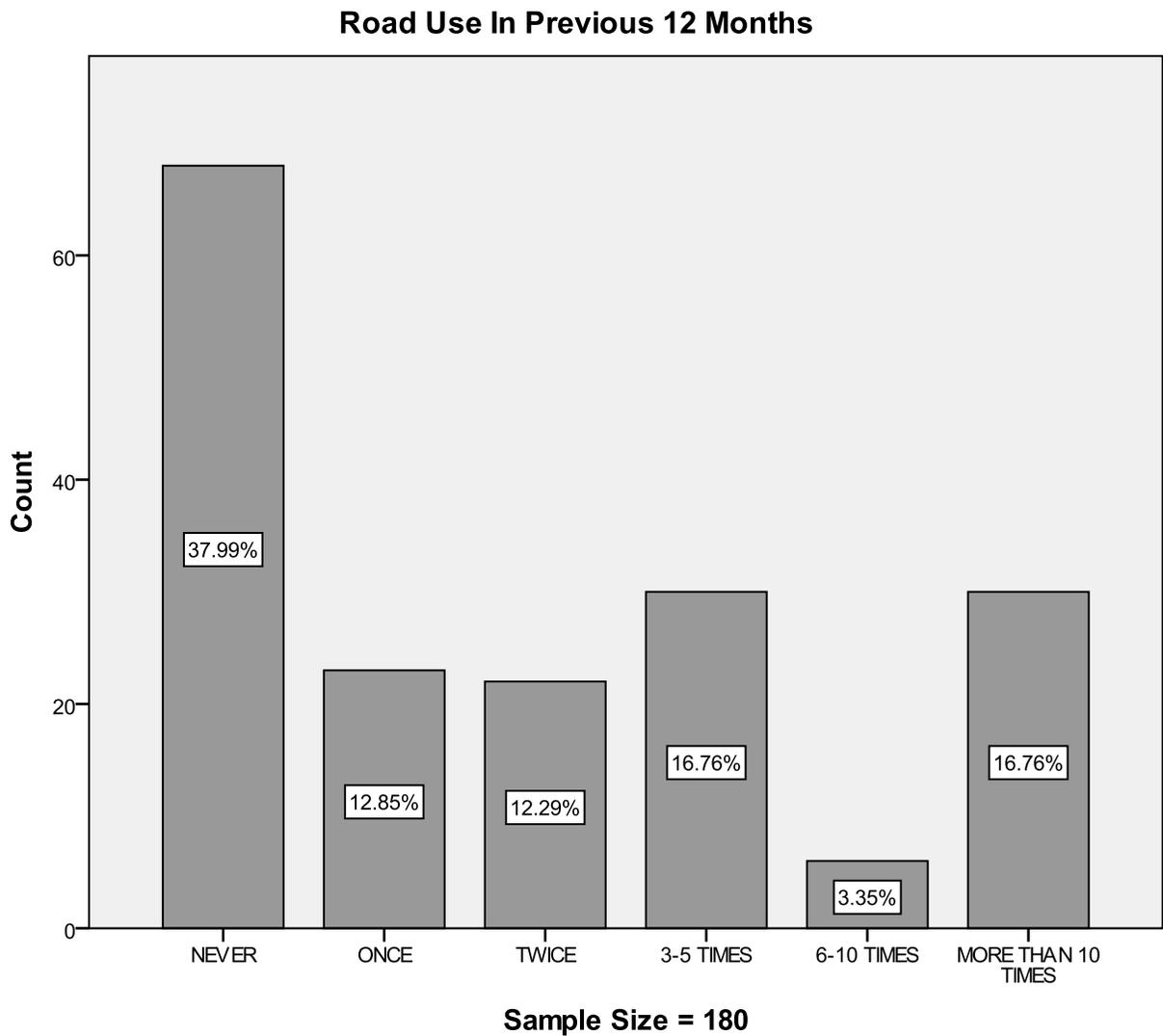
**Figure 27: Distance Ridden by Locals**

There were a greater percentage of non-locals riding between 6 to 15 miles (Figure 28). This may reflect a higher number of people choosing to tour the Moose to Jenny Lake section of the Park by bicycle.



**Figure 28: Distance Ridden by Non-Locals**

Even though no cyclists were seen on the road above Moose during this observation period, 60.01% of those surveyed said that they had ridden on the road between Dorman's and Jenny Lake at least once in the previous 12 months (Figure 29). This may indicate that some riders will chose the road over the pathway on weekdays or shoulder season weekends when motorized traffic is lower in the park. It may also indicate that some riders will choose the road if the pathway is busy on high use weekends. Further observations would be needed to establish a connection between road use and traffic pressure. Of those who said they had never ridden on the road 7.46% were local. Of those who stated that they had ridden on the road more than 10 times 70.37% were local. It may be the case that local riders who cycle the park regularly will ride on the road midweek when automobile traffic is lower.



**Figure 29: Road Use in Previous 12 Months**

### 6.3. Purpose of Trip and Effect on Wildlife Viewing

This section summarizes the responses to the following survey questions:

Q5. What is the purpose of your trip to Grand Teton National Park today?

Q6. Describe what effect, if any, the multi use pathway had on your wildlife viewing experience in Grand Teton National Park.

The purpose of trip is difficult to quantify because of the possibility of multiple response, 65.78% of the surveys had multiple responses. The most common responses were exercise, spend time with family and friends, and view scenery. A majority of people indicated that they were in the park to do anything but work. Summing all the responses shows that exercise was selected more than any other choice (Figure 30).



Figure 30: Exercise in Grand Teton National Park

The effect the pathway had on wildlife viewing was a question that was also difficult to quantify. The responses were varied as it was a write in. The responses were paraphrased into four categories:

1. Improved the experience.
2. Little effect.
3. No effect.

Most people felt that their wildlife viewing was improved as a result of the shared use pathway (Figure 31).

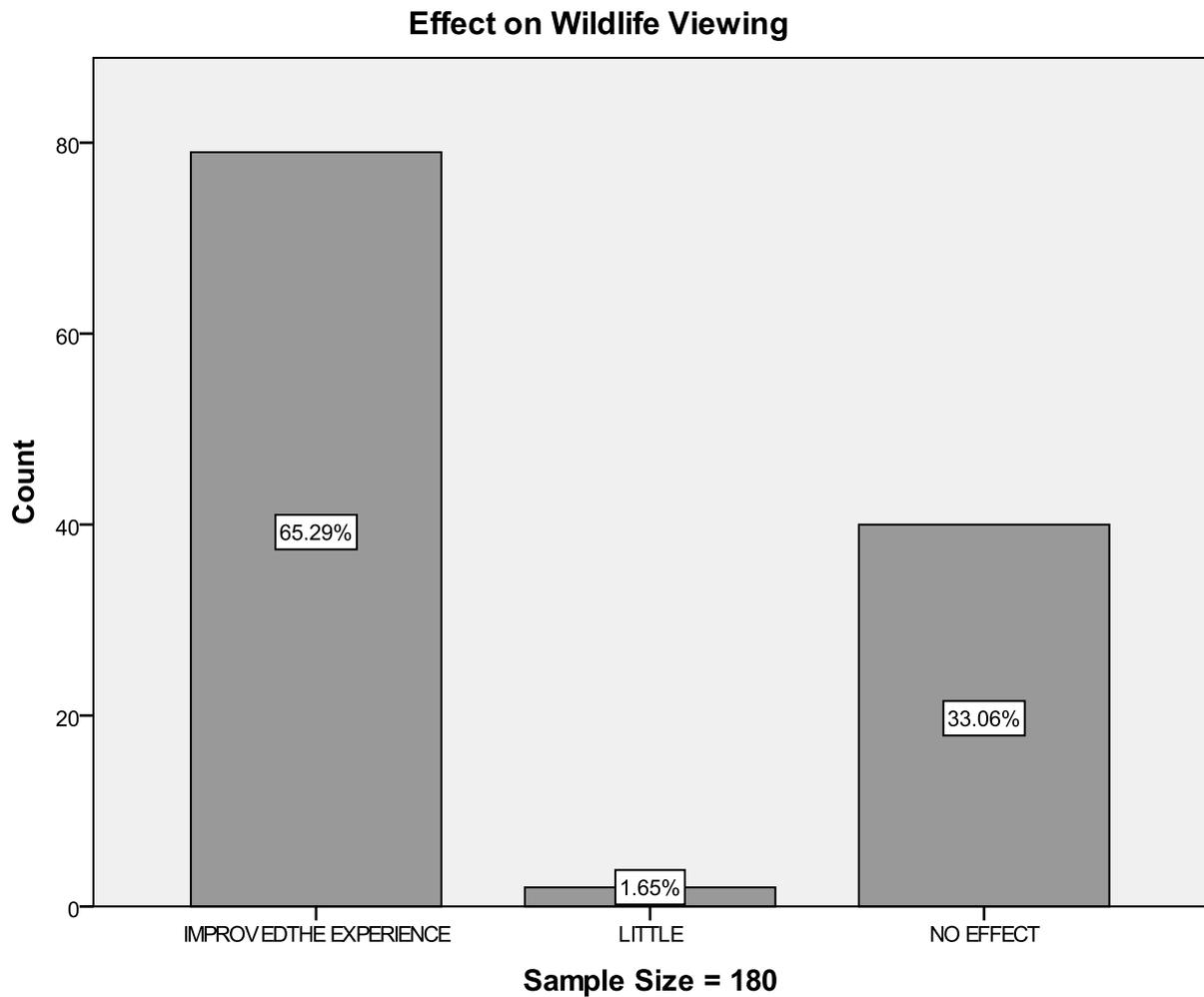


Figure 31: Effect on Wildlife Viewing

#### **6.4. Perception of Safety, User Satisfaction, and Suggested Improvements.**

This section summarizes the following questions:

Q7. How safe did you feel traveling by non-motorized mode today in Grand Teton National Park?

Q8. Are you satisfied with current non-motorized transportation conditions in Grand Teton National Park?

Q9. What non-motorized facility improvements would you like to see in Grand Teton National Park in the future?

People felt very safe on the pathway (Figure 32, 33). The percentage of those who felt very safe rose from 22% in 2007 to 81.46% in 2010. The percentage of those who felt unsafe at all fell from 21% in 2007 to 1.69% in 2010. No one responded very unsafe in 2010 whereas 9% of travelers felt very unsafe in 2007. The respondents who indicated they felt somewhat unsafe (3 of them) were road bikers who had ridden greater than 15 miles and spent a portion of their trip riding on Teton Park Road.



**Figure 32: Perception of Safety is Reflected in Who is Riding the Pathway**

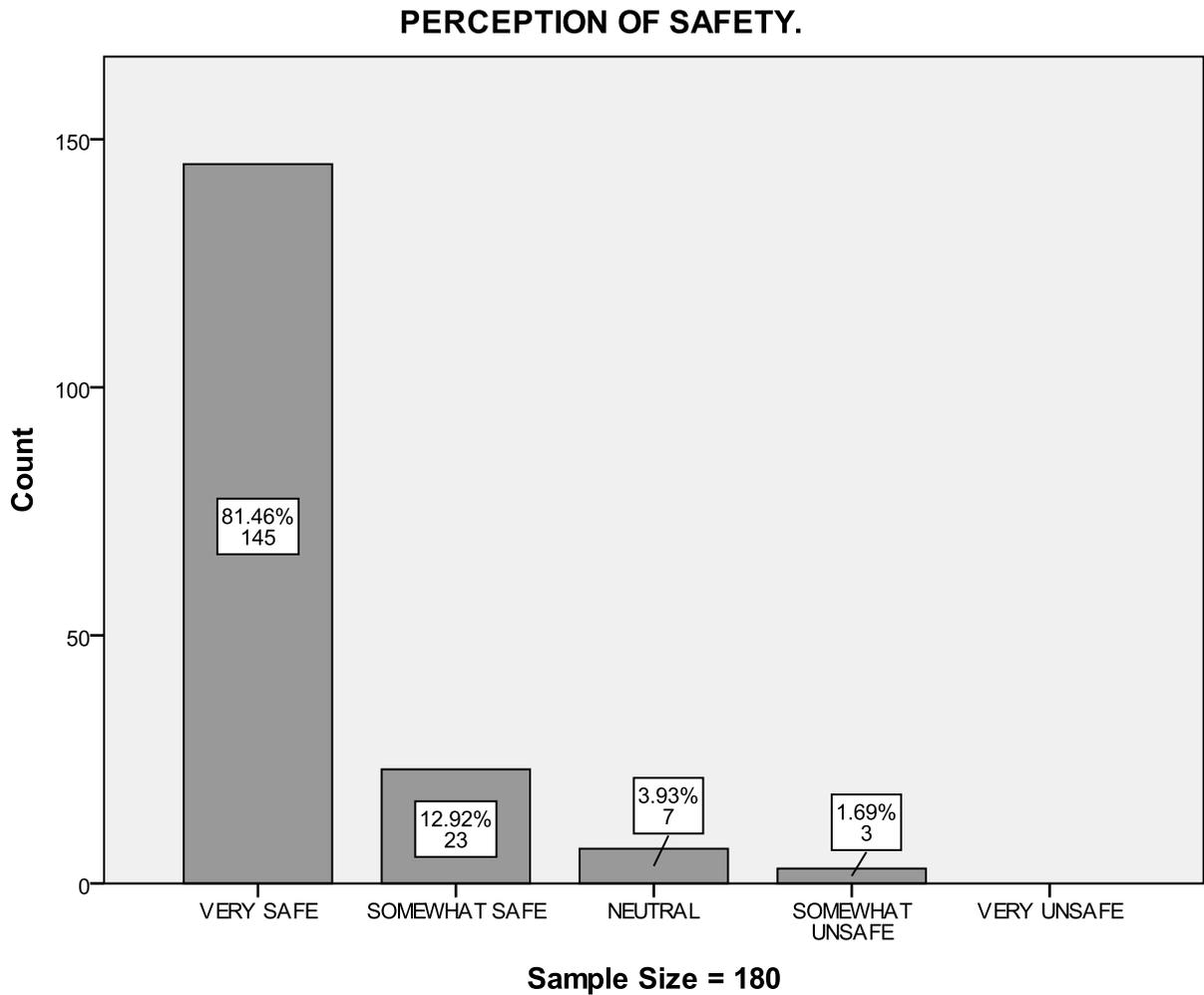
There were 2 reasons given for feeling unsafe:

1. The road (2 responses).
2. Children on the pathway (1 response).

Families and children who ride in both lanes were a safety concern for many riders. Several people indicated that they felt somewhat safe and used the comment space to explain why they felt less than very safe. There were three reasons given:

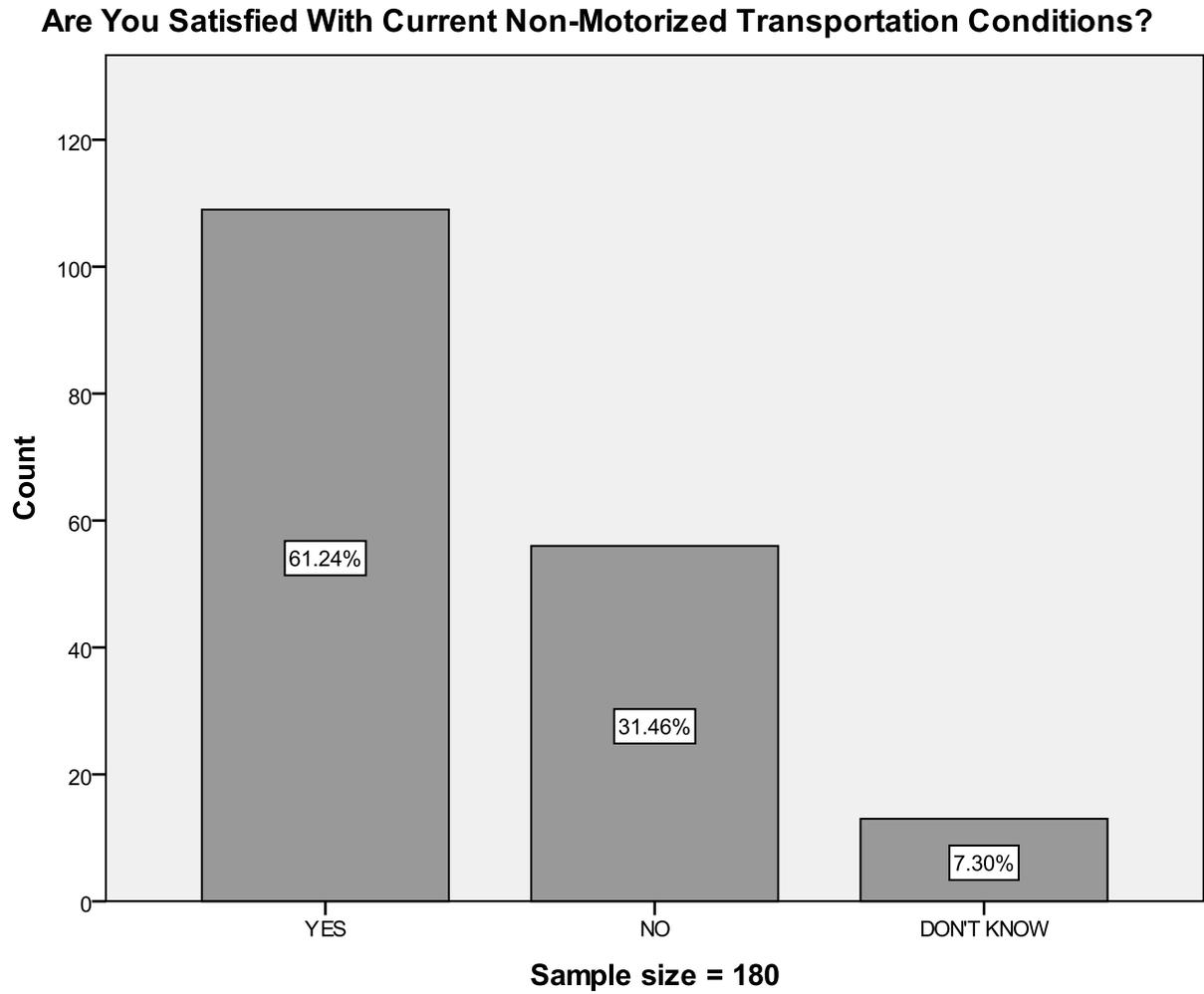
1. The road.
2. Children on the pathway.
3. The bollards at road crossing

Near misses while riding on the road, children zig-zaging in both lanes of the pathway, and the large wooden bollards were of concern to many (Figure 32, 35)



**Figure 33: Perception of Safety**

When asked if satisfied with current conditions for non-motorized users 61.24% answered yes (Figure 34). This is an increase from the 35% affirmative response in 2007.



**Figure 34: Visitor Satisfaction**

Whether answering yes or no, many used the “If no, describe why” comment space to express their concerns. The write in responses have been paraphrased but the meaning is clear. The number one reason for user dissatisfaction is the desire for more shared use pathway. Even when answering yes, people wrote in “extend the pathway”. Other comments addressed the bollards, the non-allowance of dogs, and the lack of potable water sources (Figure 35, 36).

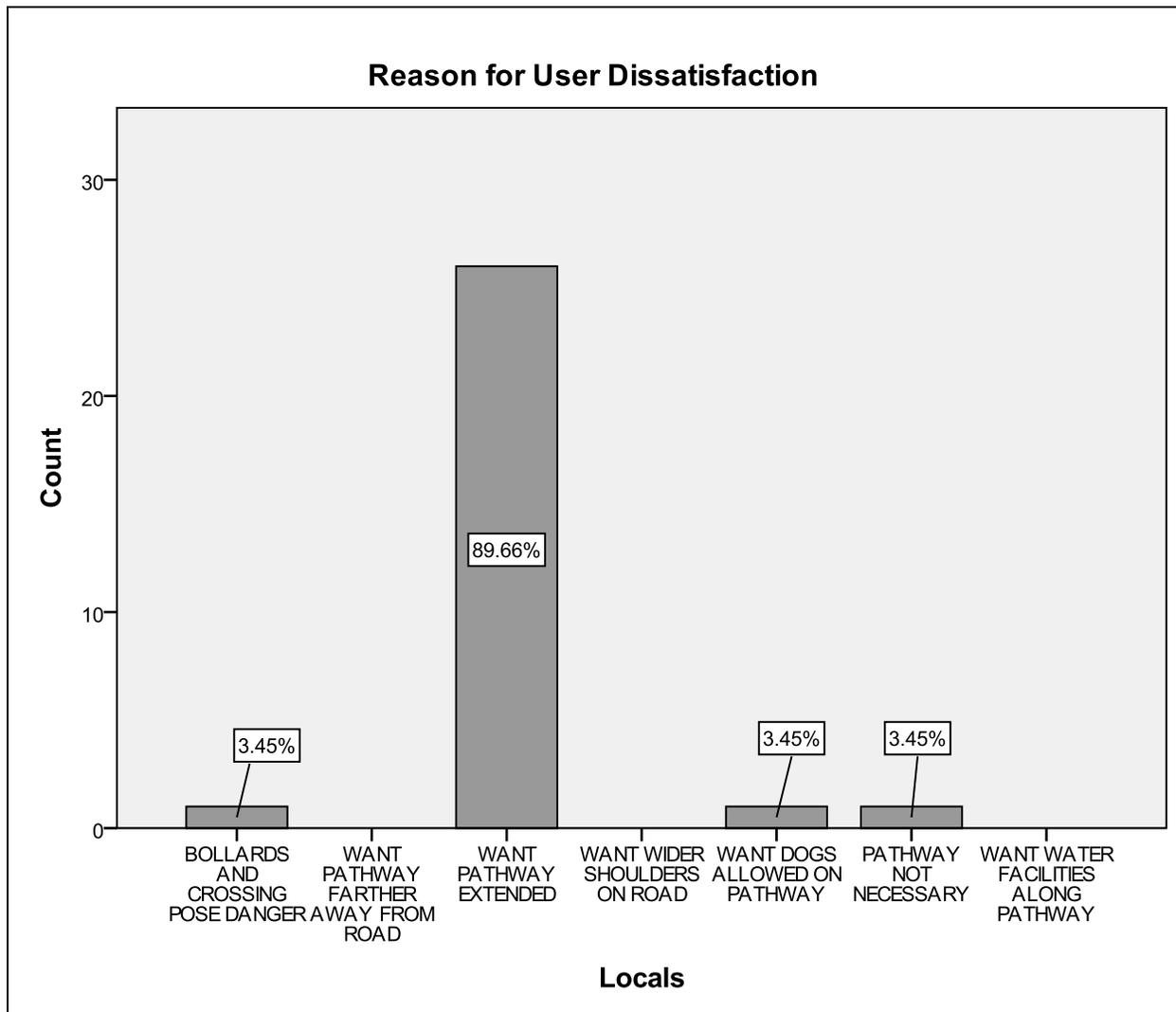


Figure 35: Local Non-Motorized User Dissatisfaction

There were many suggestions for improvement. The most suggested improvement was to extend the pathway. 74.65% of the responses were to build more shared use path, 7.75% said no improvement was necessary, and 3.52% wanted bike lanes on the road. Extending the pathway was the primary suggestion for both local and non-local park visitors. The bollards were again mentioned as being a safety hazard. People also suggested that a center stripe be added to the entire length of the pathway, that mile markers be added, that benches be added along the pathway, and that more toilet facilities be installed along the pathway.

The message is clear, people want the pathway extended. Some want it extended to Colter Bay, others to Yellowstone Park, but “build more pathway” was the main opinion expressed in the user survey.

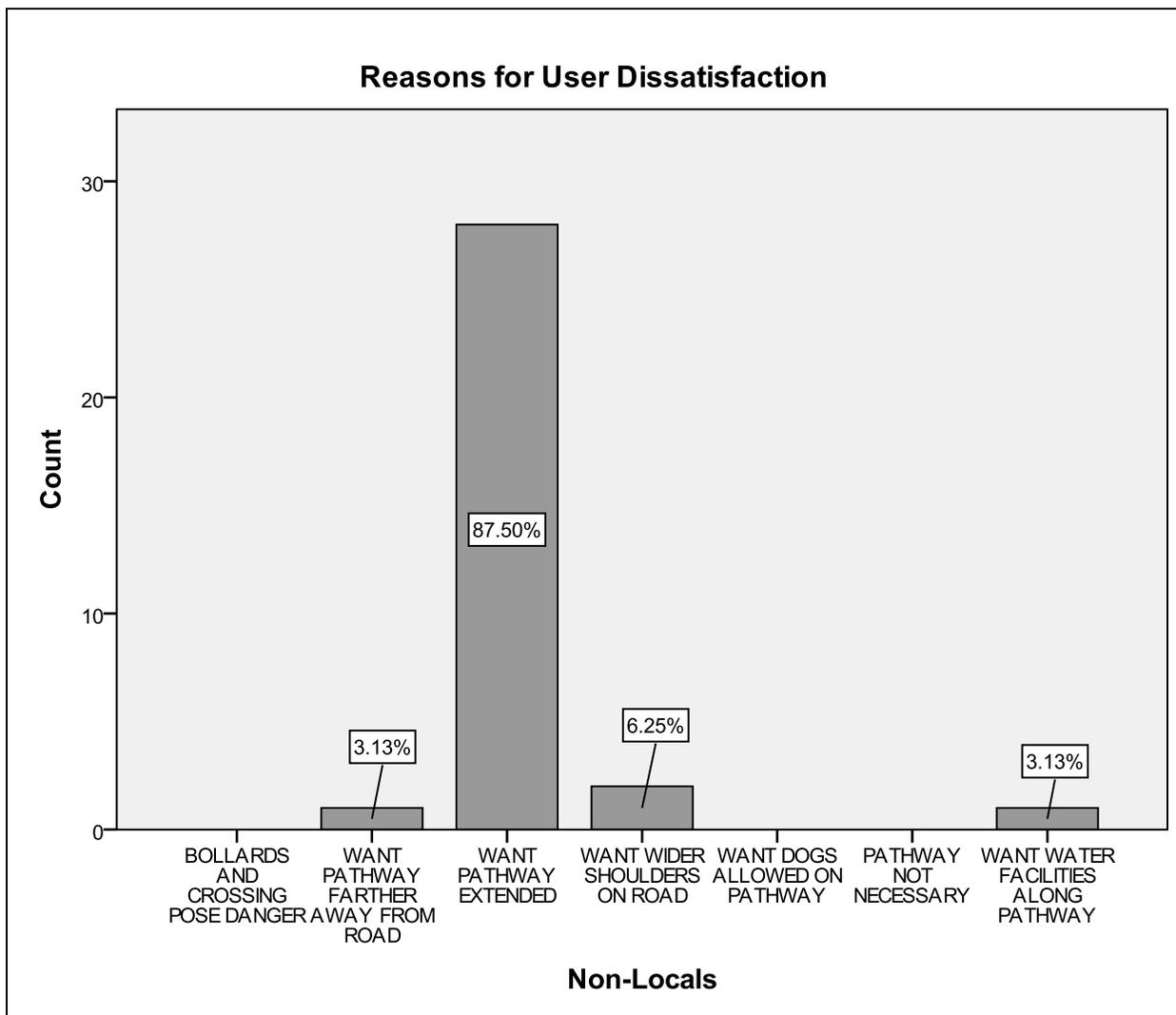


Figure 36: Non-Local Non-Motorized User Dissatisfaction

## 6.5. Information Sources

This section summarizes the following questions:

Q10. How did you obtain information about non-motorized travel options for Grand Teton National Park?

Q11. On a future visit, what type of information would you like to improve your non-motorized experience in Grand Teton National park?

Most people indicated that they found out about the shared use pathway in some way other than the listed information sources. These other sources were given as:

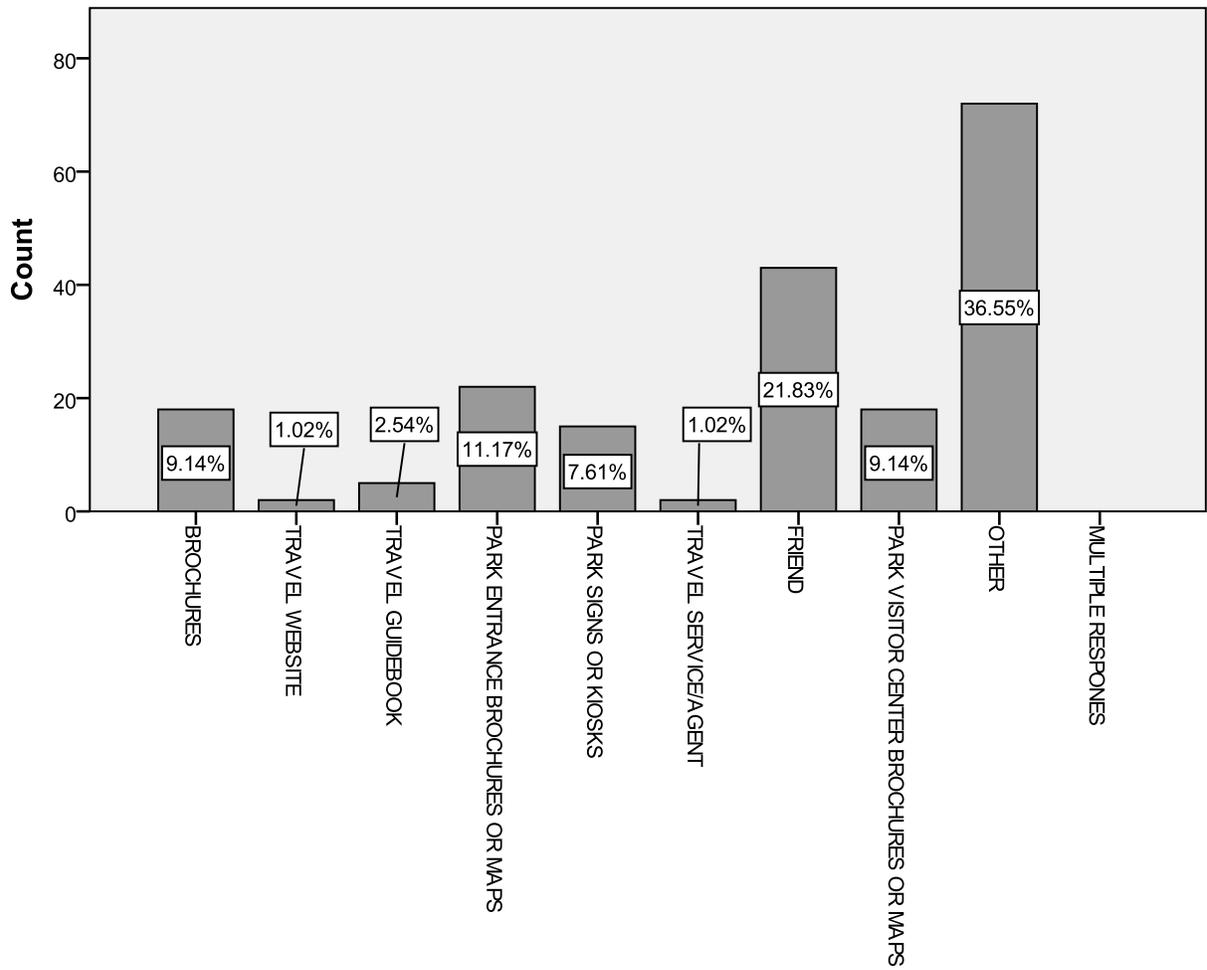
1. Being a local resident.
2. Read about in newspaper.
3. Saw from road while driving.
4. Saw construction during previous visit.
5. Was informed at place of lodging.

In the future, visitors would like more information from the Internet and from signs to improve their non-motorized experience (Figure 37-39).



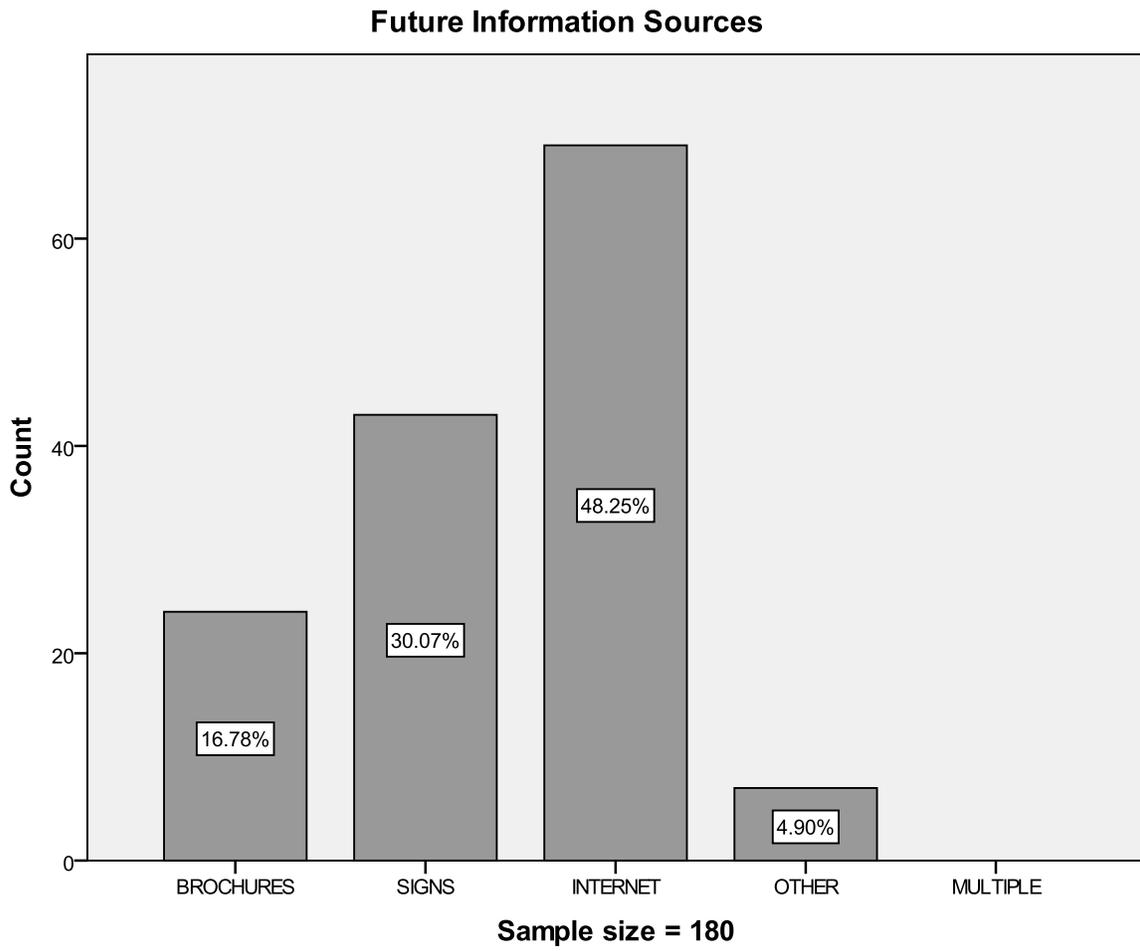
Figure 37: Pathway Information Sources

### How Did You Obtain Information About Non-Motorized Travel Options for Grand Teton National Park?



Sample size = 180

Figure 38: Park Information Source



**Figure 39: Future Information Sources**

## 6.6. User Demographics

This section is a summary of the following questions:

Q12. Do you live in the United States?

Q13. What is your age?

Q14. What is your gender?

Q15. How many people are in your group today, including yourself?

A majority of survey respondents were of retirement age. This may be a reflection of who is summering in Jackson Hole (Figure 40).

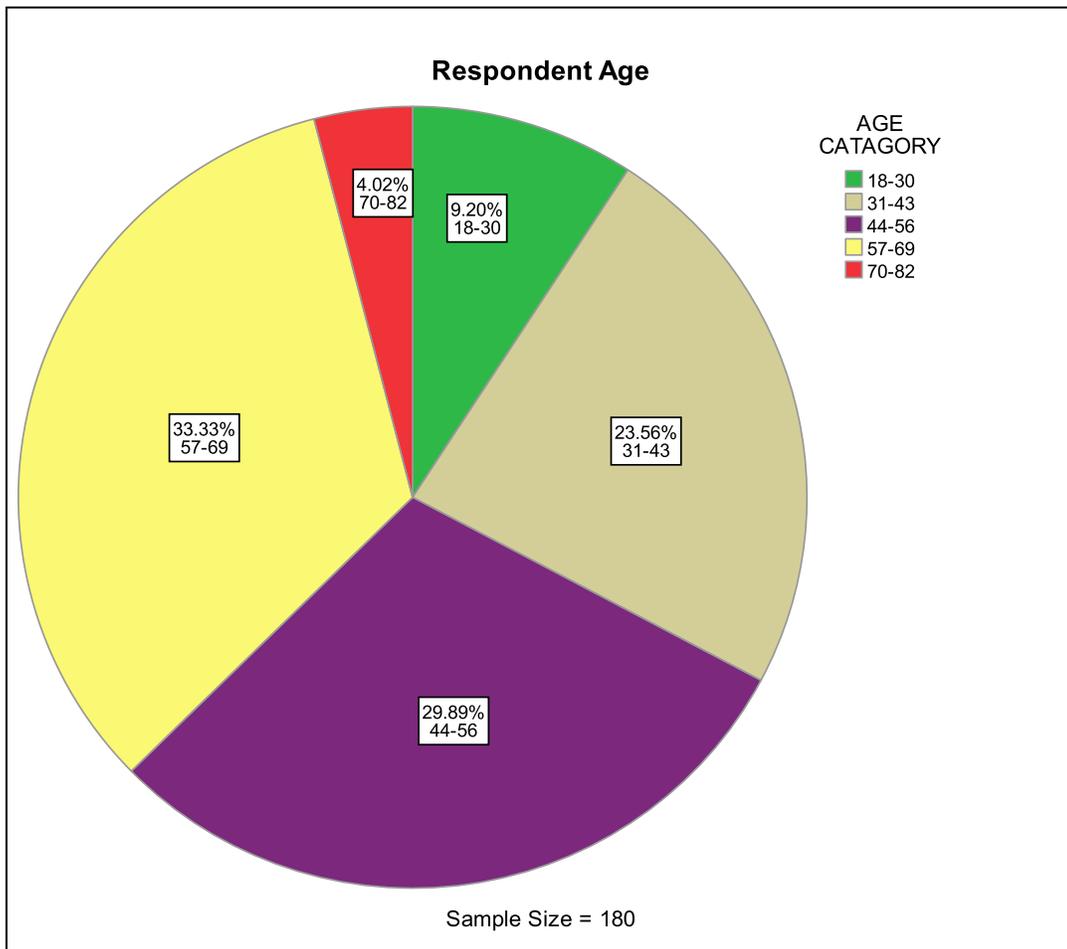
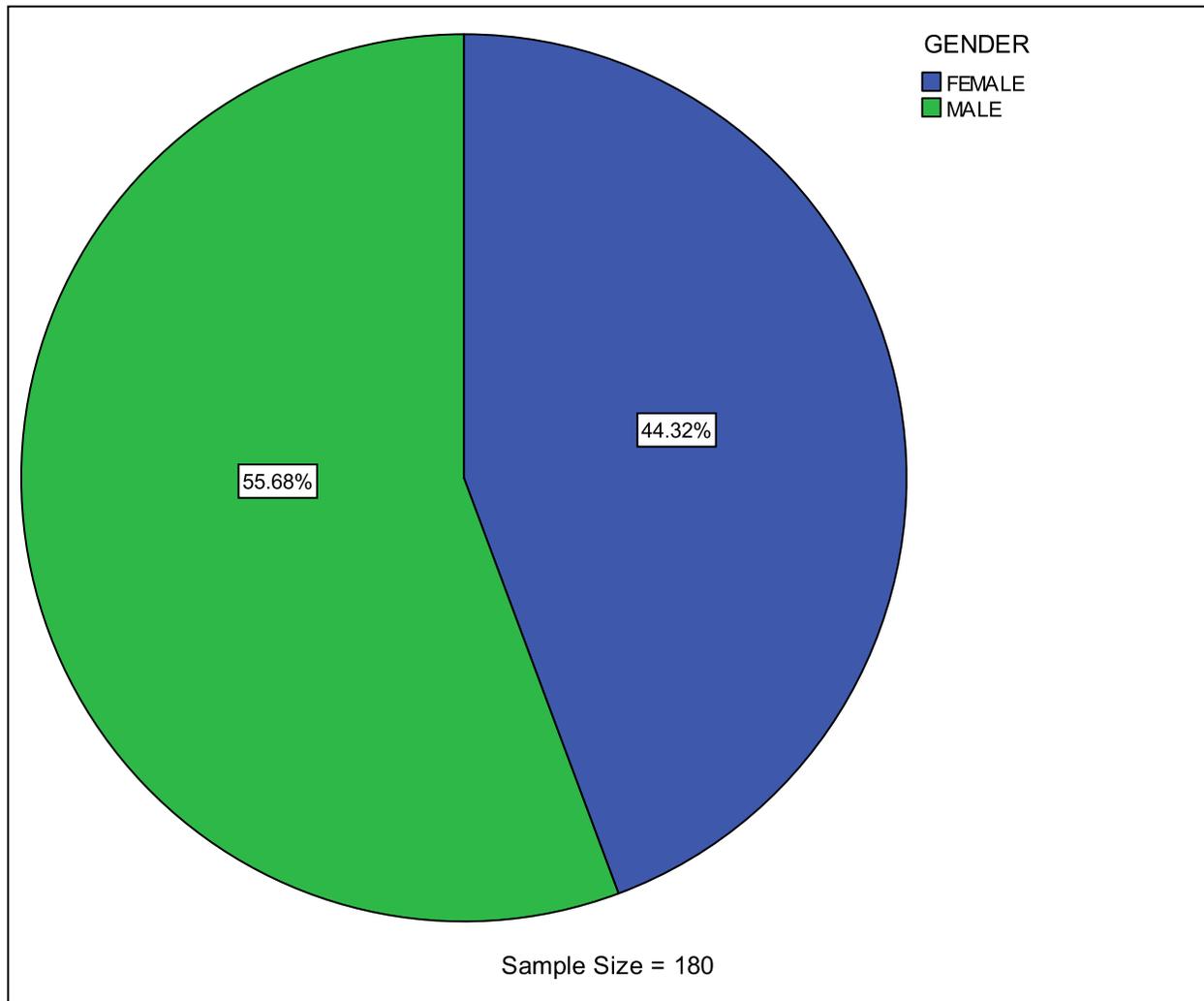


Figure 40: Respondent Age

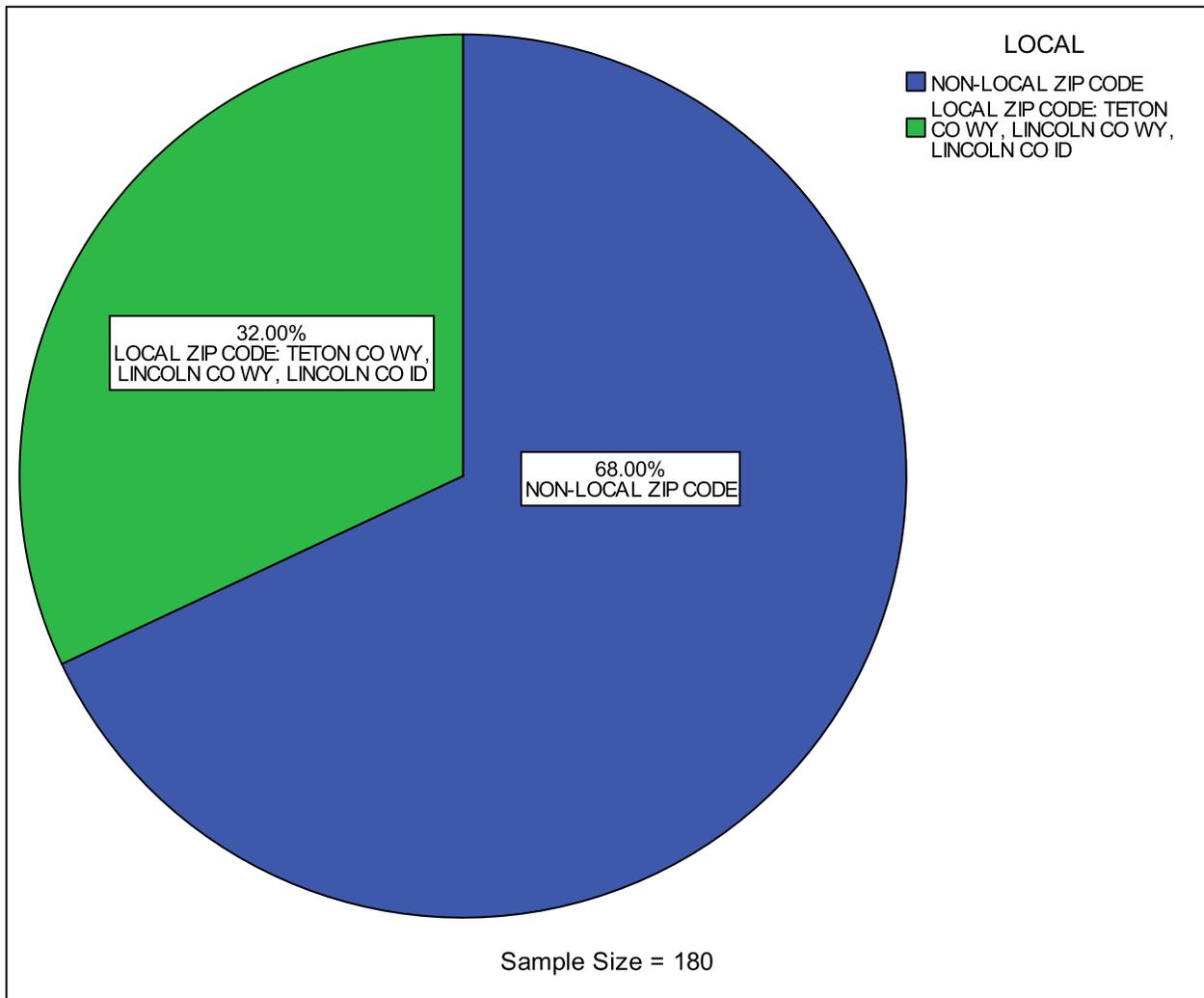
Hansen, Eric

Males outnumbered females, but not by much (Figure 41).



**Figure 41: Respondent Gender**

A large majority (98.32%) of non-motorized users were citizens of the United States. Three non-citizens took the survey: An Australian, an Austrian, and a citizen of the United Kingdom. There were more non-locals than locals riding on the pathway (Figure 42). The average group size was 3 although groups as large 24 were seen. There were several large groups of road bikers. These groups were cycling clubs on tour from Jackson to Red Lodge via Yellowstone and the Beartooth pass.



**Figure 42: Respondent Residency**

## 7. CONCLUSIONS

The construction of the shared use pathway has brought changes to the way visitors experience Grand Teton National Park. The main contribution of the pathway is choice. It is now possible for the average visitor to choose to see the park on a non-motorized vehicle. The data has shown that people are choosing to bicycle rather than drive at an increasing rate.

People have been cycling in the Park for years. Road bikers will ride on any highway, that's what they do. The road tube data indicates that there are still several bikes on the road per day. But everyone who is not a serious road biker knows that riding a bicycle on a busy, narrow, two lane highway is a dangerous idea at best. This danger is compounded by the fact that the drivers may be unfamiliar with the road and distracted by the scenery. The consequences may be dire. Without the pathway, bicycling is simply out of the question for the average person.

Most non-motorized visitors are entering the Park from the south, with a number of riders coming in on Moose-Wilson road. Traffic on Moose-Wilson road is lower than that on Teton Park road and it may be seen as safe to ride by many. It may not be necessary to build a shared use pathway along this route if a shoulder widening is done. More people are choosing not to enter the Park in a car at all.

The pathway has changed the way parking location is chosen. The southern end of the Park is the location of choice for most who wish to ride the pathway. The Moose Visitor Center, Moose Post Office, and Dornan's are logical places to begin a ride. This area offers food, bathrooms, ample parking, and is free. What's not to like? A large majority of people were satisfied with their parking location.

The most common bicycle trip is Moose to Jenny Lake and back. The one way trip is the second favorite. As visitors continue to ride the pathway and discover how short 8 miles really is on a bicycle it can be expected that the number of round trip riders will continue to grow. Those that rode to any place between Moose and Jenny Lake rode on the Shared Use Pathway.

If pathway traffic increases, road bikers will return to riding on Teton Park Road. Road bikers aren't out for a leisurely pedal, these people are covering many miles and ride fast. They perceive leisure riders as a danger and wrecking an expensive bike by running over someone's children would be bad for everybody involved. A shift in user conflict, from cars vs. bikes to bikes vs. bikes may result. However, bikes vs. bikes can be solved with some trail etiquette, educational signage, an increased level of volunteer patrol communication, and a center stripe painted the full length of the path.

People indicated that they came to Grand Teton National Park to exercise, spend time with family, and view the scenery and wildlife. Most felt that the wildlife viewing experience was improved by their ride on the pathway. People felt safe riding on the pathway. Many riders had seen the pathway on a previous visit and brought a bike on a subsequent visit. Many had seen riders on the path on this visit and stopped to rent a bike and take a spin. Many heard of the path by word of mouth or read about it in a newspaper. These riders were not on a bicycle when there

Hansen, Eric

was a perceived danger to riding a bike. The safety of the pathway is getting people out of their cars and onto a bike. This trend can be expected to continue.

The main safety concern expressed was the size and location of the bollards. People found them to be too big. At each bollard location there is also a sign on the edge of the path and even though there is an 8 ft. space between them it was felt as a squeeze. Some bollards are around a bend and seem to appear quickly while riding. Hooking a pedal on one of these log bollards could cause a nasty crash. Hitting one directly has the potential for serious injury. The individuals concerned with the bollards all offered the same solution: Replace them with something skinny and flexible.

This suggested improvement is dwarfed by the one major suggestion given by almost everyone riding the pathway; Extend the shared use pathway. People love the pathway and want it to go farther. People want to get out of the car. People want to feel Grand Teton National Park. On a bicycle it blows in your face, it can be smelled, it is seen unobstructed, and the slower pace allows time for it all to soak in.

## **8. APPENDIX**

### **8.1. Non-Motorized User Count Form**

Attached is a copy of the user count form.

### **8.2. Non-Motorized User Survey Form.**

Attached is a copy of the user survey form.

## 9. REFERENCES

American Association of State Highway and Transportation Officials (1999), *Guide for the Development of Bicycle Facilities*.

Dharmaraju, R., Noyce, D. A., & Lehman, J. D. (2002). *An Evaluation of Technologies for Automated Detection and Classification of Pedestrians and Bicycles*. University of Massachusetts Transportation Center.

Gleason, R. (2008). *Guide to Promoting Bicycling on Public Lands*. Lakewood, CO: Federal Highway Administration, Central Federal Lands Highway Division.

Goodridge, S. G. (2010, July 7). *Detection of Bicycles by Quadrupole Loops at Demand-Actuated Traffic Signals*. Retrieved July 7, 2010, from Humantransport: <http://www.humantransport.org/bicycledriving/library/signals/detection.htm>

MacBeth, A. G. (2002). *Automatic Bicycle Counting*. Christchurch, New Zealand: MWH New Zealand Ltd.

National Park Service (2009) [web content], [www.nps.gov](http://www.nps.gov) accessed in July 2010

Schneider, R., Patton, R., Toole, J., & Raborn, C. (2005). *Pedestrian and Bicycle Data Collection in United States Communities: Quantifying Use, Surveying Users, and Documenting Facility Extent*. University of North Carolina at Chapel Hill, Pedestrian and Bicycle Information Center.

Surface Transportation Policy Partnership. (2006). *From the Margins to the Mainstream. A guide to Transportation Opportunities in Your Community*.

Turner, Shawn et al (2007), *Testing and Evaluation of Pedestrian Sensors*, Texas Transportation Institute, Texas A&M University System, College Station, TX

United States Department of Transportation, Bureau of Transportation Statistics, (2000). *Bicycle and Pedestrian Data: Sources, Needs, and Gaps*.

Hunter, Jacob

Jacob J. Hunter

Prof. Chris Livingston, mentor

### Moments in Time

Terror is something none of us ever want to have to deal with, yet our world has repeatedly seen apocalyptic terror and chaos; terror that chills our spines and challenges our spirits. In fact, history has been shaped by terrifying events that have led us to this moment. And though we hate to think of these episodes, it's our duty to remember. To remember those we've lost, those who've done great things, and those who we'll never be able to help. Monuments are one way we try to commemorate and internalize events like 9/11, Vietnam, and Pearl Harbor. Monuments are appearing in this country today at a rate faster than they appeared after the Civil War. The Civil War nearly destroyed this country, and it's no surprise a boom of memorials followed to help heal domestic wounds. So the current monument movement speaks to a new maturity evolving within America. Where most feel that although our country's short history isn't all that flowery, it is clearly worth preserving. And now with the world moving faster than ever before, we're creating an abundance of monuments as anchors to mark time as we once knew it (Dupre). However, the most profound monuments harmoniously balance event, scale, and emotion.

A monument is "a fixed object in the ground as to mark a position", says The American Heritage Dictionary. Also, the dictionary gave a tombstone as an example, continuing that enduring achievements and legal documents are monuments. However, from an architectural

point of view, the most straight forward monument definition the dictionary offers is “a structure erected as a memorial”. And what is a memorial? While efforts have been made to differentiate the two terms; essentially, they’re the same thing. Monuments are linked with triumph, yet memorials speak more to loss and death. However, since both denote resolution over time, their meaning to me is the same. Ultimately, monuments encompass endings and beginnings; they are not solely about death, nor life. And it could be said they’re not entirely about remembering, rather allowing us to forget. The entire idea of developing a monument allows reconciliation with an event to take place, thus permitting history to move forward. Monuments are about our perseverance; they physically show us that an event is finalized (Dupre).

Additionally, Judith Dupre in her book Monuments explains, “monuments are history made visible. They are shrines that celebrate the ideals, achievements, and heroes that existed in one moment in time. They commemorate singular individuals, heroic accomplishments, or the millions swept away by war or disaster” (12). Monuments are to this country what a headstone or an urn is to most of us, something to mark our legacy and ensure a living memory. Sadly though, monuments often fade into the urban landscape, and eventually they disappear in that no one takes notice, even more so when monuments double as bridges, hospitals, or libraries. Now that monuments are competing with a visual jungle that includes traffic signals, billboards, cars, and store windows, they simply cannot handle the additional strain of function. Monuments seem to want to be useless. In fact, Edwin Heathcote makes reference to Loos, saying, “the prototypical early functionalist, asserted that only the monument can be true art as only the monument is released from the burden of function” (22). So, the only fundamental task of a monument is to bear witness. However, contemporary monuments ask us to do something rather than feel something. Their goal isn’t to quench our curiosity, but rather to humble us through

knowledge. In this sense of education, monument design is often pushed towards representational clarity in order to challenge us to rethink versions of American history. Throughout the country, monuments such as the Little Bighorn Battlefield are being built and amended to reflect differing political perspectives. Politics are very much a part of monument building; in fact, monuments only get built if the public opinion places importance on a given occurrence. Again, only the majority gets to decide what is to be symbolized. However, since a universal set of values seems to no longer exist, reaching such a mass consensus is becoming near impossible. Often it is history itself that gets debated, and the finished monument merely represents the majority opinion of how an event should be remembered. Bureaucracy and criticism continue when selecting designers, architects, and artists to realize a monument's design. Nonetheless, after much public prodding and dissecting, professional reconfiguring and adjusting, miraculously, monuments get built. Their designs are never perfect, but that is the nature of humanity and of art. Making thought physical or bringing abstract vision into being requires humility and courage (Dupre). And though imperfections exist in all things we design, there are specific elements of monument design that make these testaments special to us. For a monument design to have any level of success or influence, it must first deeply consider these three things: event, scale, and emotion. These three aspects can work independently, but all are necessary for a monument to effectively evoke revelation within us.

Event, scale, and emotion; with these themes in mind I set forth on a personal exploration. I traveled to the Crow Agency, near Billings, Montana to experience the Little Bighorn Battlefield. A monument with such a deep, yet sided history revealed the clash of cultures we so often see in this country. Every event has two sides, but usually only one side is viewed as just. The massacre that occurred June 25-26, 1876, shook this country the same way

Hunter, Jacob

9/11 shook it. On the cusp of her centennial celebrations, America wasn't braced for the carnage Manifest Destiny would bring forth. A huge village of Indians, 7 to 8 thousand, with 2,000 warriors settled near the Little Bighorn River. They were perhaps the freest people this country has ever known, nomadically following buffalo from Mexico all the way to Canada. Led by medicine man Sitting Bull, these Native Americans weren't about to give up their ways and settle on a reservation, especially when they'd previously been promised their land. But progress, in the form of gold in the Black Hills provoked President Grant to shun the natives as outlaws. As a result, what is now a quiet set of roaming hills was once a nightmare caused by America's indiscretion (Adloson).

So, when I look at this battle as an event, I too must look at the events that led to it, as well as those that occurred after it. For the Battle of Little Bighorn didn't end on June 26, 1876, it waged on for another hundred years in the form of a fight for equal recognition. The facts of the actual battle were misconstrued by the media time and time again in the direction of glorifying Lt. Colonel George Armstrong Custer. Only until recently, the monument was named after him, but as the true facts of the event has been amended over the years, so too has the monument. Now white and red headstones mark the site, and a new memorial themed, "Peace Through Unity" commemorates the Plains Indian women, children, and men who took part in the battle and whose spirit and culture still survive (Adloson).

Scale is something we always concern ourselves with in architecture. It is based off the dimensions of a human being. For monuments, scale is usually thought to be large. "Too enormous to be overlooked", is how Chris Scarre describes the way monuments snare our attention. However, scale can be portrayed in many ways. At Little Bighorn the scale of the battle is best illustrated not by the truncated granite obelisk erected over the 7<sup>th</sup> Cavalry's mass

Hunter, Jacob

grave, but by the scale of the site itself. Stretching nearly six miles in radius, the calm, beautiful landscape is riddled with white and red marble markers that represent final resting places of those who fought. Seeing horses calmly grazing on the hills, yet having the advantage of quickly traveling the site by car, you get a sense of the communication chaos the vast area caused. Having no way of knowing each other's hardships, Custer's divided forces stood no chance against the overwhelming strength of the American Indian Forces. Ultimately, Custer fatally underestimated the scale of the village and the spirit of the warriors within it. And seeing the tombstones spread over miles, but then the cluster at Custer Hill bring forth the reality of a massacre. The Indian warriors swept through Custer and his men like water over a stone and Custer's Last Stand really only lasted as long as it takes a hungry man to eat a meal. And with so much death swirled into one small area of such an immense battlefield, the dense scale of the hopeless horror those men must have felt confronts us, emotionally crippling our spirits (Adloson).

However, though the events of that day can never be changed, our attitudes can remain positive. Monuments aren't about dwelling on tragedy, rather moving forward from it. Emotion still runs very high at the Little Bighorn Battlefield, a feeling of "sacred ground" whispers through the wind and an unnerving sensation of grievance mutters up from the earth. Yet, the *Spirit Warrior* sculpture inspires us with a romantic image of how life once was for Plains Indians. Additionally, the Peace Through Unity memorial teaches us to come together. It is sited on axis with the earlier 7<sup>th</sup> Calvary Monument, which is framed by an aperture cut into the memorial. This window that looks to the early monument is known a "spirit gate" which allows for peace amidst the souls of the fallen combatants. By labors of compromise and mutual respect

Hunter, Jacob

similar to those seen at the Little Bighorn Battlefield, monuments persist to strengthen our spirits and minds (Dupre).

Furthermore, event, scale, and emotion are illustrated brilliantly in two of our country's finest memorials, the Vietnam Veterans Memorial by Maya Ying Lin and the New England Holocaust Memorial by Stanley Saitowitz. Both works have been done by compassionate and contemporary architects that use similar techniques in the success of their memorials. The events respected in these memorials are more common than those of the Little Bighorn Battlefield. The Vietnam War ripped through this country physically and politically, and the genocide of the Holocaust is something mankind can never let happen again. The effect any event has on the world is arguable, but all events that shape our country's existence are worth recognizing. Scale is small when considering one, but when considering many, scale can take on an immense life which can baffle us. For example, it may not take much "space" to write down the name of a fallen soldier or Holocaust victim. Perhaps just as much "space" as it takes to write an address on an envelope. But when you take the 58,267 names memorialized by the Vietnam Veterans Memorial and stretch them across a solid engraved wall that continues out of sight or the numbers one through six million representing those murdered in the Holocaust; etched them on several tall glass towers, then the magnitude of the loss confronts you head on. And seeing this scale clearly helps us to internalize the immense chaos and grief (Heathcote).

Finally, emotion is the most difficult element to rationalize. Since everyone's emotions are so different, "touching a nerve or striking a chord" is often easier said than done. It must be always suggestive, and never literal, and Saitowitz and Lin are experts. First, Lin simply uses reflection. The polished black granite walls have a mirror like surface that physically reflect not only the surrounding greens and other monuments, but the visitors. And in seeing themselves in

Hunter, Jacob

those lost, visitors are inspired to live on for those who cannot. Swaitowitz is blunt, his six chimney shaped glass towers representing the Nazi internment camps, glow at night as a vibrant beacon against bigotry. Each chamber wall is inscribed with the name of one of six primary death camps. At the bottom of the glass chamber towers, submerged into the earth, are pits with smoldering coals which illuminate the names of the camps. The heat and smell rise up and then arouse memory and horror. Memorials stir and stretch our emotions in a meaningful, sometimes uncomfortable, but necessary manner; never to break us, but always to uplift us (Heathcote).

In conclusion, as time continues to superimpose itself, recognizing the moments marked by monuments and memorials is important. As we are all but dust in the wind, monuments and memorials are ceaseless. They speak to the events that shape us, the scale that sustains us, and the emotion that drives us. Our country's past is animated all around us, and creating a vision for the future starts by correctly recognizing the past. Memorials and monuments don't alleviate pain, rather they embrace it, so we may continue on, wiser and strongly.

Hunter, Jacob

Works Cited

Adloson, Steve. Personal interview. 23 June. 2010.

The American Heritage Dictionary of The English Language. 3<sup>rd</sup> ed. New York: Houghton  
Mufflin Company, 1996.

Dupre, Judith. Monuments. New York: Random House, 2007.

Heathcote, Edwin. Monument Builders. New York: Academy Editions, 1999.

Scarre, Chris, ed. The Seventy Wonders of the Ancient World. Hong Kong: Thames &  
Hudson, 1999.

## Abstract

Xanthan gum and locust bean gum are of interest in industrial concerns and are often exploited in food, biomedical and cosmetic industries. Xanthan gum and locust bean gum, like many other polysaccharides, are characteristic in their ability to modify the properties of aqueous environments. When mixed, the two bio-polymers interact to form a firm thermally reversible gel. The mechanisms responsible for the rheological behavior of the xanthan gum/ locust bean gum gelling network under stresses and strains is under debate.

Flow and oscillatory testing was performed on xanthan gum, locust bean gum and the xanthan gum/locust bean gum gelling system in a 1:1 ratio. Under constant shear xanthan and the gelling system display shear thinning behavior. Locust bean gum displays shear thinning behavior at higher shears with a Newtonian region at lower shear rates. Oscillatory measurements at a constant strain over a range of frequencies result in a dominantly elastic response for the xanthan and xanthan/locust bean gum gelling network while a greater viscous response is observed of the locust bean gum system. Therefore, the measured rheological parameters indicate that xanthan gum acts as a “weak gel”. The measured response of the locust bean gum is characteristic of hyper-entangled polymeric solutions and the xanthan/locust bean gum gelling network results in a greater elastic response, a synergistic gelation, than either of the xanthan gum or locust bean gum systems alone.

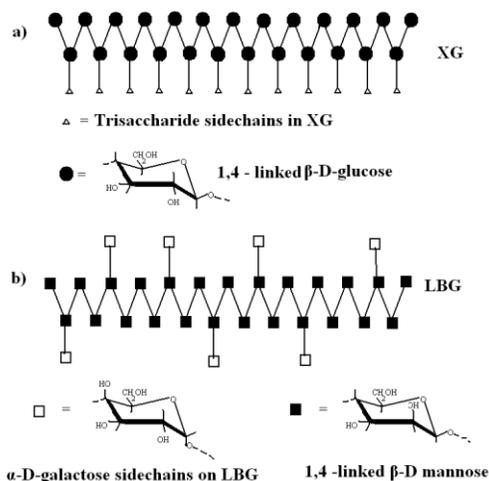
When subject to a range of temperatures the xanthan and xanthan/locust bean gum gelling network undergo changes in their viscoelastic response. Most notably are the gel to solution transition temperatures of the xanthan and xanthan/locust bean gum gelling network. Xanthan gum displays a one-step gel to solution transition point and the xanthan/locust bean gum gelling network displays a two-step gel to solution transition point.

## Introduction

Xanthan gum (XG) and locust bean gum (LBG) are of interest in industrial concerns and are often exploited in food, biomedical, and cosmetic industries. XG and LBG, like many other polysaccharides, are characteristic in their ability to modify the properties of aqueous environments. When mixed, the two biopolymers interact to form a firm thermally reversible gel. Biopolymeric gels are currently of interest as tissue scaffolds or in drug delivery(refs), applications that

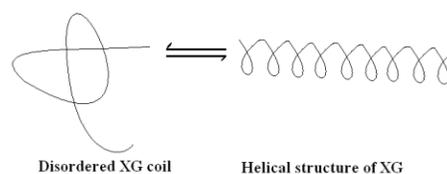
require fine control of material properties. Rheological characterization is a standard technique in defining the viscoelastic properties of complex fluids such as polymer solutions and gels.

The purpose of this experiment was to determine the rheological behavior of xanthan gum solution (XG), locust bean gum solution (LBG) and xanthan gum/ locust bean gum synergistic gelling solution (LX) when subjected to shear stress, small deformation oscillatory experiments and temperature change.



**Figure 1:** a) Structure of xanthan (XG) shown with a polymer backbone. b) Structure of locust bean gum (LBG) shown with a polymer backbone.

As shown in Figure 1, both XG and LBG are composed of a linear backbone of hexapyranose sugars lined through equatorial bonds at positions 1 and 4[1]. In sufficient concentrations ( $> 0.3\%$  w/v), high temperature and low ionic strength, the XG molecule exists in solution as a disordered coil [1]. At cooler temperatures, the structure becomes more ordered, transitioning to a helical structure characterized by higher moduli as shown in Figure 2. XG does not undergo any thermal hysteresis when subjected to heating or cooling. This indicates that the helix to random coil transition is thermally reversible. The order – disorder conformational transition of XG results in a wide range of rheological behavior[2]. In a high enough concentration, XG acts as a “weak gel” when mixed in solution. This is, in part, due to the self-association behavior of XG[3].



**Figure 2:** Proposed structure of XG polymers when mixed into solution. The disordered coil exists at high temperatures, low ionic strength and low concentrations. The helical structure exists at lower temperatures, high enough concentrations and sufficient enough ionic strength. The formation of the disordered coil to the 5-fold helix is thermally reversible.

LBG molecules exist in water solution as random coils and shows rheological behavior typical of hyper-entangled macromolecular solutions[4], with little dependence upon temperature. When the two polymers are combined into solution, the gel-like properties of XG are enhanced. This resulting mixture forms a “true gel”[1] due to physical cross-linking between the two polysaccharide chains that is characterized by a higher elastic response[4]. When this gel is heated from room temperature, it undergoes a gel-sol transition, or phase change, characterized by changes to the rheological properties of the solution[4]. The precise nature of the interactions between XG and LBG is an object of debate.

There are many proposed mechanisms for synergistic gel formation. For example, different segments of the two polymer chains may associate, or aggregate, through intermolecular interactions such as hydrogen bonds or van der Waals forces, forming mixed junction zones that make up the three dimensional gel network[5].

The rest of the polymer chain retains its structure enough to maintain solubility in water (to keep polymer from precipitating out of solution). One proposal for the formation of the XG/LBG gel network is the attachment of unsubstituted regions of the glactomannan (LBG) backbone to (?) the surface of the XG 5-fold helix (the reference I attached to the email is from 2005 and concludes the association is mainly between the backbones of both polysaccharides. Richter) Previous studies [4] indicated that to maximize the synergistic effects of the XG/LBG gelling system the XG and LBG were mixed together in a 1:1 ratio. For larger concentrations of XG, it is thought that self-association of the XG interferes with association with the LBG chains and therefore results in a less rigid gel.

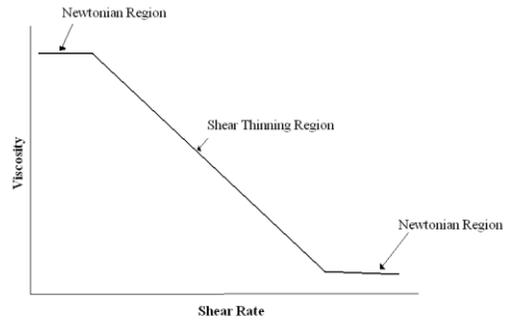
## Rheology

Rheology by definition is the science of the deformation of materials under stresses and strains. Rheology is a broad field of study including materials which display both elastic and viscous behavior.

Viscosity is the material resistance to deformation. Viscosity is subject to imposed shear rate upon the material, temperature, pressure and time of shearing [6]. Ideal viscous behavior, as developed by Newton, defines viscosity  $\eta$  as the proportionality constant of applied stress and strain rate. Shear stress  $\sigma$  is related to the velocity gradient, or shear rate  $\dot{\gamma}$  through Equation 1.

$$\sigma = \eta \dot{\gamma} \quad \text{Equation 1}$$

$$\sigma = \eta \dot{\gamma}$$



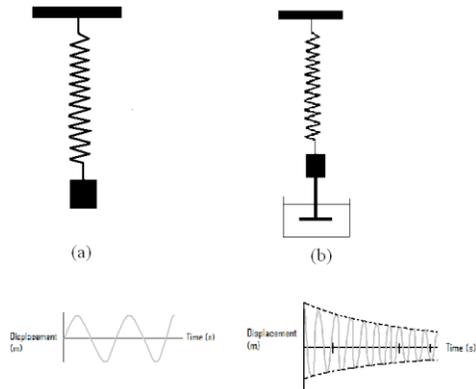
**Figure 3:** Shear thinning behavior of a polymeric fluid with "upper" and "lower" Newtonian plateaus.

Polymer solutions show a departure from Newtonian behavior. These non-Newtonian fluids, when subjected to shearing forces, display shear thinning or shear thickening behavior. Shear thinning is a phenomena where a reduction in the fluid viscosity is observed with an increasing rate of shear, as shown in Figure 3. The shear thinning region can be modeled using the power-law relation of Equation 2. At very low shears and at very high shears, however, a shear thinning material will often display "Newtonian regions" characterized by a constant viscosity.

$$\text{Equation 2}$$

$$\sigma = k \dot{\gamma}^n$$

Conversely, shear thickening is defined by an increase in viscosity at increasing shear rates. A standard rheometer can apply a rate of strain, measure the material response, or stress, and therefore calculate the constant of proportionality or viscosity. Any deviation from a constant viscosity, such as shear thinning, is due to the nature of the material.



**Figure 4: "Mechanical representation" of (a) an ideal elastic response through a Hookean spring and (b) ideal liquid behavior through a Newtonian dashpot.**

Rheological measurements can also characterize viscoelastic material properties. Many complex materials exhibit a coexistence of viscous and elastic behavior, or liquid-like and solid-like characteristics, and are defined as viscoelastic.

A mechanical model for ideal solid, or purely elastic, behavior can be represented most generally by a spring, as shown in Figure 4a, where the force is proportional to extension. This relationship is demonstrated through Equation 3, where  $\sigma$  is the stress,  $\beta_0$  is the elastic modulus and  $\gamma$  is the strain.

*Equation 3*

$$\sigma = \beta_0 \gamma$$

For a purely elastic spring where energy is not dissipated, the spring displaces by an amount relative to the applied force and the elastic modulus corresponds to the amount of energy stored in the system. Ideal liquid behavior can be modeled by a Newtonian dashpot as shown in Figure 4b. In the dashpot model, after the force is applied, frictional forces damp the displacement with time as energy is dissipated into the system.

Oscillatory shear, as opposed to the constant shear imposed on the sample when measuring viscosity, is useful for testing the linear viscoelastic behavior of materials. Linear viscoelasticity implies that the response at any time is proportional the value of the stimulus imposed upon the material[6]. In an oscillatory shear measurement, the stimulus is applied in the form of a sinusoidally varying strain. The measured stress response will also be periodic at the same frequency, but out of phase with the applied strain by some phase angle,  $\delta$ . The phase angle is the measured shift between the input wave and the output wave and describes the viscoelastic behavior of the material. In the linear viscoelastic regime, it can be assumed that the elastic response and the viscous response are independent of each other. This allows the complex modulus, the material's overall resistance to deformation ( $G^*$ ), to be represented by Equation 4, where  $G'$  and  $G''$  are referred to as the storage and loss modulus respectively. The elastic storage modulus is the measure of elasticity of a material or the ability of a material to store energy. The viscous loss modulus is the ability of a material to dissipate energy such as energy lost as heat.

Viscoelastic properties in a polymeric liquid are a result of intramolecular forces that arise from the orientations of vector chemical bonds in polymer chains and changes in the orientation caused by the imposed deformation upon the system [6].

The viscoelastic response of a material is dependent upon the parameters (ie. percent strain, time scale, or temperature) imposed upon the material.

$$G^* = G' + iG'' \quad \text{Equation 4}$$

In polymeric liquids a molecule possesses a minimum energy state. The elastic response is essentially the return of the polymer to this minimum energy state [6]. The basic physics associated with the response of a polymeric fluid therefore can be directly compared to the mechanical behavior of rubber elasticity.

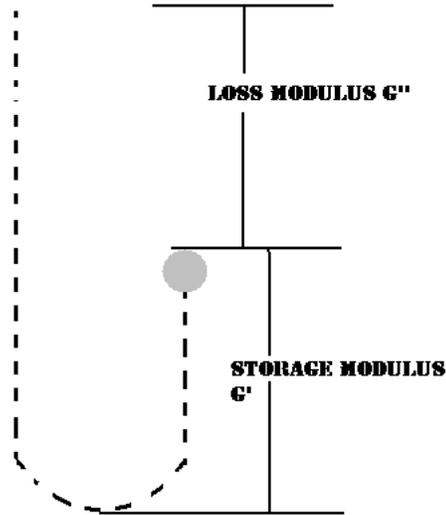
Figure 5 is a mechanical model using an elastic ball to represent a system with a viscoelastic response. When an elastic ball is dropped from a specified height and bounces back upwards, the height that the ball reaches after the first bounce is termed as its elastic response or storage modulus ( $G'$ ). The greater the elastic response the more effective the system is at retaining, or storing, energy. The difference between the original drop height and the greatest height in which the ball reaches after the first bounce is the viscous response of the ball or the loss modulus ( $G''$ ). The  $G'$  is a measure of the dissipation of energy away from the system. The moduli are related to the applied stimuli and measured response by Equations 5 and 6.

$$G' = \left( \frac{\sigma^0}{\gamma^0} \right) \cos \delta \quad \text{Equation 5}$$

$$G'' = \left( \frac{\sigma^0}{\gamma^0} \right) \sin \delta \quad \text{Equation 6}$$

While  $G'$ ,  $G''$  and  $\tan \delta$  are related through Equation 7.

$$\tan \delta = G'' / G' \quad \text{Equation 7}$$



**Figure 5:** Mechanical representation of material response relating the storage ( $G'$ ) and loss ( $G''$ ) moduli. The  $G'$  is characteristic of the elastic response of a material while the  $G''$  characterizes the viscous response.

A gel by definition is a cross-linked solution [7]. While polymer gels consist mostly of fluid, the three-dimensional cross-linked network formed by the polymer molecules causes the gel to have elastic properties. Therefore, gels display a wide range of rheological properties, such as a greater storage modulus  $G'$  than loss modulus  $G''$ . The  $G'$  also undergoes relatively small variation over a broad range of frequencies.

The rheological properties of a polymer gel are, in part, a result of the extent of physical or chemical cross-linking between the polymer chains or molecules [6]. In polymer solutions, the length of the chain is a large factor determining the rheology. If the polymer chain is long enough or the concentration of polymer mixed into solution high enough, entanglement occurs. A higher degree of entangled

polymers in solution results in higher elasticity.

High densities of entanglements that result from polymer to polymer interactions characterize the behavior of hyper-entangled polymeric solutions. Entanglements in polymer solutions result in strong couplings which act in a localized manner like chemical cross-linking between molecules [6]. Hyper-entangled polymeric solutions, when under shear, display a Newtonian plateau at low shear rates. At higher shear rates, the polymers become engaged and the solution begins to display shear-thinning behavior.

Self-associating polymers, notably xanthan gum, display “gel-like” behavior. Self-associating polymeric solutions are free-flowing and are capable of holding small particles in suspension over long periods of time [1]. The elastic response ( $G'$ ) of a self-associating polymeric solution is greater than that of its viscous response ( $G''$ ). Such a solution will flow at higher deformations.

## Materials and Methods

Xanthan gum powder and locust bean gum powder were received as commercial products from MP Biomedical and Sigma, respectively. Deionized water was used throughout. XG and LBG powders, which are highly impure, were separately mixed into solution. A series of steps were undergone to purify these solutions. They were first separately centrifuged at 14,500 RPM for 1 hour. The LBG solution was filtered through an 8 micron filter and then a 3 micron filter, respectively. These solutions were then frozen with liquid nitrogen and then placed in a vacuum for 5 days to dry. The resulting purified substances could be rehydrated to any desired concentration, in this case into a 1% by weight solution. These solutions were then combined to form a purified

XG/LBG gel in a 1:1 ratio. The XG/LBG gels were mixed at room temperature and allowed to sit for approximately ten minutes before they were subjected to testing.

All rheology measurements were taken with an AR G2 rotational rheometer. A cone-and-plate geometry (Figure 6) was used to conduct small-deformation oscillatory measurements and viscosity measurements upon the samples. The dimensions of the cone-plate-geometry are the following: 60 mm diameter and  $2^\circ$  cone angle. To avoid having the stationary lower plate and rotating upper cone touch, the upper cone was truncated by a distance of 54 microns and considered to have negligible effects on the viscosity and oscillatory measurements. The sample liquid was placed in the gap between the rotating cone and stationary plate. For a sufficiently small cone angle, the velocity field  $v_\phi$  can be represented by Equation 8.

*Equation 8*

$$v_\phi = \omega \left[ 1 - \frac{z}{h(r)} \right]$$

The gap distance between the plate and the cone is  $h(r)$  and  $z$  is the measured distance from the plate. The cone-and-plate geometry in particular was used because it provides homogeneous shear stress and strain throughout the liquid specimen, which is advantageous when interpreting experimental results for non-Newtonian fluids. The constant strain is shown in Equation 9, where  $\omega$  is the oscillation frequency and  $\alpha$  is the small cone angle in radians, represented in Equation 10 as the ratio of the gap height  $H$  to cone radius  $R$ .

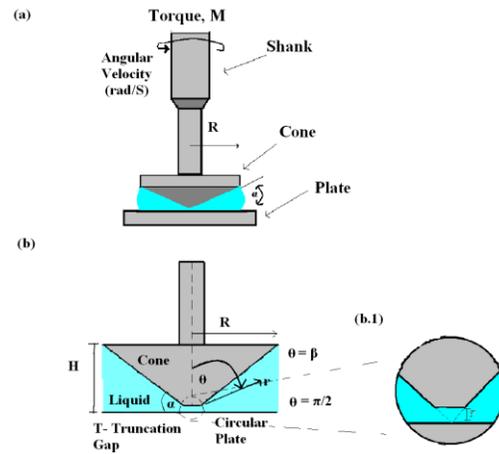
**Equation 9**

$$\gamma = \omega / \alpha$$

**Equation 10**

$$\alpha \doteq H / R$$

Steady shear flow behavior was obtained by imposing a sequence of shear rates upon the samples at 25 °C. Single viscosity data point readings were obtained when the material reached a steady state flow within a 5 percent tolerance at the specified shear rate. Shear rate was increased logarithmically over a range of 0.1000 to 100.0 (1/s), which yielded a viscosity flow curve. A multiple-step procedure was done in order to obtain the oscillatory flow behavior of the samples. To calculate viscoelastic parameters from oscillatory measurements, the rheometer assumes linear behavior under all conditions [8]. In order to minimize inertial effects and assume linearity, the pseudo linear viscoelastic region (LVR) was determined by doing a preliminary oscillatory strain sweep procedure. Within the LVR the material moduli remain constant with increasing strain amplitude at a fixed frequency, in this case 6.283 rad/s. At a high enough strain the material will undergo deformation resulting in a change in the material moduli. All subsequent oscillatory measurements were performed at strain amplitudes within this linear viscoelastic region.



**Figure 6:** a) Drawing of cone-and-plate geometry and b) close up of truncation gap between the bottom of the cone and the top of the stationary plate.

A time sweep procedure at a constant percent strain (2.835%), frequency (6.283 rad/s) and temperature (25 °C) was performed on all samples for a minimum duration of ten minutes, in order to make sure that the material properties were not changing during a given measurement time. For the LX samples, the time sweep procedure was also run for a duration of 1 hour at the temperatures 50 °C and 65 °C, again to check for time dependence of material properties and also the possible impact of sample evaporation on the measurement. The specified temperatures for this experiment were chosen due to the apparent gelling point behavior of LX within these regions as demonstrated by previous experiments. Frequency sweeps at a fixed percent strain (2.835%) and constant temperature (25 °C) were conducted on all samples over a range of 0.1 - 1000 (rad/s). Temperature sweeps in the range 25 °C to 85 °C and 15 °C to 45 °C were performed at a constant strain (2.835%) and constant frequency (6.283 rad/s),

and at a heating/cooling rate of 1 °C/min on all samples.

Liquid evaporation and outside air disturbance was minimized by covering the cone and plate geometry with a ceramic cover. Liquid evaporation was minimized further by using a solvent trap, where water was placed in the top of the cone geometry.

## Results and Data Analysis

### *Steady Shear Flow Behavior*

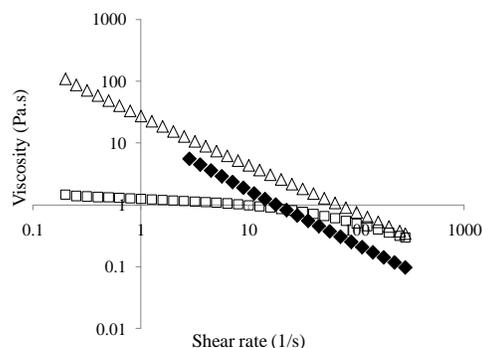
The flow behavior of the LBG system, shown in Figure 7, shows a Newtonian plateau at lower shear rates. At higher shear rates the LBG displays shear-thinning behavior. The behavior displayed by the LBG solution is typical of macromolecular solutions.

XG also demonstrates shear-thinning behavior, but over the entire range of shear rates tested. Such behavior is typical of “weak gels”. The data in this case can be fitted by the power-law model of Equation 2.

For the XG system the shear thinning constant  $k = 13.119$  and  $\eta = -0.877$ .

A Newtonian plateau, which is expected in the rheological behavior of macromolecular solutions, is not present at the lower or higher shear rates imposed upon the XG system. XG, instead, shows behavior typical of “weak gels”. At very low shear rates the molecular structure of the XG system is easily broken down.

LX, like the XG system, shows shear-thinning behavior without the presence of Newtonian plateaus. The synergistic interaction between the XG and LBG solutions results in a gel displaying a higher viscosity over a



**Figure 7:** Flow curve displaying LBG (□); XG (◆); LX (Δ).

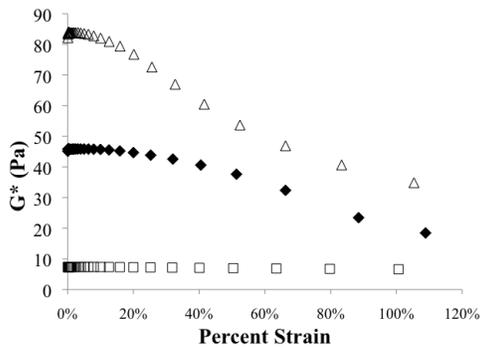
XG system the LX gel undergoes deformation even at very low shear rates.

For the LX system the shear thinning constant  $k = 27.489$  and  $\eta = -0.877$ .

### *Small-Deformation Oscillatory Flow Behavior*

The linear viscoelastic regime (LVR) was determined by systematically imposing increasing strains upon the XG, LBG and LX samples. Generally, the longer the LVR the more viscous the material [5]. LBG resulted in having the longest LVR with no observed deviation from linearity as shown in Figure 8. As is expected for gelling systems, the change from linear behavior to nonlinear behavior happens at lower strains. For XG the deviation from linearity occurs approximately at 10 % strain. LX has a small region in which the behavior of the system can be assumed linear.

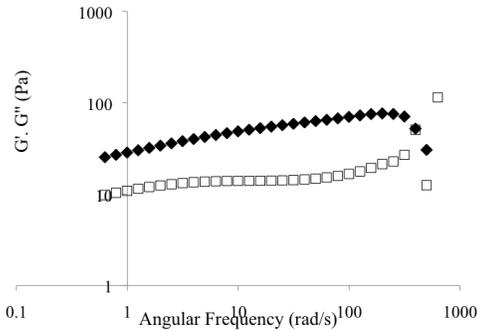
The elastic and viscous response of XG, LBG and LX when subjected to a range of frequencies can be seen in Figures 9, 10 and 11. XG (Figure 9) shows a greater elastic response than viscous



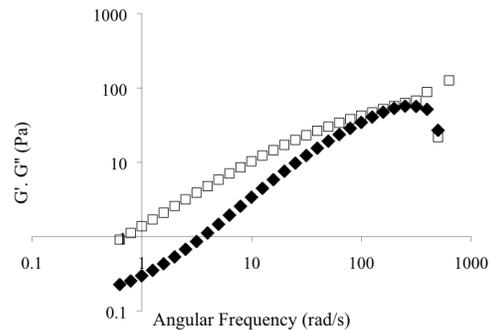
**Figure 8:** Strain sweep of XG (◆), LBG (□) and LX (Δ) systems.

response when subject to small deformation. This “weak gel” behavior shows little dependence on the imposed frequency of oscillation. Conversely, LBG shows a greater viscous response than elastic response when subjected to small deformation frequencies. This response also appears to be greatly dependent upon the degree of imposed frequency as seen by the sharp increase in the overall viscoelastic response in Figure 10.

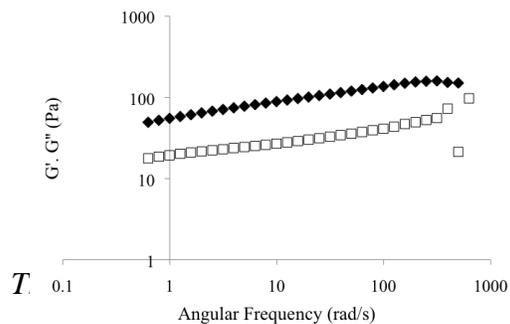
Like XG, LX (Figure 11) demonstrates behavior typical of that of gels by demonstrating a higher  $G'$  than  $G''$  over the imposed frequency of oscillation. Comparatively, the LX system shows a greater increase in the elastic response than the XG and LBG systems as displayed in Figure 12. The introduction of LBG into the XG system gives rise to an increase in the elastic behavior system. This is indicative of the extent physical crosslinking of the XG and LBG polymers.



**Figure 9:** Strain sweep of XG displaying  $G'$  (◆) and  $G''$  (□).

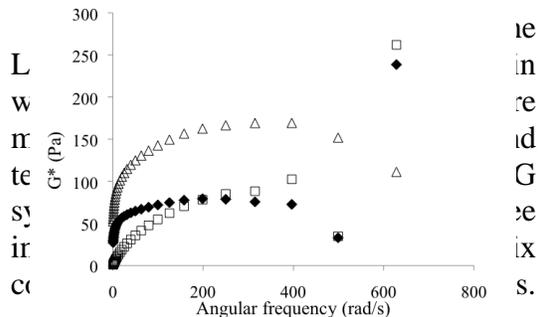


**Figure 10:** Frequency sweep of LBG displaying  $G'$  (◆) and  $G''$  (□).



**Figure 11:** Frequency sweep of LX displaying  $G'$  (◆) and  $G''$  (□).

*Thermal Behavior*



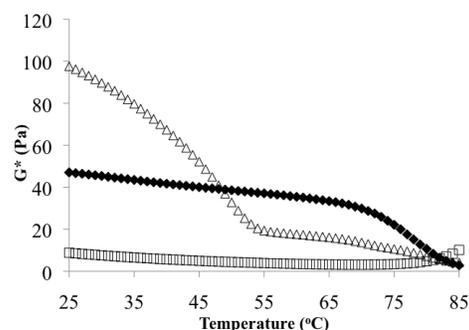
**Figure 12:** Frequency sweep displaying the  $G^*$  of LBG (□); XG (◆); LX (Δ).

The complete unwinding the XG double helix can only take place at high enough temperatures over a prolonged period of time [2].

A temperature sweep was performed on all samples over the temperature range 25 °C to 85 °C. The LX system underwent a more intensive series of temperature testing. Temperature sweeps were also conducted over the temperature range 15 °C to 45 °C. The LX sample underwent both heating and cooling in order to confirm thermally reversible behavior. Before the LX samples were subjected to testing all were mixed at 55 °C for a duration of one hour with the exception of one sample (I\*).

The XG system is characterized by one-step gel to solution transition point. In the  $G^*$  versus temperature graph (Figure 13), the decrease in  $G^*$  is gradual until approximately 70 °C at which point the decrease in  $G^*$  becomes more rapid. This change characterizes the gel to solution transition inflection point for the XG system. The structure of XG at lower temperatures is an ordered helical formation. At higher temperatures the order helical structure gives way into random coils. This new energy state allows energy imposed upon the system to be more readily dissipated.

The LBG system shows very little change in moduli over an increase



**Figure 13:** Temperature sweep ranging from 25 °C – 85 °C displaying LBG ( $\square$ ); XG ( $\blacklozenge$ ); LX ( $\triangle$ ).

in temperature. LBG, unlike the XG and LX systems, is not a cross-linked polymer network. Therefore, it cannot physically break down with an increase in temperature. The slight increase in modulus at the highest temperatures is indicative of evaporation from the plate. At high temperatures and for extended periods of time the LBG system appears to “cook”. A thin film of polymer forms along the cone and the plate of the geometry.

The LX system is characterized by a two-step gel to solution transition point. Initially, as displayed in Figure 13,  $G^*$  decreases rapidly until the first gel to solution transition point at ~ 57 °C. Up to this point, the bi-polymer gel is “melting”. As energy is introduced into the system, the physically cross-linked bonds between the XG and LBG polymers in the LX system are breaking. This permits the polymers to move past each other more readily. After the first transition step, the mechanical behavior, or the rate in which the  $G^*$  decreases with temperature, of the LX system becomes similar to that of a diluted XG solution. The second transition point for the data presented in Figure 13 occurs at 75 °C as summarized in Tables 1 and 2. For all repeated temperature sweeps upon LX the second gel to

**Table 1: Samples of LX heated from 25 to 85. Sample I\* was mixed at room temperature.**

Heating Inflection Point Temperatures °C			
Sample A	51	57	75
Sample B	48	57	79
Sample C	-	-	-
Sample D	-	-	-
Sample I*	47	56	75

**Table 2: Samples of LX cooled from 85 to 25. Sample I\* was not mixed at room temperature.**

Cooling Inflection Pt. Temperatures °C	
Sample A	-
Sample B	57
Sample C	64
Sample D	-
Sample I*	-

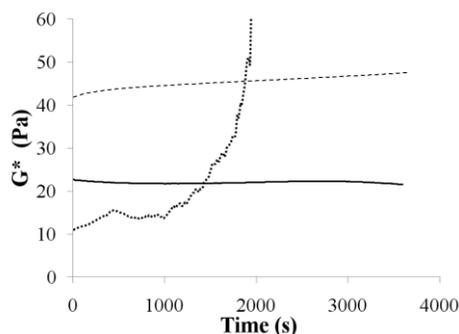
solution transition point fell within 75 °C to 80 °C.

At a fixed strain and fixed angular frequency, time sweeps of three LX samples of LX, as (summarized in Table 3 below) were run for a duration of one hour at 65 °C, 85 °C, and 50 °C respectively. The temperatures chosen were within the second phase of the two-step melting process of the LX system over the range of 25 °C to 85 °C. LX samples E,H and J were mixed at 55 °C for one hour before subjected to testing.

All samples show an increase in the  $G^*$  with time. This increase in the moduli of the LX samples is likely due to the evaporation of water from the specimens at these higher temperatures. This effect is easily observed in Figure 14, where Sample H was run at 85 °C. For Samples E and J this effect is less obvious but still observed. When Sample H was removed from the rheometer, it appeared to be “cooked”.

**Table 3: Summary of time sweep run on three separate samples of LX.**

Time Sweeps		
	Temperature	Duration
Sample E	65 °C	1 hr
Sample H	85 °C	1 hr
Sample J	50 °C	1 hr



**Figure 14: Time sweep of three separate LX samples at 50 °C (—), 65 °C (---) and 85 °C (....)**

It was a light brown brittle solid that was easily flaked away. While the behavior of the LX gel is observed to be thermally reversible over the temperature range of 25 °C to 85 °C, at high enough temperatures over a long enough period of time the sample will show signs of degradation. Therefore, care was taken in the temperature range and duration of experiment during temperature sweeps to make sure evaporation was not a factor.

### Conclusion

These experiments indicate that upon mixing, the biopolymers XG and LBG interact to form a firm thermally reversible gel. LX is characterized by having the highest moduli for all rheological measurements taken upon XG, LBG and LX systems. Evidence suggests that the physical cross-linking

between the XG and LBG polymers results in the formation of a “firmer” structure. The mechanical behavior of the LX system resembles that of strong gels. The shear flow behavior of the LX system exhibits behavior resembling that of the XG system at room temperature. At high enough temperatures, the behavior the LX system deviates from “gel-like” behavior and resembles a diluted XG system. The heating and cooling of the LX system results in a two-step transition indicative of gel to solution phase changes within the system as well as the presence of physical interactions between the XG and LBG polymers. The temperature and duration at which the XG and LBG systems were mixed to form the LX gel impacted the thermal behavior of the system.

### **Future Work**

Further rheological characterization of LX gelling systems will take place with the addition of nanoparticles to the

system. This will be in the effort to model pharmaceutical drug dispersions throughout the gels. In addition, Magnetic Resonance Imaging (MRI) measurements will be performed on the XG, LBG and LX solutions. Magnetic Resonance is capable of directly measuring the velocity field via velocity imaging, lending insight into the physical mechanisms contributing to the bulk rheology measurements, and also may be able to provide information on nanoparticle location within the gel via image contrast.

### **Acknowledgements**

Thank you to my project research advisor, Dr. Jennifer Brown for constant feedback and discussion. Thank you to the Magnetic Resonance Microscopy Lab members. Also, thank you to both the Montana State University McNair Scholars Program and Montana State University American Indian Research Opportunities (AIRO) Program for funding.

## References

1. Goycoolea, F.M., et al., *Stoichiometry and Conformation of Xanthan in Synergistic Gelation with Locust Bean Gum or Konjac Glucomannan - Evidence for Heterotypic Binding*. *Macromolecules*, 1995. 28(24): p. 8308-8320.
2. Pelletier, E., et al., *A rheological study of the order-disorder conformational transition of xanthan gum*. *Biopolymers*, 2001. 59(5): p. 339-346.
3. Mao, C.F., *Self- and cross-associations in two-component mixed polymer gels*. *Journal of Polymer Science Part B-Polymer Physics*, 2008. 46(1): p. 80-91.
4. Copetti, G., et al., *Synergistic gelation of xanthan gum with locust bean gum: a rheological investigation*. *Glycoconjugate Journal*, 1997. 14(8): p. 951-961.
5. Richter, S., T. Brand, and S. Berger, *Comparative monitoring of the gelation process of a thermoreversible gelling system made of xanthan gum and locust bean gum by dynamic light scattering and H-1 NMR spectroscopy*. *Macromolecular Rapid Communications*, 2005. 26(7): p. 548-553.
6. Barnes, H.A., *An Introduction to Rheology*. 1989, New York: Elsevier Science Publishers.
7. Ferry, J., *Viscoelastic Properties of Polymers*. 3rd ed. 1980, New York.
8. Kok, S., *Rheological study of galactomannan depolymerisation at elevated temperatures: effect of varying ph and addition of antioxidants*. *Carbohydrate Polymers*. *Carbohydrate Polymers*, 2010. 8(3).

Kuipers, Dustin

Cosmology of Incarceration: A look at the Overrepresentation of American Indians  
in Montana Prisons

Dustin Kuipers

Mentored by Dr. Walter C. Fleming

McNair's Scholars

Summer 2010

## Introduction

The following research was collected from May 17<sup>th</sup>, 2010- August 18<sup>th</sup>, 2010. Simply said, this essay looks at the state demographic of Native Americans (NA) and their disproportional numbers inside institutions of coercion.<sup>1</sup> Along with that a number of other issues arose while conducting this scholar's endeavor. The topics that will be addressed: (1) a Native American historical timeline from Trade and Intercourse Act (1790) to the present in order to better interpret the unique legal and political status of federally recognized tribes, (2) the legislation and court cases that define jurisdiction on tribal land, (3) the distinct overrepresentation of Native Americans in Montana State Prison (MSP) in Deer Lodge, Montana, (4) the qualitative research as taken from two willing previous inmates of MSP and a previous employee that were interviewed and (5) the analysis and conclusions to the evidence found to better understand this unique relationship between Native Americans and Western forms of institutions.

Prior to European invasion, the diversity of peoples and cultures in North America had existed for thousands of years. All flourished in their environments, whether sedentary or nomadic, and all had advance forms of societies, governments and economies which greatly contrasted with European systems. Native North Americans also cultivated, bred, and genetically altered a mountain grass that eventually produced corn, or maize. The exact origin of maize is unknown because "no known wild ancestor" has been found and "that maize was not domesticated, but created---almost from scratch."<sup>2</sup> This sole event changed the world forever for corn is used in a lot of modern foods in the United States. Post contact, the narrative drastically

---

<sup>1</sup> Native Americans and American Indians include the 569 federally recognized tribes and will be used broadly and interchangeably unless otherwise specified.

<sup>2</sup> Charles C. Mann, *1491: New Revelations of the Americas Before Columbus* (New York: Vintage Books, 2005), 217.

changes for Native North Americans. Many European diseases that did not exist in the Americas and extensively wiped out Native populations and those that survive partly acculturate to the European presence. European warfare wages over who possess the newly discovered continent and American Indians are cast into the middle, mostly by choice and survival. A short time later all Native Americans were marched west of the Mississippi and the populations sustained more casualties, including women and children. As the acts of warfare subsided, those indigenous peoples left were forced to preserve the little culture they had left whilst their children were being ripped away to boarding schools. These schools intended to systematically erase the traditional way of life for Native North Americans. Subsequently, they evolved and adapted into a society, into a government, and into a legal system that is alien to the teachings of their ancestors.

Here is the postulating question for my research: **Why is there a disproportional representation of Native Americans in Montana given their state population (6.4%) and their incarcerated populations (16% for males and 30% for females)?** And here is my thesis: **The overpopulation of American Indians inside Montana prisons is directly attributed to social, political, economic, and historical factors that facilitate their existence in Euro-American politics and society.**

#### Historical Timeline

The historical narrative for Native Americans, from European perspective, usually starts in 1492 as European contact commenced and leads on a long, rocky road (+500 years worth) up to the present time. For the purpose of simplicity, this essay will focus more on the 1790-

present period. In 1790, the first congressional definition was passed in the Trade and Intercourse acts that regulated trade and commerce between and with Native American tribes. Or, as William Canby explains, an act of “separating Indians and non- Indians and subjecting nearly all intersection between the two groups to federal control.”<sup>3</sup> European descendants were forming a newly independent country with which they used the philosophies of European exceptionalism and racial superiority to construct a hierarchical relationship with the Native peoples of America.

Moving down the historical timeline the Cherokee Cases starting in the 1830s was the dark time of Indian removal. Sometimes referred to as the Marshal trilogy, these three Supreme Court cases legally define what Indian nations are, and these cases are still used in Federal Indian Law today. *Johnson v. McIntosh*, 21 U.S. (8 Wheat.) 543 (1823) included a land transaction between the Cherokee and a private individual before the government said Natives cannot grant land to “anyone other than the federal government.”<sup>4</sup> A few years later, *Cherokee Nation v. Georgia*, 30 U.S. (5 Pet.) 1 (1831) and defined the Cherokee, and all American Indian nations, as “domestic dependent nations.” The last case is *Worcester v. Georgia*, 31 U.S. (6 Pet.) 515 (1832), where Chief Justice John Marshal defined Cherokee land as a place in which Georgia’s laws do not exist. During the presidency of the most famous anti-Indian, Andrew Jackson, Congress enacted the Indian Removal Act of 1830 whereby thousands of east coast American Indians were forced out of their ancestral lands west of the Mississippi river and sent to present day Oklahoma, or at that time deemed “Indian Country”.

The period from about 1850 to 1887 are referred to as the reservation movement. Military engagements across the Great Plains had many tribes forming alliances to protect their traditional

---

<sup>3</sup> William C. Canby, *Federal Indian Law in a Nut Shell*, (St. Paul, MN: West Publishing, 1998), 13.

<sup>4</sup> Canby, *Federal Indian Law*, 73.

way of life. As the concept of manifest destiny had European decedents pushing to the west, Indian and non-Indian relations became violent and subsequently forced Natives onto small plots of land called reservations. It took brutal acts of warfare and genocide to shut down the Indian resistance on the Great Plains and forcibly move those left onto reservations. The policy of assimilating the Natives into dominant culture had begun. The allotment and assimilation period (1887-1934) attempted to divert Natives away from their old ways and teach them to farm like the settlers in order for the Indians to stay in one spot and be ‘civilized.’<sup>5</sup>

In 1934, the Indian Reorganization Act (IRA) 25. U.S.C.A. 461 allowed Native Americans to reorganize their tribal and, more importantly, their political structures. By this time, the Department of Interior and Bureau of Indian Affairs (B.I.A.) had been established to deal with the “Indian problem.” The IRA allowed tribes to structure their own political bodies so long as the Secretary of Interior agreed with their proposed form of governments. With assimilation tactics in mind, these newly formed tribal political entities would most likely only be approved if they mirrored that of the United States Constitution.

From the 1950’s to the 60’s, known as the Termination era, Indians were being encouraged by the B.I.A. to leave the reservations and work in the metropolitan cities. With the B.I.A.’s support in assimilation theory, many reservation Indians relocated to larger cities to work low paying jobs. Also during this time, Congress passed Public Law 280, 67 (Stat.) 588 (1953), in which all criminal activity on reservations, among other things, was to be under the authority of the state. Following the civil rights movements in the late 60’s, the American Indian Movement (A.I.M.) rallied many Natives to meet at Wounded Knee, a historical site where a band of Lakota Indians were shot unarmed and starving in the winter of 1890. A.I.M. pressed

---

<sup>5</sup> See section on jurisdiction for discussion about allotment.

Kuipers, Dustin

the era of Tribal Self-Determination and Congress passed the Indian Civil Rights Act of 1968 (82 Stat. 77 25 U.S.C.A. 1301) among other acts that tried to ensure Native rights, such as religious freedoms.

### Jurisdiction in Indian Country

The issue of criminal jurisdiction in Indian country has become an extremely complex arena as the unique relationships between the federal government, state governments and tribal governments evolve into an entangled web of political confusion. Before reservations and allotment, tribal coercion over deviant members was handled differently than the European-American philosophies of criminality and legal proceedings. Jeffery Ian Ross and Larry Gould opined that “European (idea of the criminal justice) system rests on punishment and retribution, whereas the Native American more often relies on cooperation and consensus building.”<sup>6</sup> The strong diversity and dichotomy that exists between Euro-American and Native North American cultures always has to be taken into consideration when thinking about incarceration, jurisdiction, criminality, and criminal rehabilitation. For example, when addressing criminal jurisdiction this examination will approach it by discussing Supreme Court cases, legislation, the effects of the Allotment Act on criminal jurisdiction, and Public Law 280. All of these variables play integral roles in untangling the mass confusion concerning matters of jurisdiction on reservations in Montana to better understand the overrepresentation of Native Americans in Montana’s prisons.

From contact to assimilation, legal relations between Euro-Americans and Native Americans mostly involved treaty making, alliances in warfare, and the acquisition of Native

---

<sup>6</sup> Jeffery Ian Ross and Larry Gould, “Native Americans, Criminal Justice, Criminological Theory, and Policy Development,” in *Native Americans and the Criminal Justice System*, eds. Jeffery Ian Ross and Larry Gould (Boulder, Colorado: Paradigm Publishers, 2006), 3.

land by Europeans. The Marshal cases, during Indian Removal, defined what Indian nations are, considering their sovereignty and unique relationship to the United States government. But, of all the cases decided in Indian law concerning criminality, *Ex parte Crow Dog* 109 U.S. 556 (1883) is the most important as far as a precedent setting cases for criminal jurisprudence on tribal land. This case involved the murder of a Lower Brule Sioux, by an Oglala Sioux, that happened on the reservation and no arrest was made. The majority public was outraged that a murder was committed and no one was arrested. No other case had reached a high court that involved an Indian on Indian murder and took place on Indian land. During allotment and assimilation, The General Crimes Act held statues against murder in all claimed territories of the United States. The Supreme Court, however, ruled that the General Crimes Act excluded federal jurisdiction in criminal acts where both the offender and victim were American Indian. The court held that the responsibility of justice in this matter was of tribal jurisdiction. Essentially handing the issues of Indian crimes on Indian land over to the tribal councils and leaders to deal with, refurbishing their inherent sovereignty over criminals back to them, if only for a short time. This wrought questions about criminal jurisdiction over Indians that are not enrolled in the particular tribe where the crime took place. More recent cases (after the Indian Reorganization Act of 1934 and starting in 1924 when American Indians were finally recognized as U.S. citizens and protected under the Bill Of Rights) concern American Indians and tribal members facing double jeopardy for crimes committed. That is, being tried and prosecuted by State and federal governments as well as tribal courts. *Duro v. Reina*, 495 U.S. 676 (1990) decided that domestic dependant sovereigns did not have criminal jurisdiction over Indians who were not members of the tribe subjecting those non-members to State or federal prosecution even though the crime took place on tribal or reservation land.

The process of checks and balances that are framed inside the United States Constitution seem to work quicker with respect to Federal Indian Law. The rulings of *Crow Dog* and *Duro* show that federal and state institutions do not have jurisdiction when the crimes include Indian on Indian crimes. In response to the *Crow Dog* ruling, Congress reacted promptly and passed a new piece of legislation modifying the General Crimes Act and extended federal jurisdiction to tribal land when the crimes committed met certain criteria of criminal offences. The Major Crimes Act of 1885 originally held seven (now fourteen) major crimes that circumvented tribal sovereignty to hold and prosecute any Indian that commits these crimes whether the victims are Indian or not or whether the crime committed took place on Indian land. If any Indian or enrolled member a tribe commits a murder, rape, felony assault, etcetera on a reservation it is always a matter of federal or state jurisdiction under the Major Crimes Act. Consequently, this is the only instance in all of criminality and criminal jurisdiction in the United States from the research I collected where the *race* of the offender is completely dependent on whose jurisdiction the crime falls under. In response to *Duro*, Congress passed an act recognizing that “the inherent power Indian tribes...to exercise criminal jurisdiction over all Indians.”<sup>7</sup> Thus, this piece of legislation still conflicts with court rulings concerning criminal jurisdiction. Usually when a crime does not fit into the fourteen crimes under the Major Crimes Act, and is more often than not a misdemeanor, it is under the jurisdiction of the tribal court so long as the offender is American Indian. If an offender on a reservation is white it is always under State or federal jurisdiction according to *Oliphant v. Suquamish Indian Tribe*, 435 U.S. 191 (1978). This case postulates that Indian tribes lacked criminal jurisdiction over non-Natives considering the language of Indian Civil Rights Act of 1968. The cases and legislation explained above show matters concerning criminal jurisdiction become confusing very fast, and with the late 19<sup>th</sup>

---

<sup>7</sup> Indian Civil Rights Act of 1968 25 U.S.C.A. 1301.

century passing of the Dawes Act or General Allotment Act matters become even more confusing.

During this time, the United States government created the responsibility to assimilate Native Americans into Euro-American culture. In the Marshal rulings, Indian nations were defined as “domestic dependant nations” and “wards of the government” which stipulated that the responsibility rests in the government to ‘civilize’ Indian peoples which also entails their ‘fiduciary’ responsibility to Native Americans. They figured the most effective way to ‘civilize’ was to teach them the farming techniques of Euro-American culture and Congress enacted the Allotment Act of 1887, 24 Stat. 388. This act “authorized the president, at his discretion, to survey and break up the communal land holdings of tribes and to “allot” land holdings to individual Indians.”<sup>8</sup> The additional land on reservation was deemed as “surplus land” and was then divided out to white settlers and farmers for dimes to the acre creating a “checkerboard” effect of jurisdiction on reservation lands and perpetuating harsh relations between conflicting cultures in addition to the clash of legal institutions. Individualizing Indian allotments into 80 or 160 acre allotments decimated communal and tribal land ownership as well as tribal sovereignty and instituted a strong non-Native community inside reservation borders. Non-Natives are in no way subjected to tribal courts or prosecution for any offense including speeding and other traffic violations. They can, although, be detained by tribal police and turned over to state or county police if those departments choose to press charges. Considering these instances, the jurisdictional proceedings on reservations are awkward, specific to instances, and usually dependent on the *race* of the offender. In the 1950’s, another piece of legislation cleared some

---

<sup>8</sup> David E. Wilkins and K. Tsiannina Lomawaima, *Uneven Ground: American Indian Sovereignty and Federal Law*, (University of Oklahoma Press: Norman Publishing, 2001), 77.

of the confusion of jurisdiction on reservations but subsequently attacked another aspect of American Indian sovereignty.

Public Law 280 (PL 280), or sometimes called House Bill 55, was enacted in 1954 during the Termination period (1950-1968) that transferred almost complete jurisdiction on Indian reservations to the federal government, who thereby handed the jurisdiction to the States that house PL 280 reservations. The state of Montana has only one reservation that is deemed PL 280, Flathead reservation, where the state presides over all criminal and civil jurisdictions. In her book, *Inventing the Savage: The Social Construction of Native American Criminality*, Luana Ross describes the passing of PL 280 as “one of the most bold and discriminating actions against Natives in the legal and judicial system” and “PL 280 denies Native nations the right to govern themselves.”<sup>9</sup> This piece of legislation single-handedly erased tribal autonomy in matters concerning Indian criminality and social/tribal conflicts that happen inside reservation borders.

Many of the crimes committed on reservations by American Indians and enrolled tribal members usually involve alcohol and substance abuse. Larry Gould outlines that “alcohol is involved in 75 percent of all fatal accidents, 80 percent of all suicides and 90 percent of all homicides involving indigenous people.”<sup>10</sup> Due to the Native’s genetic vulnerabilities (the uniqueness of NA genetics), susceptibility to binge drinking, and accustomed extreme poverty on their reservations, it is not surprising that 90 percent of all homicides involving indigenous people include, in one way or another, the use of alcohol.<sup>11</sup> Bearing in mind the unique dichotomy of Euro-American and Native American cultural worldviews, PL 280 fails to involve

---

<sup>9</sup> Luana Ross, *Inventing the Savage: The Social Construction of Native American Criminality*, (Austin, Texas: University of Texas Press, 1998) 24.

<sup>10</sup> Larry Gould, “Alcoholism, Colonialism, and Crime,” in *Native Americans and the Criminal Justice System*, eds. Jeffery Ian Ross and Larry Gould (Boulder, Colorado: Paradigm Publishers, 2006), 96.

<sup>11</sup> For genetic susceptibility to modern foods and alcohol, see *Why Some Like It Hot: Food, Genes, and Cultural Diversity* by Gary Paul Nabhan.

tribal autonomy in any rehabilitative or addiction counseling for Indian criminals until retribution is made to the State for that individual's crime.

The combination of Supreme Court cases, Congressional legislation, the Allotment Act of 1887, and the initiation of House Bill 55 have resulted in what is called checkerboard jurisdiction in Indian Country. All of these factors have played a role in the defining and molding what political institution is allowed jurisprudence for criminals. Although the above paragraphs outline some of the policy, it does not entail the entire history. There is an innate difference between Native North American cultures, societies, traditions and religions that often conflict with the now dominant Euro-American culture, society, traditions and religions. Through the process of colonization and assimilation, American Indians were forced into a different world inside their own Native lands and dropped into a melting pot of a society that never even wanted them. Consequently, they now live at a social disadvantage in the criminal justice system.

#### The Overrepresentation of Incarcerated Native Americans in Montana

According to the U.S. Census Bureau, the estimated 2008 indigenous population of Montana was 6.4% of the 974,989 residents of Montana<sup>12</sup>. Native communities in Montana represent a small portion of the total state population yet represent a much higher proportion of incarcerated individuals, both men and women. According to the 2002 Montana Department of Corrections Legislative Report, Native American men represented 18.7% of incarcerated individuals in Montana and Native women represent an outstanding 30.2% of incarcerated

---

<sup>12</sup> U.S. Census Bureau: State and County Facts—the 6.4% is also individuals that are claiming one race on the census and most likely tribally enrolled.

females.<sup>13</sup> A count in June 2010 from the Department of Corrections estimated that Native American males represent about 16% of the current prison population in Montana State Prison in Deer Lodge, Montana.<sup>14</sup> These numbers beg the question of: Why does this distinct overrepresentation of incarcerated American Indians exist in Montana? These populations are unique given their federal status and sovereign status as nations, with the ability to govern themselves inside the borders of their tribal lands. The reader needs to be reminded that “Indian people must be caught up in a world not of their own making (and) find (them)selves drifting helplessly into a melting pot.”<sup>15</sup> The definite overrepresentation of American Indians inside coerced institutions of Montana is directly attributed to social, political, economic, and rehabilitative variables inside the indigenous communities of Montana.

The social factors to Native American criminality include a long, complicated history. Many of the individuals behind the percentages stated above have a direct connection and relation to those who saw and suffered the worst from colonization. That is, their ancestors and the ethnographic image of Plains Indian cultures being the resistance against the United States Cavalry and imperialism and therefore receiving the harshest acts of war and treatment from the United States military. The tribal warriors who stood up and fought against the colonizers to protect their cultures, traditions, and families from being oppressed or removed from their sacred native lands, were in turn labeled ‘criminals’ and ‘deviants’ to the greater society. Their religions were labeled ‘savage’ and ‘heathen’ and outlawed from practice. Their cultures and traditional community life were criminalized and their children taken away to strip the

---

<sup>13</sup> The numbers from 2002 do not include self-identification. With my telephone conversation with Ms. Kuka, I was informed that self-identifying Indians are now included in 2010’s numbers, which show a lower percentage of Native inmates in MSP.

<sup>14</sup> Department of Corrections, *Incarcerated Offenders by Race Code*. Data generated from OMIS 06/15/2010

<sup>15</sup> *The Seven Visions of Bull Lodge as told by his daughter, Garter Snake*, Ed. George Horse Capture, (Lincoln, Nebraska, University of Nebraska Press, 1992) 11.

intergenerational knowledge away from the unique cultures. Luana Ross outlines and analyzes these issues in her book, *Inventing the Savage*, as she addresses how the term “savage” was historically invented by *neo-colonialism* and how racial oppression is still apparent in contemporary Montana society. Relentless in her writing, she conveys that oppressed Natives communities are “couched in assimilationist rhetoric, racialized events--including treaties, reservation and pass systems, land allotments, boarding schools, and bans on Native religions--influence who Native people are today.”<sup>16</sup> The social factors of colonization are indeed disastrous for Native peoples and still influence their plight today.

Along with society, economics also plays a part in Native oppression. In 2008 poverty in Montana was at 13.6% making Montana the 16<sup>th</sup> highest in poverty rates in the United States.<sup>17</sup> From the same article, the U.S. Census Bureau revealed that Big Horn County, Blaine County, Glacier County, and Roosevelt County were the four highest poverty stricken counties and “three of the four counties are the only three counties in Montana with a majority of Native American residents.”<sup>18</sup> Criminologist Michael J. Lynch argues that life course plays a major role in the individual’s process of decision making. His theory of life course “...attempts to situate individuals within the social context in which they live and act” and “is concerned with the sociological, economically, and politically relevant forces that either enhance or limit the probability of an outcome in a life-course.”<sup>19</sup> Poverty stricken communities need to exist in order for wealthy communities like Aspen, Colorado and the Yellowstone Club in southwestern

---

<sup>16</sup> Luana Ross, *Inventing the Savage: The Social Construction of Native American Criminality*, (Austin, Texas: University of Texas Press, 1998) 52.

<sup>17</sup> David Boston, *Poverty Rates in Montana: Needs of Native American Reservations Consistently Underrepresented*, [http://poverty.suite101.com/article.cfm/povert\\_in\\_montana](http://poverty.suite101.com/article.cfm/povert_in_montana). July 20, 2008.

<sup>18</sup> Ibid.

<sup>19</sup> Michael J. Lynch, “Class, Race, Gender, and Criminology: Structured choices and the life Course.” in Dragan Milovanovic and Martin D. Schwartz, eds., *Race, Gender, and Class in Criminology: the Intersections*, (New York, New York: Garland Publishing, Inc., 1999) 6.

Montana to blossom. Elite communities like these thrive in all 50 states and have a very loud voice in the political arena and/or are major campaign contributors and/or are listened to very closely by those who make decisions for us. Native Americans, on the other hand, have almost no political voice, have some of the highest rates of alcoholism and substance abuse, have a distinct overrepresentation inside prisons, and, as nations, are confined to settling questions of sovereignty and corporate/political disputes inside the halls of long and expensive court hearings.

Aforementioned, Native communities have high rates of alcoholism and it is safe to say that the majority of American Indians in MSP most likely offended under the influence of alcohol. Larry Gould asserts that “homicide rates among indigenous people in the United States are about three times that of the overall population, and about 90 percent of those deaths involve alcohol consumption.”<sup>20</sup> Gould also criticizes the indefinite use of exploiting Indians susceptibility to alcohol addiction for private personal profit. And then, the liquor store owners being the ones who complain the most about the “drunken Indians” to the rest of the community and the police. “The people who sell alcohol to indigenous people are the same people are often the very same people who want the police to exercise a lot of control over them. They want to sell their product, but as soon as the transaction is consummated, they want the Indians to move on until they need to buy alcohol again.”<sup>21</sup> An often sad picture is painted before us on and around reservations in Montana as we look at the destructive nature alcohol has on the tribes. It is obvious alcohol abuse plays a major role in the overrepresentation of Natives in prisons.

### Qualitative Research

---

<sup>20</sup> Larry Gould, “Alcoholism, Colonialism, and Crime.” In *Native Americans and the Criminal Justice System*, eds. Jeffery Ian Ross and Larry Gould (Boulder, Colorado: Paradigm Publishers, 2006), 96.

<sup>21</sup> Ibid.

The two willing participants in my qualitative research had previously been incarcerated in Montana State Prison within the last 25 years. Their names were unrecorded and simply titled as Previous Inmate #1 (non-Native) and Previous Inmate #2 (Native). My intention was to get their perspectives and experiences with the Native demographic inside MSP, what kind of rehabilitative services M.S.P. and D.O.C. provided, and if they had any religious rights. Also, I wanted to find out more about the relationship between prisons and the social construction of race because it is often that prison subgroups are separated into racialized groups that compete against each other and those subsequent racial groups are almost always dependant an individual's security as a inmate.

Questions for Previous Inmate #1 (Non-Native):

These were the guiding questions for the interview: 1.) What were the Prison subcultures like in Montana State Prison? 2.) Were there any racists, cruel or unusual policies enforced? 3.) What kind of religious freedoms, if any, did MSP allow? 4.) What do you think about 'race' and how did your time in MSP change that? 5.) Did the rehabilitative services help you? 6.) Why or why not? Any interesting stories you want to tell about your experiences there?

Previous Inmate #1 (non-Native) was in MSP after 2000 on two separate occasions. We decided to meet at public place and I had four or five outlining questions to ask him, but I wanted the conversation to evolve and go wherever it needed. Also, I did not use the questions above in order, I would ask them at different spots of the interview when they seemed most appropriate. I had recorded what he said longhand, which consisted of mostly him talking and me writing trying to keep up. At first, I did not want to tell him exactly what I was researching to try and get him to guess what I was trying to find out, but for the sake of our time I just out right told him. I

Kuipers, Dustin

explained the overrepresentation and life course and especially how alcohol plays a key role. His response was:

**“ Yeah, natives want to portray that hard, tough guy image so they have that credibility. They get drunk and want to show the world that they’re a warrior.”**

So I immediately jumped into the rehabilitative services question and what they offer the inmates at MSP, mentioning if they were any cross-cultural services. He snickers and says:

**“No, they don’t offer any cross-cultural services, they offer the furthest thing from rehabilitative services. Their Drug Therapy program is a joke. The classes are so small and get canceled all the time and they are hard to get into. And the people that get into the drug classes will never get out (of prison), they don’t let people in who are doing a couple year stretch. They are not worried about making the inmates better citizens at all.”**

My curiosity turned to the race question. I asked him if prison subcultures were strictly divided by race. He replied:

**“ Not divided by race, per se. More like age group and who you ran with on the streets and then you were also divided by the crimes you committed sex crimes, drug crimes, violent crimes, stuff like that. No, not a whole lot of race problem. I guess the bottom line is you get what get, (those Natives) are the biggest racists too.”**

I decided to ask about religious freedoms afforded to the Native inmates in MSP and before I could finish he says:

**“Yah I hear the natives say, `we’re all being discriminated against’ when in reality they’re being convicted and sentenced to a crime that they committed just like everyone else. The natives are the biggest cry babies of them all.”<sup>22</sup>**

---

<sup>22</sup> Previous Inmate #1, interview by Dustin Kuipers, July 30<sup>th</sup>, 2010.

Kuipers, Dustin

He did say that there is a sweat lodge where they could use tobacco for their worship and once they were allowed eagle feather, but not anymore and he did not know why. We also discuss some more issues; including the nature of prisons for profit and how the state profits off MSP through the ranch, license plate factory, furniture shop, etc...

Questions for Previous Inmate #2 (Native):

These were the guiding questions for the interview: What were the Prison subcultures like in Montana State Prison? Were there any racists, cruel or unusual policies enforced? What kind of religious freedoms, if any, did MSP allow? Did those practices help with your self-esteem? What do you think about 'race' and how did your time in MSP change that? Did the rehabilitative services help you? Were they in any way affiliated with your cultural background? Why or Why not? Any interesting stories you want to tell about your experiences there?

Previous Inmate #2 (Native) is an enrolled tribal member and was in MSP prior to the 1994 Montana Clean Air act which banned smoking inside public buildings, he then reoffended years after. Again, I had a few outlining questions but wanted the interview to flow naturally. I told him what I was doing and asked first if there was any racist policy and what the prison subcultures were like.

**“Yep, them natives have a strong hold in there, they have a strong hold on prison subcultures. I think more of the racists’ policy was towards (non-Natives) because the Indians they got their sweat lodge and whatnot and they had control of the tobacco. I guess later when I wound back up in there, they had labeled some of the natives as a Security Threat Group (STG), around the time they set up these regional prisons, and they split those groups up by sending them off to regional.”**

Kuipers, Dustin

I then asked him about the tobacco and what he saw prior to the outlawing of smoking in prisons and after. He responded:

**“They always got and get the tobacco for the weekly sweat, but it’s all got to go through high security and all that non-sense and after they banned smoking, it seems like a double standard is put in place and the Natives smuggle it in now. Hell, I bought a cigarette for 5 bucks. That’s a whole week’s wages!”**

I tried to get him to talk about some of the contraband and drug trafficking inside MSP and he kind of cut me off and said:

**“With the Natives drugs ain’t the problem, its lack of self-esteem, poor upbringing, boredom, lack of education. Indians who grow up on the reservation, end up on the reservation, there is no medium all or nothing.”**

I asked him to elaborate on education and he said:

**“Education should be required to be completed by all inmates. It is not mandatory for them to go to G.E.D. programs and the like.....a lot of guys in there can lift a ton of weight and can’t spell a single word.”<sup>23</sup>**

We spoke some more of things like healthcare and correctional officers until we finished our conversation and went our separate ways. As I left, I was interested by his idea on making education mandatory for inmates as a part of rehabilitation.

Another willing participant I found to interview was a previous employee of MSP and had worked there in last five years as some kind of counselor. This particular individual was non-Native, but I could tell he had a sympathetic heart for the struggle of the Native American inside and outside of institutions. He will be referred to as Previous Employee of MSP. Like the other interviews, I brought a guideline of questions to ask him.

#### Questions for Previous Employee of MSP:

---

<sup>23</sup> Previous Inmate #2, interviewed by Dustin Kuipers, August 6<sup>th</sup>, 2010.

Kuipers, Dustin

These were the guiding question for the interview: Without going into specifics, explain your typical day at MSP. How much of the total inmate population were you exposed to? Did you feel that they were any racists, cruel or unusual policies or punishments implemented at MSP? Did you or any of the other employees receive cross-cultural training? Criminologist Michael J. Lynch postulates a premise that “Life Course” plays a major role in who people are and what they do. Do you agree? Why or why not?

Unlike the other interviews where I had the questions next to my McNair notebook, I showed the guideline questions to the Previous Employee and he answered the questions in order as he held my research outline. He would read the questions to me as our discussions concluded on good points and we could move onto the next question. As I asked him the first question, “Without going into specifics, explain your typical day at MSP”, he started being very specific. **“Deer Lodge, Montana is a desolate place with almost no social networks they had one bar and it was the cliky local people. Anyway, I would leave my house about 7:30 in the morning and drive the six miles out of town to MSP. A few minutes before 8:00 a.m. I would pull into the 1<sup>st</sup> checkpoint at the Wallace building and walk through the metal detector...”**

I had asked him what they were looking for with the metal detector because if an employee wanted to smuggle in drugs or tobacco the metal detector would not catch that. He continued to say:

**“The metal detector was for security, to make sure employees were not smuggling in weapons, they were not really looking for “contraband”, unless the metal detector was off.”**

Then we moved onto the next question because I wanted to know how much of the population he was exposed to at MSP to get an idea of how many American Indians an employee could be exposed to in a given day or week of work. He replied:

Kuipers, Dustin

**“I worked mostly on the low side, A through E unites and I worked on one of those a week. I guess I was exposed to less than 10% of the entire inmate population and they were mostly (criminal) offenders. My case load was about 35 people a week and 6 or so were Native American.”**

I asked him if he thought that was a high number of Native Americans and said he did. That indicates that Native Americans represented about 17% percent of his weekly case loads on the low side. We moved on to the next question about racists or cruel policies at MSP. He nodded his head and said:

**“A number of things have blinds spots in the procedures. I know in Crow society, cousins are just as important as fathers or brothers and funeral procedures say only close biological relationship, father, mother, sister, in order for an inmate to leave MSP and to go to the funeral. The inmates also have to pay for the correctional officer’s hourly wage to be escorted to the funeral. I remember a Crow man who’s father died, and he couldn’t go to the funeral because of financial reasons and he wanted to cut his hair in mourning, but MSP would throw his hair away if he did. Policies were very unflexible in relation to the traditional way of Native versus the western conception of how a culture should be.”**

I then asked him about religious freedoms and we discussed the weekly ceremonial sweat as well as tobacco inside the weekly sweat. Our attention was then turned to eagle feather and objects of worship for Natives.

**“Eagle feather and plumes are considered the same thing to the correctional officers, to the Natives they are completely different and completely significant for their spirituality...”**

He would stop half way through a sentence and try to remember concrete examples of racist employees and/or policies.

**“Blatant examples of employee racism was when you come out of the first sally port<sup>24</sup> at MSP, and there is a concrete wall decorated in tiles with different dioramas that teach people about life, they say things like: God,**

---

<sup>24</sup> A sally port is a secured door or entry. Typical of a room where one door closes completely behind you until the other port of entry opens, usually operated from outside the sally port.

Kuipers, Dustin

**Family, Life, Love... and one is of a Native American man praying into a pipe with the colors of the Four Directions and this officer said it needed to be taken down because he thought it was gang affiliated. Things that are used for Native culture are seen as gang-affiliated and when I went through training, the instructor said that Native Americans are the biggest gang problem in MSP.”**

We finished on that note and went our separate ways. I expressed my gratitude to him for taking the time to do this interview for me and he also gave some names and numbers of other previous employees that could be of assistance. I ran into a time constraint and could not reach these people in time. If I do decide or have the opportunity to continue this research I will already have more people to talk to.

### Conclusion

Being new to research on this type of scale, I ran into many snags and many problems. While consistently being transferred between a number of Department of Correction's employees, I was finally put in contact to Myrna Kuka. She is the American Indian Liaison for the Department of Corrections (D.O.C.). She was very helpful with sending me current inmate numbers and briefly discussing some aspects of her job and knowledge of the Native inmate population with Montana. Weighing the options of trying to get the best data, I thought a survey of D.O.C. would do well and was put in touch with Linda Moodrey, the Public Information officer. As I tried to think of the perfect questions to ask these employees, I found that I could not get the kind of data I wanted on the Native populous inside MSP.

Using the book that first got me interested in this topic, I decided that interviews would work better in understanding this unique population. I thought my best bet was to talk to Linda Moodrey, because I had heard she had been with D.O.C. for thirty years and I could get some real insight to the matter at hand. Mistakenly, through an email, I asked to interview her and to

Kuipers, Dustin

discuss cross-cultural rehabilitative services or other religious freedoms offered to the Native inmate population. She never did reply, even after a couple more emails. Desperate to talk to an inmate I tried to reach Lester Killsonotop, a Cheyenne doing two life sentences, asking the same thing--to discuss cross-cultural rehabilitative services or other religious freedoms offered to the Native inmate population.<sup>25</sup> I never did hear from him either, but now I am convinced that D.O.C. read the hand-written letter I wrote and immediately threw it out. Costly mistakes, but ones I will not have to make again.

A sad narrative encompasses the reality of the indigenous peoples of America and continues to be written in the pages of history today. This indigenous narrative includes a strong story of cultural survival and an endless legal battle with the United States government. The issue of jurisdiction on Indian land begs questions that still have not been fully answered. When freely allowed to practice their traditional way of life, they flourished and live in a harmonious existence with nature. Now, reserved to plots of sometimes unwanted land, and in most cases, the most poverty stricken community in the state, the majority of their children are born destined to end up in some form of institution during the course of their lives. The historical, social, political, and economic factors of Euro-American cultures implicate Native Americans as criminal and therefore one of the reasons to their overrepresentation inside prisons.

Charles W. Mills describes a theory of epistemology. The epistemology of ignorance, as he calls it, is a factor of the Racial Contract, "*the Racial Contract prescribes for its signatories and inverted epistemology, an epistemology of ignorance, a particular pattern of localized and global cognitive dysfunctions (which are psychologically and socially functional), producing the ironic outcome that whites will in general be unable to understand the world they themselves*

---

<sup>25</sup> See Lester Killsonotop, Interview by Marie Novakova and Zach Franz, *Common Ground*, Prague, 2007.

*have made.*”(Italics used by author)<sup>26</sup> This theory assesses the devastations of colonization and assimilation as they have systematically attempted to erase Native and indigenous cultures, or in Mills’ case African-Americans, and thus has become advantages for whites (whites being the category of Caucasian or of Anglo-European descent in the social constructions of race) and white politics that this ignorance operates on a sub-conscious or non-conscious level. Europeans made the world with live in today and while producing this “New World” they used a dysfunctional criterion of ‘race’ hierarchy that is advantageous to them and those that are genetically predisposed to the social norm of being ‘white’. Consequently in contemporary society, white politics cannot see or understand the world that has been made for those non-whites, including Native Americans.

My qualitative analysis entails a common narrative throughout the three interviews; that Native Americans, and all inmates, who are incarcerated have no rehabilitative services offered to them and also have a strong hold inside the prison subcultures of Montana State Prison. The state profit made from the countless trades inside MSP including, but not limited to, the lumber yard, dairy farm, furniture store, license plate and sign factory, and canteen services provide the state major profits in goods from the extremely cheap labor of the incarcerated individuals. One can say that inmates are like a customer to the prison. If the prison provides rehabilitative services and the person becomes ready for society, then the state will lose that customer and profits that come from incarcerated criminals. So they keep the prison full and overpopulated. As Previous Inmate #1 stipulated, they offer the furthest thing from rehabilitative services and “are not worried about making the inmates better citizens at all.” Also, with the enactments of PL 280 and other laws, tribal autonomy over their deviant members is erased and thus the

---

<sup>26</sup> Charles W. Mills, *The Racial Contract*, (Ithaca, New York: Cornell University Press, 1997) 18.

rehabilitative services through traditional healing are abolished. Previous Inmate #2 had an interesting idea about making education mandatory for ALL inmates, regardless of their social or cultural standings, and this could provide them with some tools to make it on the outside. The Previous Employee showed that procedures and policies look at the Natives as a gang and not as cultures that have unique needs. Ignorance is the opposite of education and these perspective employees for the Department of Corrections should be educated on Montana Native culture, so the epistemology of ignorance does not cloud their judgment inside the walls of MSP.

The social factors of criminal Indians on reservations entail the extreme impoverishment on reservations, the lack of financial support and subsequently improper legal representation in court. Those who cannot afford an attorney are appointed one by the state who may or may not be whole heartedly concerned with representing their client. Or, it has been argued that American Indians receive harsher sentences than non-Natives. As an inmate conveyed in an interview, “I think that the State of Montana ain’t fair with Native American’s justice system. The sentences they give us—they give us more harsher sentences than they give to non-Indians. Like they gave me and my brother. Since I’ve been here, I have seen a lot of white people that got smaller sentences for the same things than Native Americans.”<sup>27</sup> Lester was sentenced to death by a Montana Judge but it was later overturned because the state did not have enough evidence. Instead, he has received two consecutive life sentences which is a sentence he no doubt deserves. Native Americans lost the world, whether by conquest or disease, that they once flourished in and had to rebuild their nations through assimilating into a European influenced culture.

---

<sup>27</sup> Lester Killsontop, Interview by Marie Novakova and Zach Franz, *Common Ground*, Prague, 2007.

## Bibliography

- Boston, David. *Poverty Rates in Montana: Needs of Native American Reservations Consistently Underrepresented*, [http://poverty.suite101.com/article.cfm/povert\\_in\\_montana](http://poverty.suite101.com/article.cfm/povert_in_montana). July 20, 2008.
- Canby, William C. *American Indian In A Nut Shell*. St. Paul, MN: West Publishing Group, 2004.
- Horse Capture, George, ed. *The Seven Visions of Bull Lodge as told by his daughter, Garter Snake*. Lincoln, NB: University of Nebraska Press, 1980.
- Killsontop, Lester. Interviewed by Maria Novakova and Zach Franz. *Common Ground*. Prague, 2007.
- Lynch, Michael J. "Class, Race, Gender and Criminology: Structured Choices and the Life Course." In *Race, Gender and Class in Criminology: The Intersections*, eds. Dragan Milovanovic and Martin D. Schwartz, New York, NY: Garland Publishing, 1999.
- Mann, Charles C. *1491: New Revelations of the Americas Before Columbus*. New York: Vintage Books, 2005.
- Mills, Charles W. *The Racial Contract*. Ithaca: Cornell University Press, 1997.
- Nabhan, Gary Paul. *Why Some Like It Hot: Foods, Genes and Cultural Diversity*. Washington, D.C.: Island Press, 2004.
- Ross, Luana. *Inventing the Savage: The Social Construction of Native American Criminality*. Austin, TX: University of Texas Press, 1998.
- Ross, Jeffery Ian and Larry Gould. *Native Americans and the Criminal Justice System*. Boulder Colorado: Paradigm Publishers, 2006.
- U.S. Census Bureau, *Montana QuickFacts*: <http://quickfactsw.census.gov/qfd/states/30000.html>. April 22, 2010.
- Wilkins, David E. and K. Tsianina Lomawaima. *Uneven Ground: American Indian Sovereignty and Federal Law*. University of Oklahoma Press: Norman Publishing, 2001.

## **Water, the Essence of Survival and the Symbol of Oppression: Gender Inequalities Collide with Development**

### **Introduction:**

There are many images that pop into my head when I think of Africa. I think of: grasslands; giraffes and zebras grazing in the Serengeti; baboons ransacking houses; the vibrant red colors of the Maasai people; the minarets that tower over the buildings in Fez; the Bedouins traversing the sea of sand on their graceful camels; young girls and boys walking the red clay dirt paths to go to school; and mothers and older girls walking miles and miles up and down steep trails to gather water. It is those last few images of women and girls walking to gather water, which, for me, inspires an ominous feeling about Africa. Africa is a rich and diverse continent that is riddled with poverty and home to many development projects.

Women are to give birth to healthy children. Women are to care and nurture their family. When one's country is stricken with famine and hunger women will give everything to make sure her children and husband are fed. In times of hardship women are the first to make the sacrifices. In Africa women living in rural areas often have to travel miles to gather water to complete daily activities like cooking and laundry. It seems as if spending the day collecting water expresses the gender inequalities that affect so many women. However, I explore different modes of inequalities like education, religion, and female genital mutilation. I take into consideration the fact that roughly 90 million girls and women are affected by female genital mutilation, and about 2 million Kenyans are riddled with HIV/Aids<sup>1</sup>. Looking at these different

---

<sup>1</sup> Statistics found at [www.who.int](http://www.who.int) and [www.kenya.usaid.gov](http://www.kenya.usaid.gov)

Malone, Megan

areas of inequalities I take the stance that water is a symbol of oppression and not the reason for gender inequalities. The cultural barriers placed before women such as the education system, polygamy, and societal stigmas collide with global development and bring to light the areas in which women struggle. Through the analysis of focus groups, case studies and ethnographic work, this paper will explore gender inequalities. Their inequalities have become quite apparent to me during my time with a nongovernmental organization in the developing Western Province of Kenya. In this paper I will treat water as a symbol of gender inequalities. This paper brings attention to the barriers to gender equality that are revealed by collecting water.

## **Background**

Engineers Without Borders-Montana State University (EWB-MSU) chapter has been working in the Khwisero district of the Western Province in Kenya for the past 6 years. Ronald Omyanga, a native of the Khwisero district, wrote a proposal to Engineers Without Borders-USA (EWB-USA) in 2004 looking for a way to improve access to water and develop sanitation in his home village by way of supplying the primary schools with boreholes and composting latrines. EWB-USA accepted Ronald's proposal and handed the project over to EWB-MSU. One aspect of Ronald's proposal claimed that by improving sanitation and drilling boreholes, girls would not have to spend as much time gathering water and therefore would be able to spend more time in school. When I read that initial proposal I questioned how something as simple as building a borehole or a composting latrine could change the girls' lives so dramatically. This was also not the first time I have heard people reference some kind of relationship between water and gender inequalities. This is indeed a common argument in the development literature (Zwarteveen 1997; Nations 2005; Ray 2007). While working in Kenya I saw many young girls walk to and from school every day. No sooner had I seen the girls leave for school to head to their

Malone, Megan

compound, they were down at a borehole or protected spring collecting water for the evening. My general inquiry for my research was to observe what gender inequalities impeded the women from leaving the compound and how water was connected to that. Was it the culture behind FGM or HIV/Aids or was it something rooted in the understanding of the roles of men and women. But upon initial observations made during my first visit to Kenya, I found that gender roles and education were the root of the inequality.

During the summer of 2009 I traveled with EWB-MSU to Kenya. I spent six weeks trying to understand the impact that EWB, a non-governmental organization (NGO), was having on a developing country in a rural district that has had the presence of NGO's for most of its history as an independent country. While I was working for EWB-MSU (2009-2010) I conducted initial research based on interviews and observations to better understand the connection between water and gender inequalities (however, at the time I was just trying to understand the connection between collecting water and women's daily activities). For my first trip (2009) I had six weeks to build relationships with the women in the area, meet with head teachers of some of the primary schools, hold focus groups, and spend time with Nellie, the wife of the Kenyan coordinator for EWB-MSU.

Ronald is from the Khwisero district in the Western Province but has been living in Nairobi for a number of years. He is now a professional architect who spends much of his time working with the UMANDE Trust (<http://www.umande.org>) that has been building biogas latrines in the Kibera slum. However, most of his family still remains in the Khwisero region. Jackson Nashitsakha, Ronald's uncle, is the coordinator of the EWB-Kenya team who determines which primary schools have the most need for a latrine or borehole. He also helps decide where each EWB-MSU team stays during the implementation trips. EWB-MSU recently

Malone, Megan

designed and placed a composting latrine at the Shirali Primary school. Ronald's vision for Khwisero has been to develop it and by turning his project over to EWB-MSU he has been able to work on developing the slums.

### *Free Education in Kenya*

The Kenyan Education system, along with most developing countries, changed drastically when the United Nations Educational, Scientific and Cultural Organization, UNESCO, established the *Education for All* movement, a goal to be reached by 2015.

Established in 1990, *Education for All* has six goals:

- 1) Expanding and improving comprehensive early childhood care and education, especially for the most vulnerable and disadvantaged children.
- 2) Ensuring that by 2015 all children, particularly girls, children in difficult circumstances and those belonging to ethnic minorities, have access to, and complete, free and compulsory primary education of good quality.
- 3) Ensuring that the learning needs of all young people and adults are met through equitable access to appropriate learning and life skills programmes
- 4) Achieving a 50% improvement in levels of adult literacy by 2015, especially for women, and equitable access to basic and continuing education for all adults.
- 5) Eliminating gender disparities in primary and secondary education by 2005, and achieving gender equality in education by 2015, with a focus on ensuring girls' full and equal access to and achievement in basic education of good quality.
- 6) Improving all aspects of the quality of education and ensuring excellence of all so that recognized measurable learning outcomes are achieved by all, especially in literacy, numeracy, and essential life skills. (Unesco.org)

In the Khwisero district there are approximately 58 primary schools and the ministry of education divides the primary schools into East and West divisions. Those 58 primary schools do not fall under the same categorization of private versus public institutions. Most of the schools were established by a missionary group but now the government maintains them. Missionary groups do not play the same role in primary schools as they did before.

Malone, Megan

In 2003, the government passed a law that it is mandatory for children to attend primary school, and to get at least 8 years of formal education. However, secondary and post secondary institutions remain expensive and one man I met said it cost him and his family about 200,000 KES (2,478.31 USD) per child. The main philosophy behind a formal education in Kenya is to promote a,

“...holistic quality education and training that promotes education that involves both cognitive and affective domains. Instilling values such as patriotism, equality, peace, security, honesty, humility, love, respect, tolerance, cooperation, and democracy through education and training will be critical (section 3.1 (Ministry of Education 2004)).”

Another aspect of the education policy is one that questions the issue of equality. The policy recognizes inequality and gender boundaries and suggests how to overcome this. The policy says educators need “to ensure that all children, including girls, children in difficult circumstances, and those from marginalized/vulnerable groups, have access to and completely free and compulsory primary education by 2010(Ministry of Education 2004). How do they know who is on a need basis, when some of these rural areas have very poor people? But also, the education is not completely free because each family needs to buy uniforms and books for their children. According to one head teacher I spoke with, money from the government is based on enrollment. Each child that the school is able to have attend, the government gives the school 185 KES per child, that is roughly \$2.50.

**Methods:**

I am a student of sociology and anthropology. EWB-MSU needed a social scientist’s perspective to help with their implementation trips. It is important to have a specialist in culture and society during development projects because he/she is trained to understand the feelings of the society. Even though EWB-MSU was just placing latrines and boreholes at primary schools,

Malone, Megan

they are also developing a culture. EWB-MSU needed to see the significance of the culture behind collecting water and the cultural impact of a borehole and a latrine. For example, I posed questions to the teams like, “What impact does collecting water have for women?” “How would women fill their time if they were not gathering water?” and “Is there a direct translation for the word ‘maintenance’ in Luhya?” It is important to have a person who can act as mediator and a sounding board so that before projects get too far along, the community is comfortable with the progress and the developers understand the reality of the community. I was able to travel with EWB-MSU because I was the sole anthropology volunteer and one of three sociology volunteers.

The first summer I was with EWB-MSU, along with my own research, I helped train local Kenyans to conduct household surveys. The purpose of this was to try and track the consumption rate and habits for collecting water. I helped the group come up with the appropriate questions so that they would not pry too deeply into personal life and not offend anyone. We created the surveys, and then they were translated into Luhya, the local language, and not Swahili so that there would be a complete understanding of what the question was asking. Swahili is taught to the children at the same time English is. English and Swahili are the two official languages of Kenya; at home the children are learning their family’s local/tribal language. These surveys had questions concerning water usage and habits. One of the tasks I gave the sociologists of the group was to walk with the local surveyors to GPS the location of each household we surveyed, and to give the locals a familiar face. It was important to establish relationships with the locals so that the locals felt that they could come and talk to us about any concerns they might have with the survey and what we were doing as an organization. I spent time explaining to the communities in the east area of the district how the surveys would help us and their community. Luckily, since there has been a history of different NGOs working in the

Malone, Megan

area they were used to people asking about surveys. This later helped when I approached the local women about writing time stamps, because according to Ronald, past surveyors have asked for articles like time stamps. Time stamps/journals are another form of data collection that gives the participant a lot of freedom on the information shared. The use and purpose of time stamps will be explained further on in the reading.

Fortunately, I had the privilege this summer, 2010, of traveling with EWB-MSU again as a project manager. As project manager I was in charge of a travel team made up of four engineering students. I worked as a moderator between the primary school's community and my travel team, and I made sure that things ran as smoothly as possible for the construction of the borehole and the composting latrine. My team and I were placed in the East division with the Elwangale and the Ekatsombero primary schools.<sup>2</sup> While I was there this summer I worked with a team of engineers to create a composting latrine and drill a borehole. I was able to continue my research from the previous summer. Through my initial research based on observation, limited interviews, and focus groups, I concentrated on the daily activities of the women in western Kenya. Through my field research my interpretation of their struggles shifted to see access to water as only one of many indicators of their status in society. What stood out most in my data is how the cultural expectations of gender conduct in rural Kenya collided with the progression of modernization in the developing country.

### *English as a Second Language*

Rina became a part of my research because I spoke to her often but only a few times was there another Kenyan around to help translate however I learned a lot about the inequalities that

---

<sup>2</sup> For the last three weeks of my trip in 2009 I spent time working with the community around the Ekatsombero primary school. The relationships I created during that time impacted my research for this summer.

Malone, Megan

can befall women in the area from her. Most of the time I would sit with her in the kitchen or help her with the laundry. It was during those times that we had to try and figure out different ways to communicate. Often enough it ended in laughter. The point I am making is that with the information that I took down each night, I questioned how wrong my interpretation was. Unless, there is a common language, there is meaning and culture that is lost in the interpretation. Todd Edwin Jones argues that ethnographers cannot really understand belief ascriptions (Jones 2000). How do you observe meaning? When people speak with one another in their native tongue the ideas and meaning themselves are not always clear. So, when there is a language barrier than it is even harder to find meaning. Jones states,

[the problem] is that the behavior or environment we observe can't tell us what beliefs are there, unless we first know about the other auxiliary beliefs that are 'in the neighborhood,' contributing to the production of a certain behavior or the formation of a new belief (2000).

For example, EWB-MSU cannot just build a composting latrine or a borehole without people being trained to maintain the pieces of equipment. What if in their native language there is no term for "maintenance?" Most meetings and training sessions, we hold are in Luhya, their tribal language, but even then the translator does not fully understand our meaning. This will continue to remain an issue.

Ethnographic research was my main form of gathering information during my first trip in 2009. I led three focus groups, with 7 to 8 teachers at a time. This past summer, 2010, I utilized another kind of research method, time stamps, which I have turned into case studies. Time stamps are a way for the individuals participating to calculate how much of their time is spent on activities throughout the day.

Malone, Megan

*Ethnographies & Focus Groups*

I spent 6 weeks in Kenya during the summer of 2009. There were a few different focuses of my trip; the first was to learn how the Khwisero community was responding to the work that EWB was doing. But I was also there to work with the young girls and women of the community. My initial idea was to take a pedometer and collect water with some of the women and figure out how far they walked. I found that I could collect vital information spending time in the kitchen or around the compound with the women and all the pedometer would do was tell me how far they went. But instead I spent time talking and watching the interactions between EWB-MSU and the community.

Ethnographic work was my first step to gaining insight into the connection between water and gender inequalities. The point of ethnographies is to watch and take note of “different cultures and subcultures to make sense of their lived reality (Sharlene Nagy Hesse-Biber and Leavy 2006). As a participant observer, it was best for me to watch and write down my questions before approaching the women with those questions. To note, the language barrier was made less apparent when I was just observing people’s daily activities. Language barriers allow researchers to miss part of the cultural context of the people they are studying. However, daily labor tasks look similar. For example, collecting water for some looks like going to the kitchen sink and filling a pitcher or glass full of water, for others it is taking a bucket down to a stream, filling it with water, than carrying it on their head back to their home. Or doing the laundry: for me, doing the laundry is placing my clothes in the washing machine, adding soap, and pressing some buttons. For those in Khwisero washing their clothes consists of gathering three or four

Malone, Megan

buckets of water<sup>3</sup>, then spending three or four hours hand washing their clothes. My point is that women's tasks are fairly universal.

Though I had some reserves about trying focus groups in a foreign country, I knew that they would be the best way to gather information and data. Focus groups provide insight into a culture through a small group of people. But not only are you looking for their answers, but you are looking to their reactions. You have to be tuned into how the emotions of the group change. I had never actually held a focus group in previous projects of mine, so I was aware of my goal, but did not know how well I could interpret their emotions. I think focus groups are important to incorporate into one's research because they allow the participants to interact with one another and even invent new ideas because their ideas play off of one another. Hesse-Biber and Leavy explain that focus groups help to "generate, develop, and screen ideas or concepts." I was able to define my research topic. To "generate" the information concerning gender inequalities and even development ideologies, my focus groups were composed solely of women that were the teachers of three of the primary schools that EWB-MSU work at.

To gather participants for the focus group, I asked the head teachers of Shirali, Ekatsombero, and Mwisena primary schools if I could interview the female teachers of their schools. I was invited to come during their break. For all three group sessions, I told the women what the goal of the interview was and that they did not have to answer any of the questions. I had some question in mind but I really wanted to just generate conversation so that they would just start discussing issues among themselves. I did not ask about gender roles or inequality, rather I asked them what issues they ran into trying to work and take care of their children. I also

---

<sup>3</sup> They used jerry cans and drums to collect water

Malone, Megan

allowed them to ask me questions about the United States.<sup>4</sup> The focus groups lasted anywhere from 30 minutes to 45 minutes. The teachers from Ekatsombero were least receptive while the teachers at Mwisena were the most receptive.

### *Time stamps*

Time stamps were a new and important method for me to try because it gave insight into another angle into the women's lives. In many respects time stamps are like in-depth interviews. A researcher does not collect as many time stamps as they would surveys. The purpose of the time stamp is for women to write down their daily activities according to how they break down time. Time stamps gave the women the ability to track their tasks throughout the days. I had them keep track of their time for seven days from when they woke up to when they went to sleep. I did not tell them how to break down their day; I just suggested that they write down every task once it was completed. I am able to look at how they divide up their time and what they prioritize. The women seemed to break down their day according to task and chore.

Another reason I gave them time stamps was so that I would not inhibit their work. I am very aware that my presence is daunting. With the Kenyan culture everyone is a guest who does not live on their compound, so whenever I was with the women they were constantly worried I was not comfortable. So, time stamp allowed them to be fully honest and not worry about my presence.

---

<sup>4</sup> I thought this was important because allowing them to ask me question gave me insight on some of the issues that concerned them.

## Literature Review

This section looks into different aspects of development and gender studies. The literature review looks at the language barriers and challenges associated with ethnographic research; issues concerning water and development; how women play a role in development; and what I see as the important institutions that have to be put in place or changed before water and land rights can become a focus or reality for women. The practices I focus on are female genital mutilation/cutting (FGM/C), polygamous marriages, and the dynamic battle of education rights. Concerning education, I look specifically at the goals of *Education for All*, enacted by the United Nations Educational, Scientific, and Cultural Organizations (UNESCO) and how they affect young girls in Kenya. FGM/C will be approached from cultural and scientific perspectives.

When I travelled to Kenya, I knew they spoke English as one of at least three languages that they know. English and Swahili are the two official languages of Kenya, while each household speaks their tribal language. There were a few Kenyans in the Khwisero district that I met that also knew Arabic because they travelled up north to find work or they were from the coast that has as a high Arab population. In my opinion research is hard to analyze, even when both the researcher and the participant speak the same language fluently. However, working in Khwisero, where they speak mostly Luhya and Swahili, trying to gather information was hard.

The women I worked with and interviewed all spoke English well, which made research easier. They were the women I spent the most time with during my first trip. Heading back this past summer, Christine the mama of the house where my team stayed at Elwangale spoke English very well, however, this trip around Rina who spoke very little English I spent the most time with.

*Women's Interactions with Development*

Water policies and gender inequalities were established as an important aspect of development in the mid 1970's (Ray 2007) however early on in the studies, questions were posed concerning how women should be incorporated into the development policies. Part of the debate was whether or not women should be just considered in development projects or should the women be actively involved in how projects are conducted. Studies are showing that there is a slight beneficial outcome if women are directly involved in the design and implementation of projects, but it is not conclusive (Zwarteveen 1997; Nations 2005; Ray 2007).

Another way to look at it is through the eyes of Isha Ray. Again the issue in the literature concerning women and development are the ideological shift in women *in* development, women *environment* and development, and gender *and* development. The approach that women *in* development theory takes is to just take women and throw them into development, assuming that just women giving their opinion is enough for development. While gender *and* development looks at the relationships between men and women, the cultural implications of what it means to be a man or woman, and how women will be effected by development. It is argued in the literature on water *in* development that women need easier access to water so that they can spend their "new" free time working on providing a new source of income to the family while gender *and* development addresses the complexities of the dynamics between men and women and what women need. The other issue that gender *and* development assess is how women's roles have been formed through cultural, ethnic, and social ties throughout history (Ray 2007). Women, *the environment*, and development argues that women have a special tie to natural resources and have an understanding for the land and water that others do not understand because women need to understand the land to feed and care for the family (Ray 2007).

The International Conference on Water and the Environment held in Dublin, Ireland, in 1992, established four points to which water and sustainable development policies should be based on. The points are referred to as the Dublin Principles which state the following:

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
2. Water development and management should be based on a participatory approach, involving users, planners, and policy makers at all levels.
3. Women play a central part in the provision, management and safeguarding of water.
4. Water has an economic value in all its competing uses and should be recognized as an economic good. (Ray 2007)

I think that these four principles are important to be aware of when development projects are being produced. Again, I question whether or not water should have an economic value attached to it, since it is the essence of sustaining life. Based off of experiences working with EWB-MSU water should not have a monetary value, but the maintenance of the pump and other machinery should have value placed on it.

#### *Female Genital Mutilation/Cutting (FGM/C)*

Female Genital Mutilation/Cutting (FGM/G) is a procedure that alters the vagina and makes it painful to impossible to have sex. According to The World Health Organization (WHO), FGM/C affects between 100 and 140 million young girls and women. There are four different techniques to FGM/C: clitreductomy, partial or full removal of the clitoris; excision, partial or total removal of the clitoris, the labia minora, and sometimes the labia majora; infibulation, which is the narrowing of the vagina with a seal by cutting and reposition parts of

Malone, Megan

the labia and removing the clitoris; finally, there is other forms of harming the vagina and clitoris by forms of pricking, piercing, incising, scraping and cauterizing the genital area<sup>5</sup>.

The procedure starts between the ages of infancy to fifteen years of age and in Africa alone affects more than 90 million girls and women. This tradition can cause cysts, infertility, bladder infections, risks during childbirth including the death of the newborn, and if the girl has had the infibulation procedure done, they have to undo it so that she can conceive a child and give birth to the child to later have the procedure performed again. (According to UN Refugee Agency roughly 30%-50% of women have undergone FGM/C, the numbers fluctuate depending on age.)

Beatrice A, one of the women I grew to know very well, was the one and only woman who approached me about this issue. She asked if women in the US go through this procedure. I said no, and I reacted in such a way that I thought was inappropriate. I was negative about the issue and told her we thought it was bad. Later on I did further research on the topic and I found that FGM/C is an invasive procedure, it leaves a lot of women deformed and in pain, but I also saw the cultural side of the issue.

Why is this procedure still being conducted today? There are strong religious and cultural traditions that are still ingrained into today's culture. Was it a procedure to control women or protect them? In Europe and America the procedures were introduced during the 19<sup>th</sup> and 20<sup>th</sup> century to curb women's sexual desires. I think originally in African and Middle Eastern tradition, it was a procedure not to control one's desire, but to preserve purity and chastity.

---

<sup>5</sup> Unless otherwise specified, all statistics and definitions are found on WHO.int

For Nigerian women FGM/C was a sign of chastity, purity, and a passage from a young girl to womanhood (Prisca O. Anuforo 2004) it is a procedure to be revered. However, Anuforo et al, also found that the tradition is fading and that it is the grandmothers that would like the tradition to be maintain and the young girls and their fathers want to see the procedure removed. That can be seen in Kenya where in the western region it is basically nonexistent. There are people that believe that FGM/C is against human rights, "...only someone who was coerced, manipulated, or highly irrational would agree to undergo female genital mutilation and...valid informed consent... is impossible (Sally Sheldon 1998). I think if we still saw FGM/C as a means to control women as it was in the United States and Europe than it should be eradicated. But if the individual feels that it is a rite of passage, or they think that it represents chastity, does that mean that the procedure is wrong? Especially when in today's "modern" society, piercing one's clitoris and having labiapasty has become increasingly more popular. What is the difference between a religious procedure and plastic surgery? My point is that our perception is that women do not have a choice when it comes to ceremonies like FGM/C, but if it is becoming less and less of an issue than there has to have been a cultural shift and women must have a choice.

### *Monogamy, Polygny, and Religion*

The Kenya National Bureau of Statistics and USAID published another years worth of data from their annual *Kenya Demographic and Health Survey (KDHS)*. They report that birth rate is at an all time low at an average of 4.6 births per woman. The average woman in urban areas has 2.9 children, while in rural areas it 5.9 children (Statistics 2010). There is also a strong correlation between the low birth rates of women who are educated at 3.1 to those who are uneducated at 6.7 births. The data reported that 95% of all women and 98% of all men who took the survey were aware of different kinds of family planning methods whether it is condoms or pills. If that is the case then how is the birth rate still so high in rural areas?

The Daily Nation in Nairobi reported that the birth rate is high in the rural areas because Polygamy/polygny is high in those areas and that often the co-wives compete for the number of children between them and they seem to have preferences on the sex of the child (Siringi 2010). A study done in 1998 showed that women in a polygynous marriage have more control over the number of children and if contraceptives are used (Dodoo 1998). Along with that competition I found in my daily conversations with the women that among them, their pastors and missionaries are always telling women and their husbands that each child is a blessing.

Another area of question I saw arise was that of wife inheritance. The practice of wife inheritance is that when a husband dies, the wife or wives and their children would be taken in by a brother or perhaps an uncle so that they can be taken care of. However, what choices are the women given once taken by their husband's brother or uncle?

## **Findings**

Looking at the different water polices and the gender and development I think that each theory has its place but I look to questions that are not asked in those ideologies. There are two problems I see here based from my observations from the Khwisero region. First, if you make water access easier for women, the development group needs to spend time convincing the community that the new source was the cleanest water so that the water will help prevent disease and illness. Secondly, the women need to be taught what free time is. Women know how to keep their houses clean and keep food on the table for their families. Feeding and nurturing the family is a woman/mother's number one concern. I saw no such time spent as "leisure" unless it was right before the woman went to sleep. Women are constantly filling up their time with other occupations. My concern with the second issue is this: If they learn to make products, who is going to want to buy the products the women make in this new free time? In Khwisero I saw

Malone, Megan

women doing different kinds of activities for the welfare of the family. If the woman was a stay at home mother, she was collecting water, preparing the food, or cleaning the compound. If the woman was also a working mother; i.e. teaching, working at their shop in town or selling food, she was doing all the activities of the stay-at-home mother plus going off into town, or to work to bring in some income while the husband was off working in the fields or at a business in town. The products of most concern are the foods needed for the family. If women are taught to knit hats or bracelets tourists are going to be the intended party. Out in rural places like Khwisero tourists are rarely seen and I have yet to run into a NGO that provides the means for women to send the products to stores in the states.

It seems to me, based on my observations that men and women understand that the more mouths you have, the harder it is to feed them. But in these rural areas most people have 5 or 6 children. Granted some of these children are products of co-wives that have died like the case of Nellie and Jackson, but most of these people seem to just keep having children even if they are poor. However, Nellie, Christine, and Beatrice M are all well educated women, with multiple certificates and have or still do work other places; these women all have 4 or more children. Tradition and God (according to most religions) say that the more children, the more bountiful and fruitful your life is and will be. But when that collides with modern technology like contraceptives then how can people justify going against God's Will verses what might be seen as healthier.

During the 2009 and 2010 trip, I spent a lot of time in the kitchen with the women.<sup>6</sup> It did not matter that there was a language barrier; women's work is very similar across cultures. Mother's are the care takers and are to provide sustenance to their family. The kitchen is an important place because the women are usually preparing food and the children are always with

---

<sup>6</sup> The Kitchen for most compounds consists of a separate hut that is smaller than a typical house, and us usually just one room. Their houses are being modernized and on certain compounds the kitchen is placed within the main house.

Malone, Megan

their mother. The kitchen is where the women, who are not away working in the shambas<sup>7</sup> or own businesses, would be working on the meals all day. For example, Christine from Elwangale, who I stayed with, would wake around six in the morning, prepared breakfast while getting ready for work, sweep and clean parts of the compound, by eight in the morning start walking to work. She would work at a secondary school about a 45 minute walk from the compound. She would be home around five in the evening, and immediately start preparing dinner. Dinner would be set on the table, the whole family sits down for dinner, and she would then start to grade homework, spend time with her husband, and then go to bed around ten or eleven at night. The dishes from dinner would be saved for chores in the morning. My point is that the work of a woman is to not only to prepare the food, but make sure that everyone is content. Towards the end of my trip this summer when I was just overseeing the last pieces of our projects I would wash clothes and help the women prepare dinner. Just watching the cooks interact with the mother of the house, or watching the mother of the house interact with her husband allowed me to observe the dynamics in the different relationships.

Having the ability to just sit and listen to the women speak of normal activities and issues gave me great insight into how far off my original research question was: How does collecting water impact education? The focus groups allowed me to see that the issues Kenyan women face are not so different from American women. For example, Kenyan women struggle with trying to balance a family and a job (like most women they have to do all the house work and be finished

---

<sup>7</sup> Fields, they grow the main staple foods: corn, potatoes, tomatoes, napia grass (for the animals), and tea.

Malone, Megan

by the time they have to start walking to work) and it is common knowledge that husbands beat their wives, but not an issue for the women to discuss together, it is a private matter.<sup>8</sup>

### *Case Studies & Time Stamps*

To try and figure out the role that women play in the Khwisero district and perhaps all of Kenya, I wanted the women to complete time stamps. Each booklet would record one week's worth of work and daily activities of each woman. Within these booklets I also asked five open-ended questions:

- What does education for girls mean?
- What values have you taught your daughters and young girls?
- How has your role of wife and daughter changed from your mother's?
- What are the roles of women in society?
- What hopes and wishes do you have for young girls?

I was originally going to ask three or four women that I know to complete time stamps for me and give them 2 or 3 extra booklets to hand out to random women they know. However, I realized that they would probably give the extra booklets to women that knew English, and knew English well enough to write and comprehend the questions I asked without having to translate them. But I also realized that the women I know well because they were either related to Jackson or were teachers. Teachers have a higher level of education and people who know Jackson just want to please the visitors. My natural inclination when travelling is to gravitate towards English. I am more than willing to learn local languages; I think that Luhya, the tribal language of the region is beautiful, but working on research and learning what chicken is in Luhya is not conducive to getting my work done. My time was limited so I had to gravitate towards people who could help me gather information the quickest.

---

<sup>8</sup> In the Khwisero region there is a women's group that meets once a week or so to discuss issues of inequality, this apparently is a new kind of group.

Case studies are a form of research that allows the researcher to get the story of individuals with more breadth. I focused on three women who I felt comfortable talking with. Case studies allow the research to dive deeper into the culture of the people they decide to follow. Case studies look for trends but recognize that quantitatively the numbers are not there.

This second trip to Kenya allowed me to do a few case studies and the time stamps accompanied these case studies. Case studies is a form of research that allows the researcher to focus acutely on a few women and their lives unlike surveys that just gather surface information and look at general themes. When I left last summer I had met some amazing women from the focus groups I conducted, like Beatrice A whom I mentioned earlier. Going back and approaching them made me realize that there were a few flaws in my research. I realized that the women I was about to approach are all highly educated women, especially for a region like Western Kenya. I gravitated towards these women because I found that their accomplishments in their lives seemed more typical from the standpoint of someone (me) who has grown up with equal rights to education and gender issues.

Now the main purpose of the time stamps was to see how the women conducted their everyday life. The women spent most of their day doing house chores. The house chores being; sweeping, cooking, digging, washing dishes, fetching water, and collecting vegetables to name a few. Many things did not change from day to day. Nellie and Beatrice A would bathe the children, and both the Beatrices would go to school to teach. Nellie and Beatrice M mentioned time spent in leisure being either watching TV as Beatrice M did or spending time with her husband as Nellie had reported.

Malone, Megan

*Nellie*

Nellie was Jackson's second wife. However, as long as I have known her she has been his only wife. I have established the most comfortable and closest relationship with her. During my first six week stint, I spent a lot of time observing her and talking with her about her life. She is a very educated and accomplished woman. She is certified as a secretary and she has finished secondary school and some other certifications. By the time I left after those six weeks she was travelling to Kakamega to work. That meant that Jackson would take care of their children Monday through Friday and Nellie would come home on weekends. That was very unusual to see and I never really questioned why she went away to work. Jackson and Nellie had four children and a nephew that lived with them; Johnson, 15 is their oldest and Jackson's first wife's child; Vivian, 5 their only daughter is Nellie's biological child; Hilary, 3 ½ years is also Nellie's biological child; and finally Sims, 3 ¼ years is their youngest and Jackson's first wife's other child.

I knew that polygamy was still an acceptable practice in Luhya culture, Kenya, and most of Africa. I noticed that Hilary and Sims are only 4 months apart. Soon after Nellie had Hilary, Jackson's first wife Elizabeth gave birth to Sims and died of complications from his birth. When Nellie told her story to me, she expressed how hard it was to raise two babies. She said it was basically like raising twins, "One child carried on my back, and the other child carried on my side." When I first met Nellie I was very surprised to find that she was originally a second wife, because she was so educated it surprised me that she still practiced polygamy. She took care of her family so well and treated her guest so well, that it was hard to imagine her has a second wife taking orders from the first wife. To this day, Jackson has not taken a second wife, and I do not think he will.

Malone, Megan

When Nellie would discuss her story she has so proud of her family and her accomplishments, but what seemed to make her the proudest was the fact that she had healthy children and was able to run a strong secure household. The children are bathed every day, she walks to the market everyday to buy food, and she prepares food all day long. When I visited both times, she had other women in the community helping her prepare meals and clean for her because she and Jackson would house EWB-MSU members throughout the summer.

There are two incidents at the end of my trip in 2010 with Nellie that stand out. Nellie, I had asked to complete a time stamp. I had also asked her to attend the opening ceremony of the borehole and the composting latrine at Elwangale Primary. On the day of the ceremony a *piki piki* driver<sup>9</sup> picked her up and brought her and she remained close to me throughout the day. During the ceremony, Jackson was asked to speak: during his speech he said, “Behind every great man, stands his wife,” and asked Nellie to introduce herself to the crowds. I had never seen a man acknowledge his wife like that before in Kenya.

The other incident was later that day. At the end of the ceremony, after we all ate, Nellie and I were speaking. She handed me back her time stamp, looked at me, and said thank you. She went on to mention that she is either on the compound or at the market, never able to go other places. She was grateful for the opportunity to spend time with other people and see other events. I knew that women stayed on their compound; I just never knew what it meant to them when they could leave and see something new. These examples are just some of the social constraints women face.

*Beatrice M*

---

<sup>9</sup> *Piki piki* is the term for a motorcycle driver

Malone, Megan

Beatrice M and her husband Laban both teach at schools in the east part of the district. The Summer 2009 trip was the first time we worked in the east. She and Laban have five children, and which two of those children are girls. I chose her for my time stamp this summer because she and her husband seem to have a very nontraditional relationship. I met Beatrice M and Laban separately because Laban worked at the other east school we were working at. The two of them are very calm, very understanding people, who are obviously highly educated. Laban was very patient with us and he just had a good understanding of us. Beatrice was just very kind and very understanding of us also, but she had a general sphere about her that made her almost seem like the matriarch of the primary school.

#### *Beatrice A*

Now Beatrice A also worked with Beatrice M but she is significantly younger and her children are also very young. Beatrice M's children are all older and out of the house. Beatrice A. has three children, two of which are girls. I wanted to get a sense of who she was and what she believed was the role of women because when I did the focus group at her school she asked me if Americans believe in female circumcision. There I saw was a level of education and knowledge that was beyond what I had run into before. She was obviously keeping touch with the current issues of the world.

The other question I found that had intriguing answers was “What are the roles of women in society?<sup>10</sup>” Beatrice A had a completely different answer than Nellie and Beatrice M. She believes that women should;

- Guide young girls/children on to good behavior.
- Provide basic needs e.g. goods, clothes and shelter

---

<sup>10</sup> These answers were provided in the same order the women placed them.

Malone, Megan

- Ensure that children have medical care
- Provide security and protection of girls

While Nellie answered the question with the following answers;

- Giving birth to children
- Taking care of her children and husband
- Preparing food for the family
- Welcoming visitors
- Taking care of the house: sweeping, cleaning, arranging, dusting and planning how the family will eat and at what time
- Planting vegetables so that she should not waste time and money going to the market to buy vegetables
- Joining with other women in sharing ideas on how they can develop their houses.  
It is wall in Kiswahili: *Maendeleo ya wanawake*

Beatrice M's answers seemed to follow Nellie's;

- Cooking
- Laundry
- Giving birth
- Baby Care
- Fetching firewood
- Fetching water
- House and home maintenance
- Serving visitors
- Serving husbands

I find these answers fascinating especially because Beatrice M's answers do not link up to her answer about the role of education for women. She says she wants equality among girls and boys, but does equality mean serving ones husband? Nellie's answers again seemed typical for the way she ran her house and treated her husband. With Beatrice A's answers do not really come close to matching Nellie's or Beatrice A's answers. It seems to me that she is more concerned with young girls learning to take care of the community at large.

#### *My Interactions with other Notable Women throughout the Community*

There were many women who I had the pleasure of running into. The women above fit into my research as specific case studies and were the easiest for me to contact in my time frame.

Malone, Megan

However, the women I mention next were just as crucial to my research but for various reasons I was not able to ask them for time stamps.

I gave a time stamp to Alfreda for numerous reasons. She is a teacher at Mwisena primary school in the east district and works with the young children. She is the mother of 5, 4 girls and her youngest is a boy. She and her daughters do everything, whether it is cooking dinner or washing clothes to make sure their brother can spend all his time studying and become a successful man. Her daughters were very self-sufficient and when I arrived at their house with Alfreda the girls were making dinner, doing chores, and working in the shamba.

The other reason I thought her influence was important was the fact that her husband was working in another city, and living with another woman. Alfreda told me that unless her husband could afford raising their kids and providing enough money for them to survive; he could not marry this woman.

During the summer, 2009, I stayed in the east with a polygamist family. Christine, the mother of the house that we stayed with on the compound was one of four wives. The compound was owned by Christine's mother and her eldest son. (I would like to note that Christine's mother, and two of her sisters are pastors.) The four wives all lived on the compound with Christine's mother while the eldest son was living in another city with another woman. Christine was the first wife, had four children, and her youngest child was visiting when I was staying on the compound. We did not see Christine much because she was a meat inspector and was constantly travelling from one market to the next making sure the meat kiosks were up to code. They were obviously wealthy because there were four wives, and this past summer I found out that her son was in London for two weeks.

Malone, Megan

During the summer of 2010 I stayed with a woman named Christine who lived near the Elwangale Primary school, her husband Fred, was the head teacher of Ekatsombero Primary school. She was notable in my research for a few reasons. She was a mother of four who only ever wanted three children. She felt it was best to have few children to take care of. She worked full time as a secretary at Eshinutsa Secondary School. She was also nominated as the Chairwoman of the School Management Committee, which EWB-MSU asks the community to set up so that there is representation of the parents of the students to communicate with EWB-MSU. While my team and I were staying on their compound, Christine would wake up around 6 in the morning, help her hired workers get breakfast ready and do some house cleaning chores. But once my team left she did all the cooking and cleaning in the morning before she left at around 8:30 for work. She would arrive home around 5:30 or 6 and then get dinner prepared for me and the family.

I distinctly remember one day when we were sitting in the kitchen, she looked at me and said "I am done" she decided that that was the day where she was not going to do any work. No house cleaning, no ironing, and no cooking. Just go to church and "hang out." She was going to leave the cooking and cleaning to the women she hired to help while my team was there. Living with her family for 6 weeks gave me great insight into how women's roles were defined. She worked five days a week getting paid, but she was also expected to fulfill all her duties as a wife and mother. She was supposed to cook every meal, clean the house, and make sure her husband and children had everything they needed. Her eldest and youngest children lived at home, but the two middle children were away at boarding school about an hour from their home.

One incident I had with the family allowed me to see what they thought of Americans. I was home with Christine while my team was away on a weekend trip. I offered to wash the

Malone, Megan

windows for them (they were fixing up their house so there were repairs that had to be made). I offered to get water and soap, but she said no, the hired help would get it. So, once I had everything, I started to clean the windows. Fred came home soon after I started and he told me right way that I did not need to do that. Christine then said I was doing a good job and she did not know I knew how to do that. She almost seemed surprised to see that I knew how to clean. I had to spend time explaining how Americans quantify work. She said she pictured us sitting around and having other people work for us. I had to explain to her that most Americans put money behind an education, and for the most part, our parents take care of us while we gain an education so that we can increase our capital. The biggest realization I had was that in the U.S. we quantify work by the hour. Wages depend on what the job is and how many hours a week we put in. In Khwisero, people pay by the day. Fundis (labor workers) are paid by the day. For example, when we hired people to build the composting latrine we paid the head worker 300 KES a day and the people he hired got paid 250 KES a day. That is roughly 3 US dollars a day for the fundis to feed themselves and their families. The point I am trying to make is that it is hard for me to critique their work and support development when they are working in a very different cultural system than Americans.

The following three women I will mention briefly. They were women that in my mind have either overcome or coped with gender inequalities. Josephine is a teacher at Mwisena primary and this past summer I found out she had one son. He stayed at school with her because she could not afford to pay for a nanny. Under the right conditions Josephine would have been able to pay for a nanny so that she could work, and the nanny could take care of her son and take care of the compound.

Malone, Megan

Sophia is a woman who was a translator for us while we were conducting the surveys in 2009. Since her English was so good, we knew that she had completed secondary school. She is a mother of five girls. I remember her telling me that she had no sons, and that her five girls were a “blessing.” She did ask about birth control and having girls verses boys. I told her that some people used birth control, but that there were many people who felt that God provides them with as many children as He wants. When it came to the gender of the child, I said that each child is a “blessing” and that one gender is not better than the other.

When I came back in 2010, Jackson had assembled the previous translators, however, Sophia was not there. I asked him where she was and he said, “You know Megan, some men want their wives to stay at home and do their duty.” It was alright for her to make a little money the previous year being our translator, but for her to do it again this past summer was out the question.

Rina spoke the least amount of English of all the women I got to know. But she gave me the most amount of contrast to women like Beatrice M and Nellie. Rina was the cook and cleaner that Christine decided to hire when my team was staying at Elwangale. She is around 30, married, and has a four year old son, Paul. Rina has her own hut on her husband’s mother’s land. Her husband lives in another city, and gives his mother the money for the family. Her husband has another wife and Rina would like to just live alone and have her husband send her money so that she can survive, but she wants to be on her own. Rina may be a mother, but she does not get to raise her son. The mother-in-law takes care of Paul and Rina sometimes sees him at school.

Malone, Megan

I recognize that all of that seems typical, but I found out that she lived with a white man in Nairobi for many years. She learned to cook all kinds of foreign food. She did this all while she was married. Christine said Rina was happy then. When I heard Rina's story I distinctly remember Christine saying that, when Rina lived with the *mzungu*<sup>11</sup> she was happy, and Christine said that she did not understand why her husband would not just let her go and let her be happy. That seemed like such an odd comment, because it means that Rina was living outside the sanctity of marriage, and that Christine was alright with that.

### **My perspective as a project manager:**

I had very positive experiences while I was in Khwisero for both summers. However, there were some cultural boundaries such as women in power, and the idea of women as homemakers that made my role hard. There were definitely experiences I had that had more impact than others. In the summer of 2009, that trip was about getting to know the culture and the expectations of women. I would sit and watch what Nellie would work on during the day. She taught me how to cook local foods and by the end of the trip threatened to marry me off to one of her brothers. That seems minimal; however, I could tell that being able to cook well and serve meals was a sign of having the potential to be a good wife.

2009 and 2010, both proved to have gender struggles. Kenya is a very traditional, patriarchal society; there are very few women who hold high positions. In 2009, I was the coordinator of the surveys. I knew what the two EWB-MSU teams had to do, and I was the one to facilitate training the Kenyans to conduct the surveys. I remember when I stayed in the East, one of the male head teachers asked when I was going to work on the surveys. I gave him an

---

<sup>11</sup> *Mzungu* is a term in Swahili that means European, foreigner, and sometimes translated as white person.

Malone, Megan

answer. He then went to my teammate, asked him the same question, and believed the answer that my teammate gave. (My teammate did not have the correct information, because we had not seen each other all day.) In 2010, three of the four project managers were women. To ease this stigma, I made it very clear to the Elwangale community that I am “just” an anthropologist and sociologist that the experts were my teammates, made up of four engineers. Jackson and I had very a good working relationship in 2009 so working with him was not an issue, but for many people taking strong suggestions from women is very uncommon. The fundis understood to talk to my engineers, but if I was not satisfied with the work, they were not getting paid.<sup>12</sup> At the time it did not necessarily seem like it was hard for them to listen to me. But at the opening ceremony at Elwangale three groups of students, made up of girls, all wrote songs about how strong and courageous I was, and that they wanted to be just like me. (Wow, talk about the pressure.) To be noted at Elwangale, the water user committee and the school management committee that the schools set up, both of the chair people were women.

Another interesting incident I found at the opening ceremony was at the end of the day. We ended the festivities with food. I was walking around saying goodbye to guests, and I walked over to one of the classrooms. There I found all the women who were apart of the festivities were also the cooks. They were sitting in the back eating because they had to make sure that there was enough food. I did not feel comfortable to stay, because they immediately treated me like a guest. I just wanted them to relax.

## **Analysis and Discussion**

---

<sup>12</sup> Note: all the treasurers I have met of committees, except one, have been women.

Looking at the answers to the five in-depth questions I gave the women, the word choice was quite similar, like equality, discrimination, the right choices, enablement, courage, communication, and direction to name a few. I think that this is a sign that the women are educated and know words that follow the common issues that run through Kenya, like gender dynamics or the idea of colonialism and discrimination. When I saw words like equality and enablement I thought of NGOs and other development groups that would use words like that. I do not think the women are liberated by using big words like that, however, I do wonder if it is one of the first signs that allow women to become liberated.

For Nellie educating girls meant that they were to learn their role in the house and learn how to handle her family. While Beatrice A said that educating girls meant to teach them how to adapt to changing circumstances with courage and Beatrice M said that educating girls meant educating their families to understand that girls are equally important as boys and for that should not be discriminated. All those answers are extremely different from one another, and in getting to spend time with each one of these women, their answers fit the way they ran their households.

Nellie is very traditional and she has a certificate in typesetting, like I said earlier she was allowed to go work in Kakamega during the week while Jackson stayed at home and took care of the children. Later in 2010 I asked Nellie why that stopped and she explained to me that it was too hard for the family and she missed her children. When I spent most of my time with Nellie in 2009 she taught me how to cook traditional foods and serve the family. I felt very much like I was being converted and it seemed important for Nellie to teach me the ways of her house. For Nellie the sign of a good education is a household running smoothly. While I was growing up my mother taught me how to clean, set the table, and cook some meals, but she also stressed the importance of getting a formal education. From my observations it does not seem that women

Malone, Megan

are stressing to their children the importance of school and what gaining a formal education means.

Beatrice A is the young teacher who works with preschool age children at Mwisena and wanted girls to learn to walk with courage. She wants her children to be able to get a good job. She herself is a certified teacher and from what I can see has taught her children to get a formal education. She seemed to see the advantages to a formal education, but I also wonder what part her husband and her parents have played in that.

Finally, Beatrice M wanted girls to be taught along with their parents that they are equal to boys and should not be treated differently. This philosophy is mirrored in her marriage. Laban treats his wife with equality. Beatrice M does not have to do all the house work and make sure the food is always ready to be served. Laban once said that sometimes when he gets up early and Beatrice M is not ready to go to work, he heats up the water, gets the breakfast ready for both of them. That is very untraditional, and they have raised their children to know what equality is.

These women fetch water everyday but it is not their main concern for their children. These women want their children/girls to understand equality and equal opportunity. These women want their children to run a household. But these concerns sound very similar to the way myself and my friends were raised. I was taught that I was equal to everyone else around me. Perhaps my class status was not the same, but I was getting the same education. Education is where I see the difference. In the United States and most European countries our parents take their time and money to make sure that we can acquire an education. But according to those terms, that is a formal education. The people in Khwisero are just beginning to understand the

Malone, Megan

importance of a formal education. For me and my family getting a degree means that I have a chance to make money and own a home. For the people in Khwisero an education for their children means that they have to spend money on uniforms and books, and not food for the family. Finally it means that the free labor they need to keep their farms going is gone.

## **Conclusion**

Gender inequality is rooted in education. A formal education allows women to be equal to men. The purpose of *Education for All* is clear in that it is looking towards a future where women are created equal and treated with equality. The idea is that when women are educated they then can take part in their own welfare. They are able to limit the number of children they have, they can work outside of the home, and they are able to leave the control of their husbands. As I have stated, the problem with this process is that it expects that men and women can see the benefits of formal education right away, and make the necessary changes right away. I contest that there needs to be a cultural shift that allows women to make steps to learn about their rights. But what also needs to occur is that there needs to be a broader definition of development and education.

Access to clean water delegates how easy it is for women to spend time on their daily activities. Clean water means that people are healthier and can live longer. The distance to get water means that women can invest more work on the compound or find time to work at a shop so that they can learn different trades. But access to water does not mean women are disadvantaged. What determines who is and who is not disadvantaged is the cultural history of a nation or a tribe.

Malone, Megan

Development groups go in seeing a problem and they want to solve the solution. For example, missionaries believe that they need to convert people so they can be saved. Christian religions polygamy is prohibited; however, in Africa polygamy still runs rampant. EWB-MSU believes that to solve the issue of clean water and create better access to water is to build a pump at a primary school. Africa Now wanted to solve the problem of water, so they just built giant tanks at each school. Yet, each school that we have worked at still has those Africa Now tanks that are falling apart. My point, developers are missing a step. Developers are not spending the time to understand the culture they want to help. Take the time to understand the cultural specifics behind the importance of polygamy; take the time to understand the issue of access to clean water. Take the time to understand the culture before fixing it.

Though I spent only a few months in the community of Khwisero over two years, I have learned a lot about the role the women play in that area, I have seen the effects of development, and I have seen the issues of educating young girls. In the United States children and specifically girls are being told to gain an education, but maintain the gender boundaries that are placed on us. Girls and boys are being told to gain a formal education so that they can gain a job and have options when it comes to career choices. But young girls are still being told, obtain a degree, get married, have children, be a stay at home parent, and sufficiently provide for those children, if need be, quit your job. Today, women want to have choices. Some women do not want to have children, and because much of the ideology in the United States is still patriarchal, women are seen to be criticized if they do not want children. But what women in the global north have, are choices.

Women in Kenya seem to be fast approaching those gendered issues. Specifically from the observations I have made, women and girls are being told to gain an education, but are still

Malone, Megan

asking, What is the point of my formal education? Nellie, Beatrice A, and Beatrice M, have all gained a formal education of some sort. Nellie spends each day on the compound and rarely leaves, but she expects herself and her daughter to be treated fairly at home. Beatrice A. and Beatrice M. both teach and want to tell young girls that they are equal to boys. For the girls in Khwisero, this is the stepping stone. Once they believe that they are equal and once Kenya has developed further, the girls and women will also have choices. As I saw, I think developers see women who are dependent on their husbands, like the cases with wife inheritance. The Global North wants to see women have the choice to raise their children on their own, marry another person, or even in cases like Rina, be able to watch her son grow up and not live under the scrutiny of a mother-in-law or husband that does not like her.

## Bibliography

- Dodoo, F. N.-A. (1998). "Marriage Type and Reproductive Decisions: A Comparative Study in Sub-Saharan Africa." Journal of Marriage and Family **60**(1): 232-242.
- Jones, T. E. (2000). "Ethnography, belief ascription, and epistemological barriers." human Relations **53**(1): 117-152.
- Ministry of Education, S. a. T. (2004). A Policy Framewokr For Education, Training and Research: Meeting the Challenges of Eduacation, Training and Research in Kenya in the 21st Century. S. a. T. Ministry of Eduacation. Nairobi.
- Nations, U. (2005). Women and Water. D. f. t. A. o. W. D. o. E. a. S. Affairs. Beijing, Women 2000 and Beyond.
- Prisca O. Anuforo, L. O., Dula F. Pasquiao (2004). "Comparative Study of Meanings, Beliefs, and Practices of Female Circumcision Among Three Nigerian Tribes in the United States and Nigeria." Journal of Transcultural Nursing **15**(2): 103-113.
- Ray, I. (2007). "Women, Water, and Development." Annual Review of Environmental Resources **32**: 421-449.
- Sally Sheldon, S. W. (1998). "Female genital mutilation and cosmetic surgery: refulating non-therapeutic body modification." Bioethics **12**(4): 263-285.
- Sharlene Nagy Hesse-Biber and P. Leavy (2006). The Practitce of Qualitative Research  
Thousand Oaks, Sage Publications, Inc.
- Siringi, S. (2010). Polygamous Marriages Exposing Kenyans to Risk of HIV/Aids, Warns New Survey. Daily Nation. Nairobi, Nation Media Group.
- Statistics, U. a. K. N. B. o. (2010). Kenya Demographic and Health Survey 2008-09. K. N. B. o. Statistics. Nairobi, USAID.
- Zwarteveen, M. Z. (1997). "Water: From Basic Need to Commodity: A Discussion on Gender and Water Rights in the Context of Irrigation." World Development **25**(8): 1335-1349.

# X-Ray CT Scanning Techniques on Soil Samples

Zachary Lee Morris  
McNair Scholarly Research  
Montana State University-Bozeman

McNair Mentor: Dr. Robert Mokwa  
McNair Director: Dr. Shelly Hogan

**Table of Contents**

1	Abstract.....	1
2	Introduction .....	2
3	Review of Literature .....	4
4	Methodology.....	5
4.1	Background of Methodology .....	5
5	Data and Findings.....	7
6	Conclusions .....	12
7	Areas for Improvement.....	13
8	Appendices .....	14
8.1	Laboratory Manual for Destructive Testing Techniques .....	14
8.2	Laboratory Manual for Non-Destructive Testing Techniques .....	17
8.3	Images from the Scanner after Editing in ImageJ .....	30
9	References .....	35

**List of Tables**

Table 1. Samples Used for Analysis ..... 7  
Table 2. Void Ratios, Porosities, and Percent Differences ..... 8  
Table 3. Specific Gravity Example Calculation ..... 14

**List of Figures**

Figure 1. Grain size distribution plot for gravel sample G-2..... 9  
Figure 2. Grain size distribution plot for gravel sample G-3..... 10  
Figure 3. Grain size distribution plot for coarse sand sample CS-3. .... 10  
Figure 4. Grain size distribution plot for coarse sand sample CS-5. .... 11  
Figure 5. Grain size distribution plot for coarse sand sample CS-6. .... 11  
Figure 6. 2" PVC pipe and platform. .... 17  
Figure 7. CT scanner's control panel. .... 18  
Figure 8. CT scanner 'Motion Control' and 'Xray Control' boxes. .... 19  
Figure 9. Collimator and CT platform. .... 20  
Figure 10. CT scanner 'System Control' box. .... 21  
Figure 11. Image tab, expose. .... 21  
Figure 12. CT loop tab. .... 22  
Figure 13. CT to PJ converter program. .... 23  
Figure 14. Selecting proper file when using CTSim..... 23  
Figure 15. Parameters used for reconstruction of images..... 24  
Figure 16. Import image sequence in ImageJ. .... 25  
Figure 17. Parameters used for filter in ImageJ..... 25  
Figure 18. Thresholding the image. .... 26  
Figure 19. Parameters used for binary conversion..... 26  
Figure 20. ROI Manager in ImageJ. .... 27  
Figure 21. Parameters used for ROI Manager. .... 27  
Figure 22. Analysis using histogram. .... 28  
Figure 23. Analyzing particles. .... 29  
Figure 24. G-2 image after editing in ImageJ..... 30  
Figure 25. G-3 image after editing in ImageJ..... 31  
Figure 26. CS-3 image after editing in ImageJ..... 32  
Figure 27. CS-5 image after editing in ImageJ..... 33  
Figure 28. CS-6 image after editing in ImageJ..... 34

## **1 ABSTRACT**

This research focuses on the refinement of x-ray computed tomography (CT) on soil samples. The primary soil samples that were used were gravel and coarse sand. Because these two soil samples were used, the software processes and manipulations were calibrated to provide analysis only for these granular soil types; however, the general process should be similar for most soil samples.

The goal of this research is to provide non-destructive techniques for determining the following soil properties: void ratio, porosity, grain size distribution, and pore size distribution. After finding proper techniques for determining these properties, a lab manual was created to aid future students and individuals in understanding CT technology vs. traditional geotechnical laboratory techniques.

## 2 INTRODUCTION

X-Ray computed tomography on soil samples is a science that is currently still in its infancy in the engineering field. Computed tomography involves non-destructive testing and therefore provides the ability to re-run multiple tests on a soil sample, which is valuable because it reduces or eliminates testing bias. Another important factor for non-destructive testing techniques is efficiency. Traditional destructive testing techniques are time consuming and may involve considerable labor. As a consequence, variability between lab technicians and their results can frequently occur.

The x-ray CT scanner at Montana State University-Bozeman (MSU) is not nearly as efficient as currently available devices. MSU has a 2-dimensional 3<sup>rd</sup> generation diverging scanner, whereas the new scanners are 3-dimensional cone beam; this creates for a large difference in scanning time. MSU's current scanner takes approximately six to eight hours to complete a scan, and then another four to six hours to analyze the scan. Whereas, the current 3-dimensional scanners can complete a scan in less than thirty minutes; however, the analysis time for the new scanners is currently unknown for the soil samples and parameters analyzed in this research.

This report addresses: a review of the literature used; how soil samples were obtained; data, results, comparisons, and findings; destructive and non-destructive testing techniques; lab manuals of the two testing methods; end results, ways to improve, and research areas that were not explored due to time constraints. The main soil properties that will be evaluated are void ratio, porosity, grain size distribution, and pore size distribution.

Void ratio ( $e$ ) is defined as the volume of voids ( $V_v$ ) divided by the volume of solids ( $V_s$ ),  $e = V_v / V_s$ . Porosity ( $n$ ) is similar, and is defined as  $n = (V_v) / (V_v + V_s)$ . Porosity and void ratio are directly related using the following formula,  $n = e / (1+e)$ .

Grain size distribution is a statistical distribution that is used for soil classification (Mokwa 2008). It is determined by using multiple sieve sizes and then using a machine to shake the sample for approximately ten minutes. The returned soil is weighed on each sieve, recorded, and plotted on a percent finer by weight vs. grain diameter graph.

Pore size distribution is a soil property that is very hard to precisely analyze. It is similar to grain size distribution, but it is based on pore or void sizes, rather than solid particles as in grain size distribution. There are currently no precise methods for determining this property for gravel and coarse sand samples.

### **3 REVIEW OF LITERATURE**

Otani (2004) reported on x-ray research performed at Kumamoto University. Otani's research primarily focused on four main topics: 1) the characterization of soil behavior, 2) the development of new triaxial compression test apparatuses, 3) more applications of x-ray CT data, and 4) bearing capacity mechanisms under vertical pile loading (Otani 2004).

Kobayashi et al. (2010) analyzed the change in porosity of a biogROUT specimen using a micro-focus x-ray CT scanner and image processing.

Cnudde et al. (2010) described a 3D analysis of geomaterials utilizing the software program Morpho+. Morpho+ is a flexible 3D analysis program that provides petrophysical parameters of scanned samples in 3D. Cnudde et al. applied Morpho+ to analyze geomaterial properties such as porosity, partial porosity, pore-size distribution, grain size, grain orientation, and surface determination (Cnudde et al. 2010).

Zacher et al. (2010) micro analyzed geological samples using a high-resolution CT scanner. Zacher et al. primarily focused on pore analysis, pore network and surface extraction, and micro fossils using the 'nanotom.' The nanotom is "the first nanoCT system featuring voxel resolutions of less than 500 nanometers ( $<0.5\mu\text{m}$ )" (Zacher et al. 2010). The nanotom also has "the ability to deliver ultra-high resolution images of any internal object detail at virtually any angle" (Zacher et al. 2010).

## **4 METHODOLOGY**

For each scan, destructive test methods as well as non-destructive test methods were performed. This was necessary in order to compare traditional methods vs. non-traditional methods. Much of the results were comparable to the results of Brent Nielsen's research (Nielsen 2004) because some of the same samples were the used. Nielsen's research provided a check on the destructive testing methods that were performed, and the destructive testing methods provided a check on the non-destructive testing methods.

Research was conducted in both Bozeman and Lewistown, Montana. In Bozeman, research, CT scans, and some of the destructive tests were performed at MSU. In Lewistown, research and destructive tests were conducted at the Montana Department of Transportation's Laboratory.

### **4.1 Background of Methodology**

The main source used in this research was Brent Nielsen's thesis (Nielsen 2004). Nielsen's work was well received and due to his success, research in this report was adapted off of his, further developed, and compiled into a lab manual in order for students to gain a better understanding of the two different methods of determining soil properties.

The following software programs were used in conducting research: CT to PJ Converter, CTSim, and ImageJ. These software programs made analyzing and editing the scans possible and more efficient. The CT to PJ Converter software was created at MSU, and its function is to take the CT files that are created during the scan, and then convert them with a specified offset, to PJ files. Once this is performed, then CTSim uses the PJ files to reconstruct the images and converts them to Dicom files so that the ImageJ software can make the final edits, calculations, and analyses.

Another main source used was the user manual created by Bryant Robbins and Josh Nichols (Robbins and Nichols 2010). This manual provided a brief overview of the processes involved with the software used in this report and the procedure for setting up the scanner. Furthermore, Robbins and Nichols assisted with the research in this report by providing a hands-on demonstration of how to use the scanner, and an in-depth explanation of the processes for performing successful scans.

Lastly, Dr. Robert L. Mokwa assisted in this research in many ways. His Geotech Lab Manual (Mokwa 2008) provided the methods of destructive testing techniques, and therefore provided for another check between destructive and non-destructive tests. Dr. Mokwa also determined that a lab manual should be created to introduce future students to the new technologies and advances in geotechnical engineering. The lab manual that was created from this research incorporates both destructive and non-destructive testing techniques, and describes how both techniques measure void ratios, porosities, grain size distributions, and pore size distributions<sup>1</sup> for gravel and coarse sand samples.

Additionally, Dr. Mokwa's personal guidance throughout the research kept it in focus, on schedule, and accomplishable.

1 – Pore size distribution methods are only briefly described for non-destructive testing techniques.

## 5 DATA AND FINDINGS

Data was collected from multiple scans and tests were performed on gravel and coarse sand samples. Table 1 details the list of the samples used in the analyses:

**Table 1. Samples Used for Analysis**

<b>Title</b>	<b>Date Performed</b>	<b>Increment of Rotation (degrees)</b>	<b>Abbreviation</b>
Gravel 2	5/31/2010	1.00	G-2
Gravel 3	7/18/2010	1.00	G-3
Coarse Sand 3	7/2/2010	1.00	CS-3
Coarse Sand 5	7/5/2010	0.50	CS-5
Coarse Sand 6	7/18/2010	0.25	CS-6

Note: Coarse Sand 3, 5, and 6 were all taken from the same soil sample. Gravel 2 and Gravel 3 were taken from separate soil samples.

The void ratios, porosities, and grain size distributions, obtained using x-ray CT for both G-2 and G-3, were close to the values obtained with the destructive testing methods, indicating that the gravel samples provided relatively accurate non-destructive testing results. The pore size distributions were analyzed as well, however because there were no non-destructive tests to compare this data to; there was no accurate way to know whether or not the pore size distribution model was correct.

The x-ray CT results for the coarse sand samples did not match the mechanically measured results, even though the same methods for determining the soil properties as was used with gravel. The coarse sand images had to be adjusted in the ImageJ software by adjusting the threshold to a darker level. By doing this, the binary image became blacker resulting in changes to void ratios and porosities. This adversely affected the quality of the grain size distributions. Consequently, adjusting the threshold to a darker level was avoided in all analyses.

The results are summarized in Table 2, which shows that the x-ray CT results for coarse sand samples did not correlate well with measured results, while this method of CT analysis worked very well for the gravel samples.

**Table 2. Void Ratios, Porosities, and Percent Differences**

<b>Sample</b>	<b>e<sub>Dest.</sub></b>	<b>e<sub>CT</sub></b>	<b>% Difference</b>	<b>n<sub>Dest.</sub></b>	<b>n<sub>CT</sub></b>	<b>% Difference</b>
G-2	0.84	0.84	0.69%	45.55%	45.73%	0.38%
G-3	0.82	0.73	-11.26%	44.94%	42.32%	-6.20%
CS-3	0.49	1.55	68.29%	33.02%	60.86%	45.74%
CS-5	0.48	1.08	55.88%	32.28%	51.93%	37.84%
CS-6	0.52	0.81	36.07%	34.15%	44.78%	23.75%

The percent differences were evaluated with the CT values in the denominator. An example of the CS-3 percent difference for void ratio is shown below:

- Percent Difference =  $[1 - (e_{Dest.} / e_{CT})] * 100 = [1 - (0.49 / 1.55)] * 100 = 68.39\%$

\*Numbers differ due to rounding

The difference between gravel and coarse sand becomes even more apparent when grain size distributions are analyzed. On the following pages are comparisons of the five different scans that were analyzed and their grain size distributions (Figures 1-5). Each image shows both the destructive test results (sieve analyses) as well as the non-destructive tests results (CT scans).



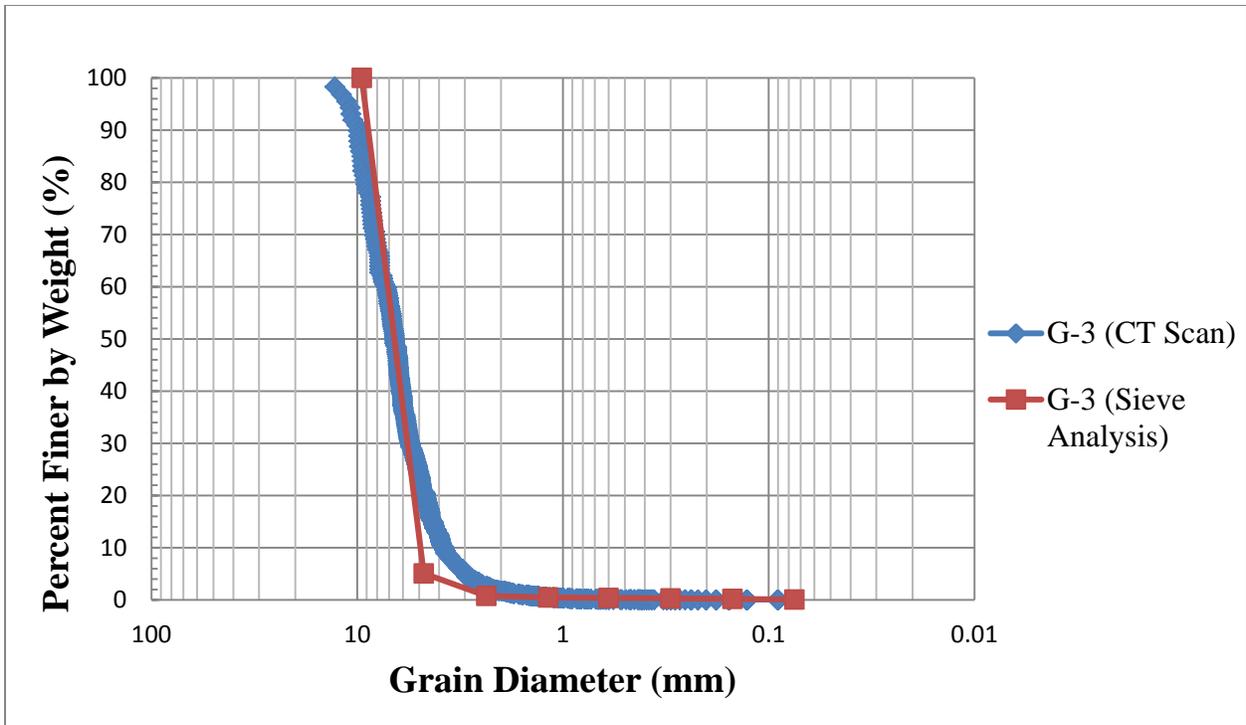


Figure 2. Grain size distribution plot for gravel sample G-3.

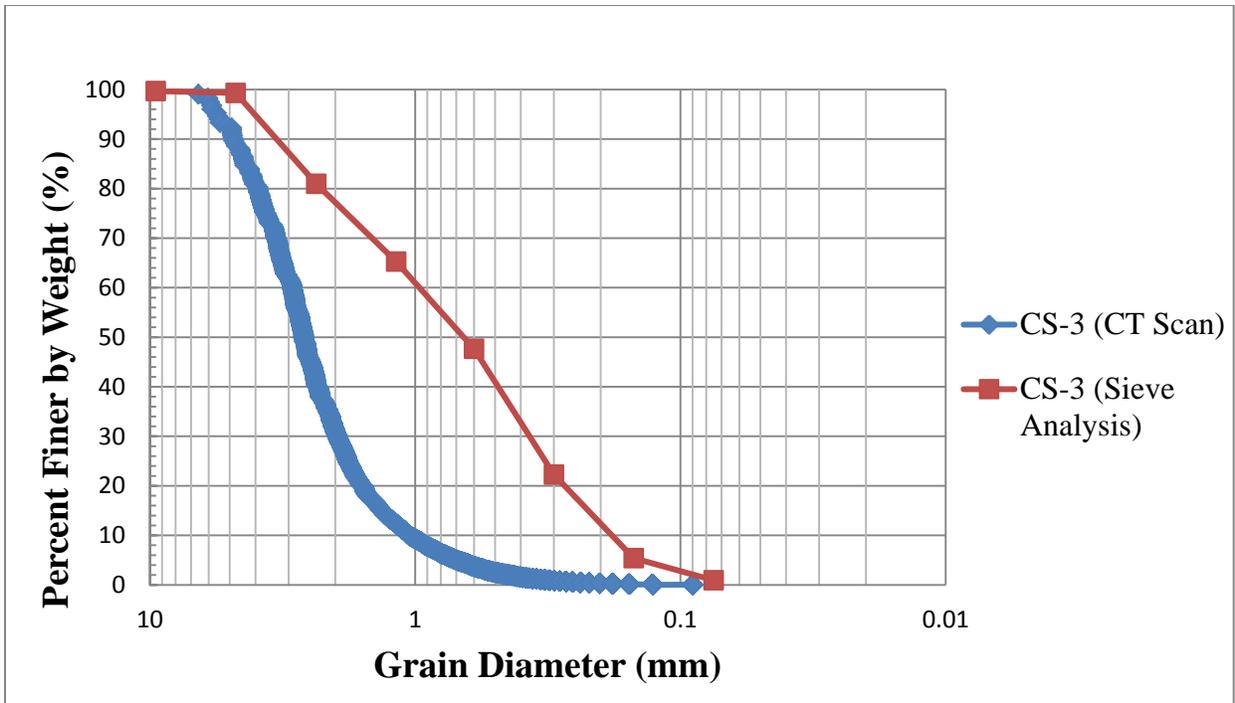


Figure 3. Grain size distribution plot for coarse sand sample CS-3.



## 6 CONCLUSIONS

This research has shown that CT scanning methods can provide accurate results for gravel type materials. It has also shown that the smaller the degree of rotation between x-ray shots, the more accurate the results are. This was most evident with the coarse sand samples because CS-3 had one degree of rotation, CS-5 had  $\frac{1}{2}$  degree of rotation, and CS-6 had  $\frac{1}{4}$  degree of rotation.

X-ray CT results for void ratios, porosities, and grain size distributions matched closely to mechanical measurements for both testing methods for the gravel samples. On the other hand, the coarse sand scans did not match very closely with the coarse sand destructive tests. This is because the coarse sand samples had smaller particle sizes and therefore it is necessary to apply more adjustments and refinements to improve the CT resolution. These include adjusting the exposure time for the camera and energy intensity of the x-ray device.

Because the grain size distributions for the gravel samples were accurate, especially for the G-3 sample, the pore size distributions were further analyzed. This analysis, while not included in this report, demonstrated that analyzing pore sizes using non-destructive testing techniques is possible, and that more research and development should be applied in this area to further the advancements in geotechnical engineering.

CT technology is still in its infancy in the geotechnical engineering field; however, it is starting to be looked at as a gateway for improving efficiency and enhancing testing methods. This research paper and the two lab manuals were created to aid future students and individuals interested in this technology, its applications, and its potential as an upcoming and prominent method for determining the properties of soils.

## **7 AREAS FOR IMPROVEMENT**

One area that could be improved when using the scanner is the platform which holds the soil sample and attaches to the scanner (Figure 6). The current platform is not level or centered, and therefore error is introduced in the images. If a platform was created that provided a level and centered image, then the end results would improve. Furthermore, if such a platform were created, it would be beneficial to make it compatible with soil samples from a Shelby Tube so that it would be more applicable to the technology used to acquire soil samples.

A major issue that was not caught until the end of this project was how adjusting the threshold for a stack (group of images) was inaccurate because it based the threshold for all of the images on just one image. It would be better to analyze each scan individually and then determine the void ratio, porosity, and grain size distribution. Note: this issue could potentially go away if a proper platform was constructed. However, with the current hardware setup, manual editing of each image would improve the computed tomographic results.

Another area for improvement applies refining adjustments to the camera exposure time, kilovoltage, and milliamps used when running a scan. These three parameters all play an important role in the quality of an image, and they were held constant throughout the majority of this research.

Of all of the areas for improvement, the greatest step in improving efficiency and accuracy would be with a new, state of the art scanner. A new scanner would significantly decrease the time it takes to run a scan, increase the quality in the imagery, and provide for a 3-dimensional image which would provide benefits far beyond the scope of this research project. This would significantly advance our technological capabilities and move us closer to the goal of a non-destructive method for measuring pore size distributions.

## 8 APPENDICES

### 8.1 Laboratory Manual for Destructive Testing Techniques

#### Specific Gravity

The specific gravity determination is in general accordance with Montana’s Materials Manual of Test Procedures, Section MT-204 (Montana Department of Transportation 2010), and Dr. Mokwa’s Geotech Lab Manual, Specific Gravity Lab (Mokwa 2008). The tests follow MT-204 up until the final calculations are to be made; which then, Dr. Mokwa’s Lab Manual is to be followed. Below is an example of the calculations for the soil sample CS-5:

**Table 3. Specific Gravity Example Calculation**

Mass of Flask, H <sub>2</sub> O, and stopper (M <sub>pw</sub> )	830.3	G
Temperature	77	°F
Relative Density at Temperature	0.9971	g/cm <sup>3</sup>
Mass of dry soil (M <sub>s</sub> )	100.0	G
Mass of Flask, H <sub>2</sub> O, soil, and stopper (M <sub>pws</sub> )	893.0	G
Temperature	77	°F
Relative Density at Temperature	0.9971	g/cm <sup>3</sup>

$$G_s = \left[ \frac{M_s}{M_s + M_{pw} - M_{pws}} \right] * \left[ \frac{\rho_w}{\rho_{w20}} \right]$$

$$G_s = [(100.0\text{g}) / (100.0\text{g} + 830.3\text{g} - 893.0\text{g})] * [(0.9971\text{g/cm}^3) / (0.99823 \text{g/cm}^3)]$$

$$G_s = 2.68$$

Morris, Zachary

### Water Content

The method for determining water content is in general accordance with Dr. Mokwa's Geotech Lab Manual, Water Content Determination Lab (Mokwa 2008).

### Soil Bulk Moist Density

The method for determining the soil bulk moist density is in general accordance with Nielsen's procedure described in his thesis (Nielsen 2004, pg. 45).

### Void Ratio (e)

After the specific gravity, water content, and soil bulk moist density are all known, the void ratio can be determined from the following equation:

$$e = \left[ G_s * (1 + w) * \frac{\rho_w}{\rho_m} \right] - 1$$

- $\rho_m$  = Soil Bulk Moist Density
  - $G_s$  = Soil Specific Gravity
  - $w$  = Water Content
  - $e$  = Soil Void Ratio
  - $\rho_w$  = Density of Water (0.998 g/cm<sup>3</sup>)
- \*Assumes ideal conditions

### Porosity (n)

Porosity can be determined as soon as the void ratio is known because they are both directly related by the following equation:

$$n = \frac{e}{1 + e}$$

Morris, Zachary

### Grain Size Distribution

The grain size distributions were in general accordance with Montana's Materials Manual of Test Procedures, Section MT-202 (Montana Department of Transportation 2010), and Dr. Mokwa's Geotech Lab Manual, Mechanical Sieve Analysis Lab (Mokwa 2008).

### Pore Size Distribution

Pore size distribution was not tested destructively because there currently are no proven, reliable, or readily available methods to determine pore size distribution on gravel and coarse sand soil samples.

## 8.2 Laboratory Manual for Non-Destructive Testing Techniques

### Preparing the soil sample and running the scan

1. Obtain a dry soil sample.
2. Compact soil in 4-5 equal lifts in the 2" SCH 40 PVC platform: do this with a standard proctor hammer and apply 6" blows at 10 blows per lift. Compact beyond the top of the PVC tube, and then level off the top with a ruler/scraping tool.
3. Attach the PVC platform to the CT scanner platform using duct tape (Figure 6) and place platform in CT scanner.



**Figure 6. 2" PVC pipe and platform.**

4. Close the door to the scanner and open the 'CTScan041410-TRYME' icon on the desktop.

5. Turn the CT scanner's control key on (Figure 7) and plug in camera located beneath the scanner.

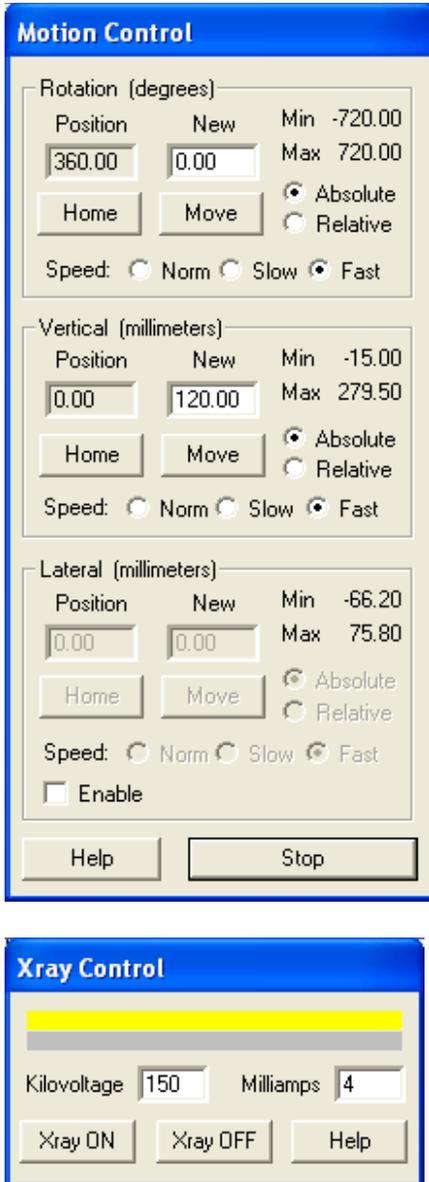
(NOTE: REMEMBER TO UNPLUG THE CAMERA WHEN FINISHED)



**Figure 7. CT scanner's control panel.**

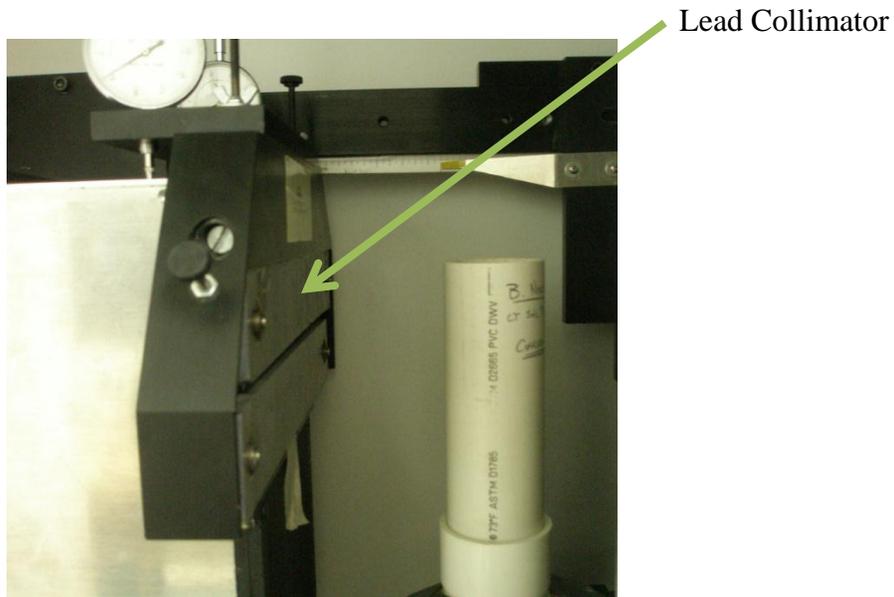
6. On the CT scanner's control panel, select the 'tube to be warmed up' time for 1-2 days, the energy for 150kV, and then hit start and the scanner will warm up.

7. On the computer, make sure that the program is set at 150kV and 4mA in the 'Xray Control' box (Figure 8). Now, position the soil sample using the computer: enter in 120 in the Motion Control box, under Vertical, New. Typically, around 120mm is a good position. Now, hit home, and then hit move, which is located underneath the vertical section of the Motion Control Box (Figure 8).



**Figure 8. CT scanner 'Motion Control' and 'Xray Control' boxes.**

8. If the scanner's warm up cycle is complete, hit enter on the CT scanner's control panel and then you can open up the CT scanner door and look at the position of the PVC tube. Note: the PVC tube should be slightly above the collimators and their openings (Figure 9).



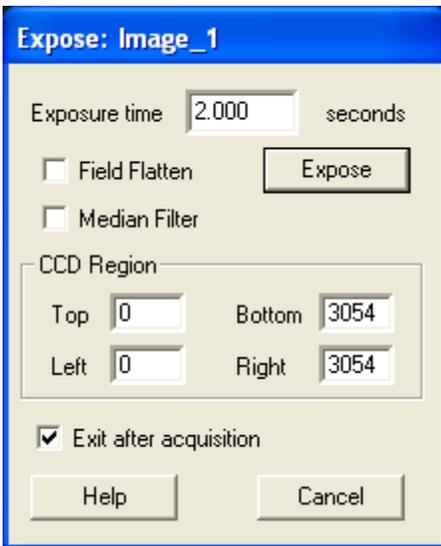
**Figure 9. Collimator and CT platform.**

9. After visually checking the position, close the door and then turn the x-ray on using the x-ray control box on the computer: wait for the red status line to fill (line beneath the yellow line, Figure 8). This process should take less than 30 seconds. If nothing happens within 30 seconds, close the program, and then open it again and turn the x-ray on.

10. Click the Image tab from the System Control box (Figure 10), ignore the debugging errors, and click the expose tab. Use the following settings for exposure (Figure 11):



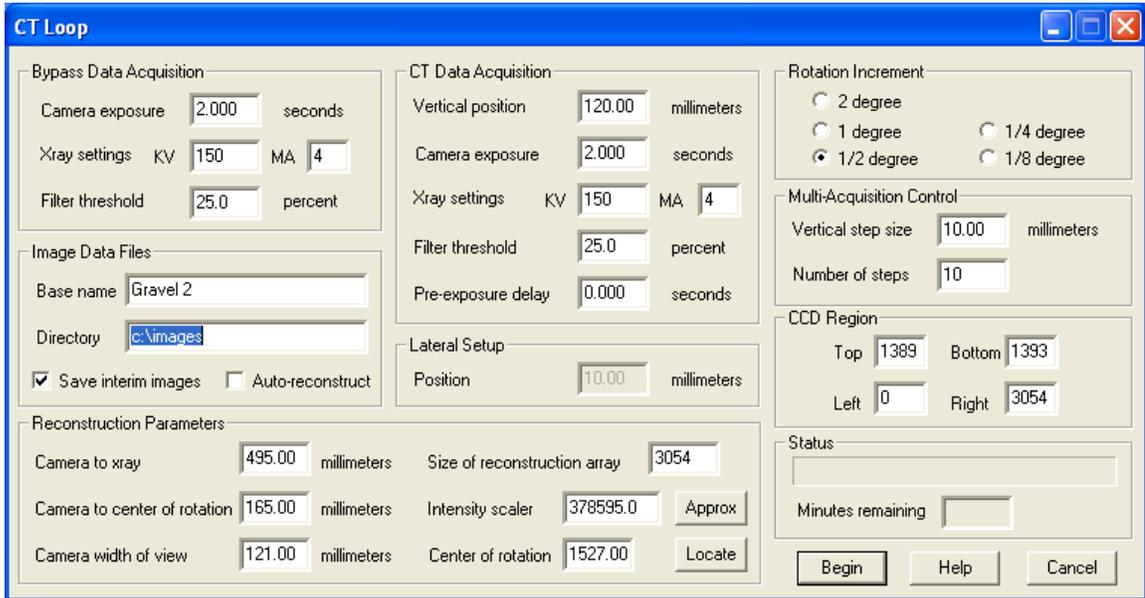
**Figure 10. CT scanner 'System Control' box.**



**Figure 11. Image tab, expose.**

11. If, in the center of the pop up screen, an image is displayed, then exit out and click the 'CT Loop' tab in the 'System Control' box (Figure 10). Note: if, after scrolling to the center of the pop up screen, an image is not shown, turn the x-ray off using the 'Xray Control' box (Figure 8) and recheck the position of the PVC tube.

12. Make sure all of the data for the CT Loop is correct and be sure to save the scanners data to a specified location. Figure 12 shows an example of the general settings used in this research:

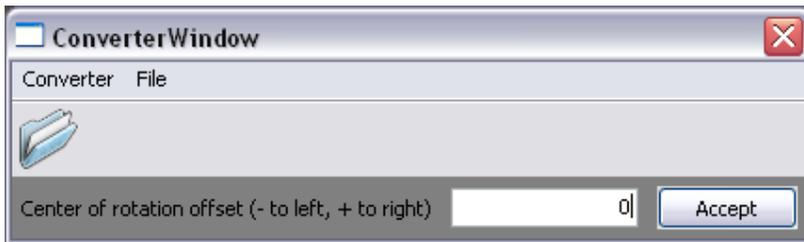


**Figure 12. CT loop tab.**

13. Click the begin button on the CT Loop screen.

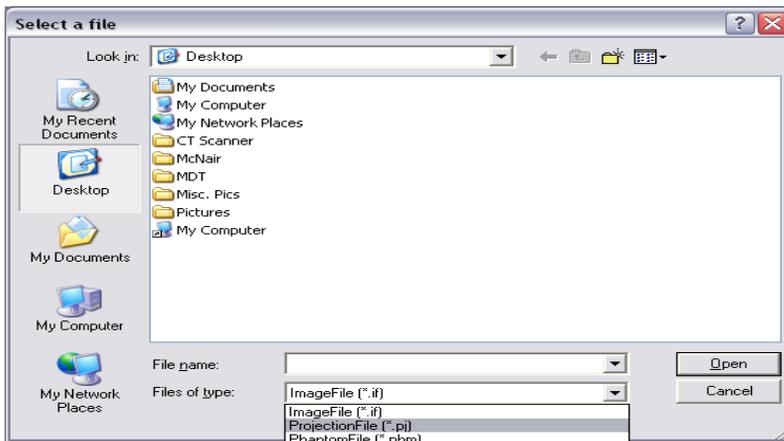
### Analyzing the Results from the Scan

1. Go to the folder where you specified to store the images. Sort the files by type and then create two folders, 'SSD files' and 'CT files.' Move all of the SSD files to the SSD folder and all of the CT files to the CT folder.
2. Open up the 'CtToPjConverter' icon and the image shown in Figure 13 will appear. Now, start with opening the first CT file of the scan and guess a few offsets (typical offsets are between 0 and 80). For each guess, click accept and save the file with a name that specifies its soil type, scan, position, and offset.



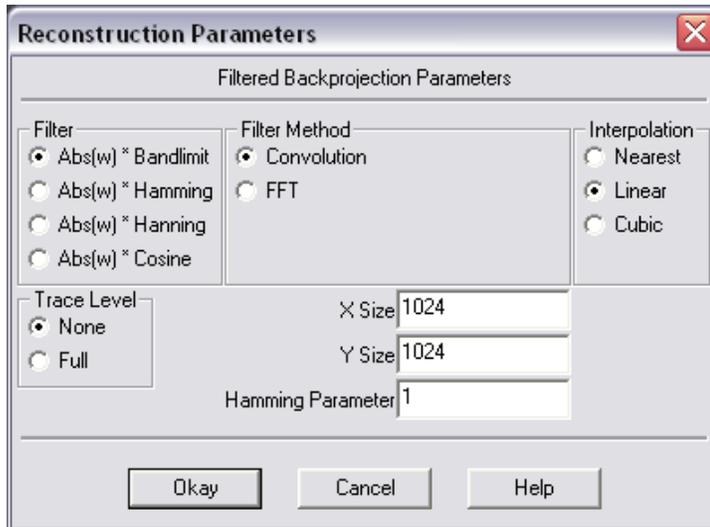
**Figure 13. CT to PJ converter program.**

3. Open the software program CTSim. When opening the files from step 2 with CTSim, one must select ProjectionFile (\*.pj) from the 'Files of type' option at the bottom of the prompt screen (Figure 14).



**Figure 14. Selecting proper file when using CTSim.**

- Once the file is open in CTSim, click the Reconstruct tab, and click Filtered Backprojection (Rebin to Parallel...). Use the following parameters shown below (Figure 15), and then click okay.



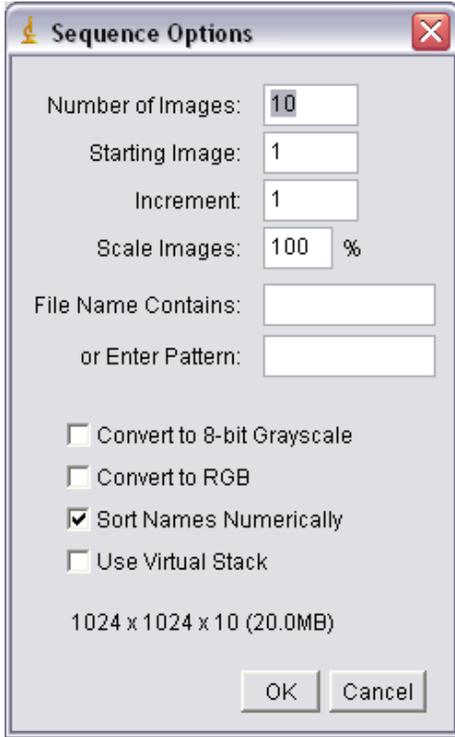
**Figure 15. Parameters used for reconstruction of images.**

- Analyze each scan for clarity and determine which offset is the best (round to nearest 5).

Note: you only need the file that produces the best clarity with its given offset.

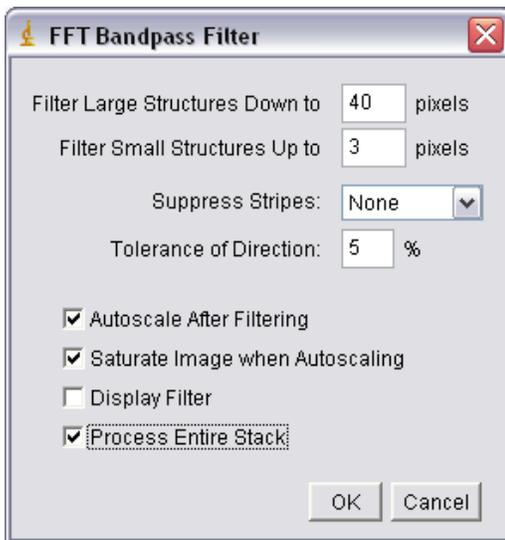
- Repeat steps two through five for the last CT file of the scan. Once the offset is determined for this image, then use linear interpolation to determine the offsets for the rest of the CT files.
- Once all CT files are converted to PJ files, use CTSim and follow the same reconstruction process as described in step four. Now however, after the image is reconstructed, click file, export, and select Dicom as the file type: do this for every file.
- Open up the software program ImageJ and click File, Import, Image Sequence. Click on the first Dicom file of the scan and then click open on the prompt window.

9. Input the options shown in Figure 16 from the box that pops up, and then click okay.



**Figure 16. Import image sequence in ImageJ.**

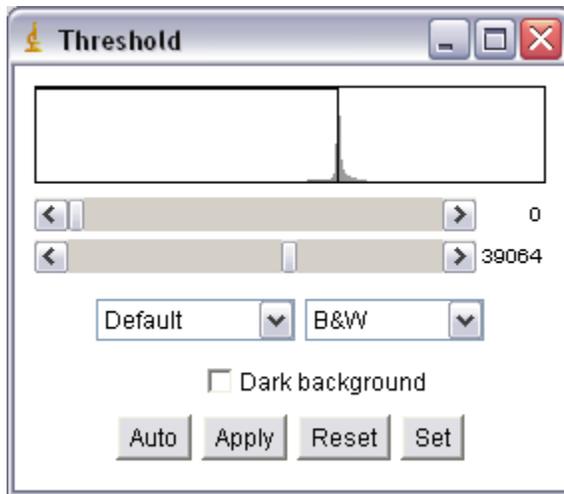
10. Select the Process tab, FFT, Bandpass Filter, use the settings shown in Figure 17, and then click okay.



**Figure 17. Parameters used for filter in ImageJ.**

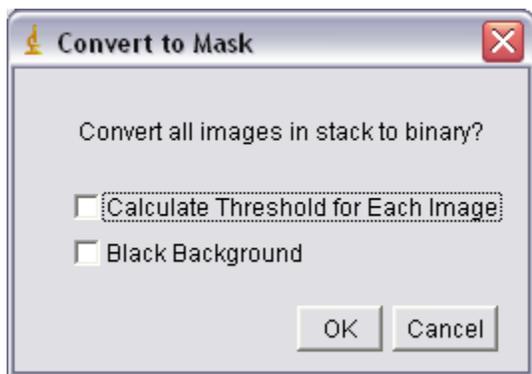
11. Select the Image tab, Adjust, Threshold. Move the line to the center of the bell curve

(Figure 18):



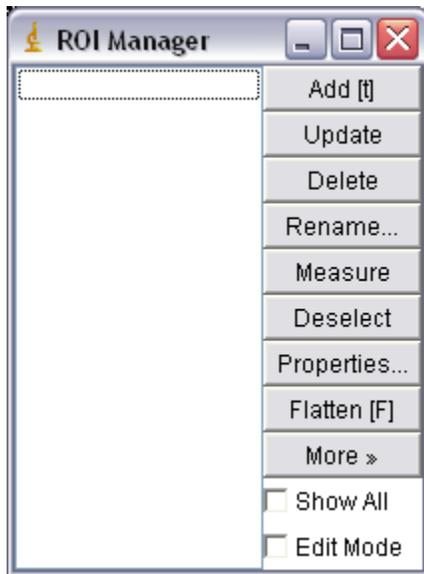
**Figure 18. Thresholding the image.**

12. Select the Process tab, Binary, Make Binary. Do not select any options from the box that pops up (Figure 19). Click okay.



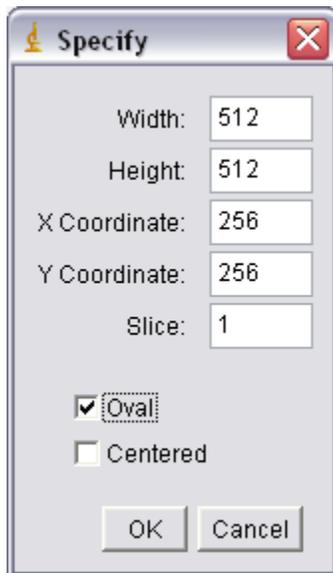
**Figure 19. Parameters used for binary conversion.**

13. Select the Analyze tab, Tools, ROI Manager..., and the screen shown in Figure 20 will open up.



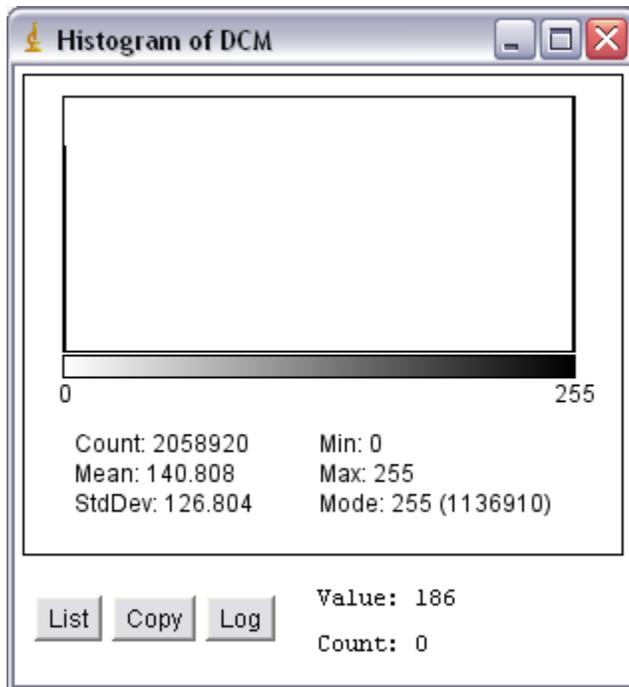
**Figure 20. ROI Manager in ImageJ.**

14. Select More, Specify. If using the same platform as was used in this report, then the options shown in Figure 21 should comply. Click okay.



**Figure 21. Parameters used for ROI Manager.**

15. Now, go to the Analyze tab, Histogram, include all images, and a histogram will open up as shown in Figure 22.

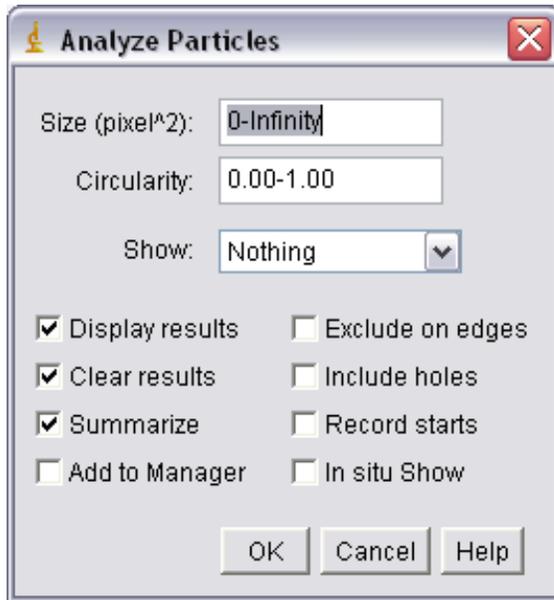


**Figure 22. Analysis using histogram.**

16. Click List, and then write down the number of void counts (Value = 0), and the number of solid counts (Value = 255).
17. Calculate the void ratio,  $e = (\text{Voids}) / (\text{Solids})$
18. Calculate the porosity,  $n = [(\text{Voids}) / (\text{Voids} + \text{Solids})]$

19. Grain size distribution can now be determined as well.

Click the Analyze tab, Analyze Particles, and use the options as shown in Figure 23, and then click okay. When prompted, select to 'include all images.'



**Figure 23. Analyzing particles.**

20. There will be a substantial amount of results: select the particle number column and the area column, and paste in an excel spreadsheet. By taking the square root of the area, an average diameter can be determined and this can be used as the determining factor of whether or not the particle will pass through a certain sieve size. Note: the particle area size needs to be adjusted because the scale is not correct. This is accomplished by measuring the outside diameter in pixels, and comparing it to the outside diameter in mm. Upon doing this, one can now adjust the area properly. For example, if 670pixels = 60.325mm, then the True Area of the particle equals is evaluated as:

$$\text{True Area of the particle} = (\text{Area in pixels}) * (60.325\text{mm} / (670 \text{ pixels}))^2.$$

### 8.3 Images from the Scanner after Editing in ImageJ

In Figure 24, the white areas represent the voids and the black areas represent the solids. The solid black circle represents the 2" PVC pipe used to scan the soil, and the colored inner-circle represents the region of interest (ROI). The area inside of the ROI is where the soil is analyzed, and the area outside of the ROI is disregarded. Inside of the ROI, there are void spaces inside of the solid spaces. These void spaces are known as holes and were filled-in for analysis using ImageJ. Therefore, the holes were counted as part of the solid in which they existed.

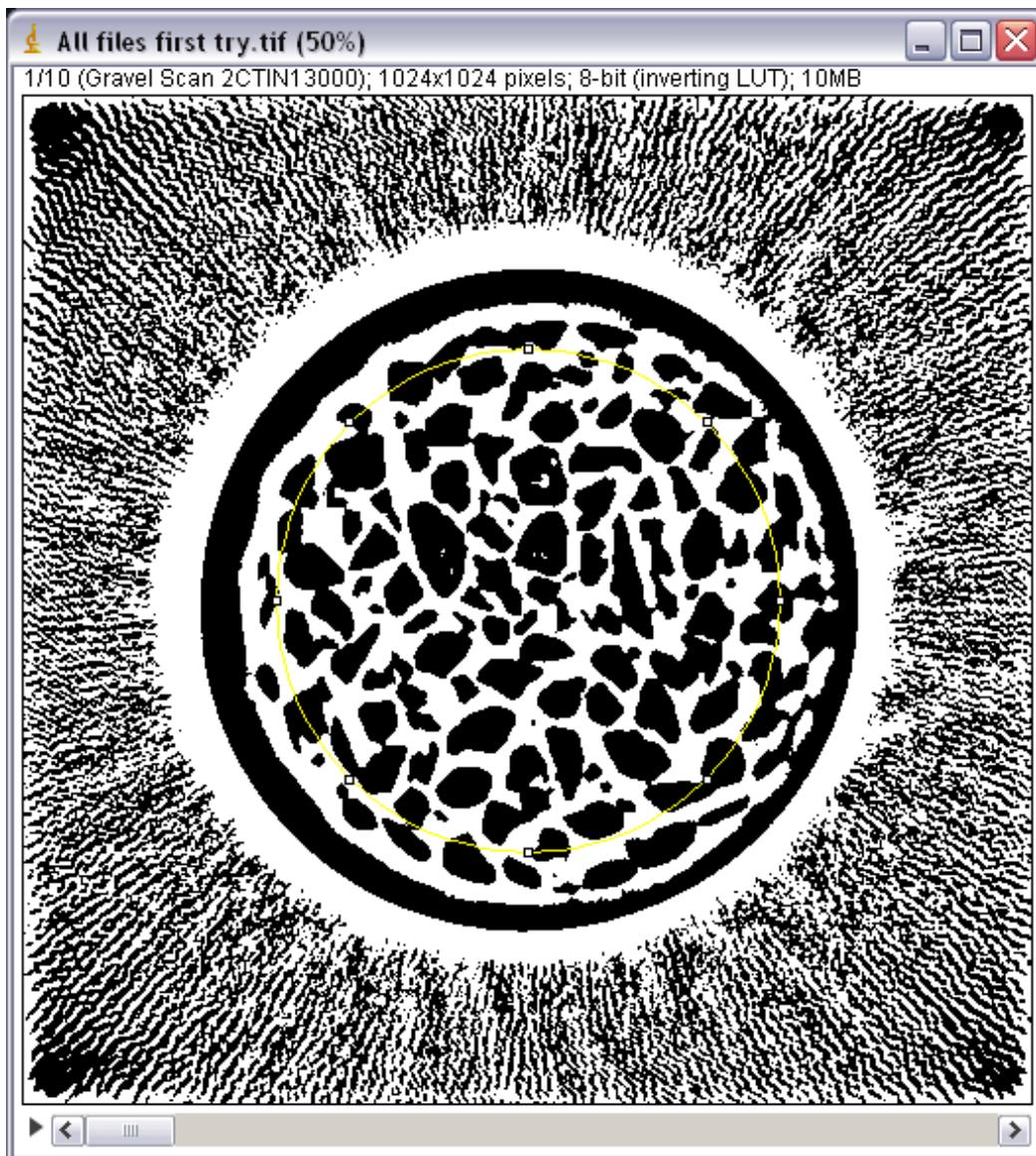


Figure 24. G-2 image after editing in ImageJ.

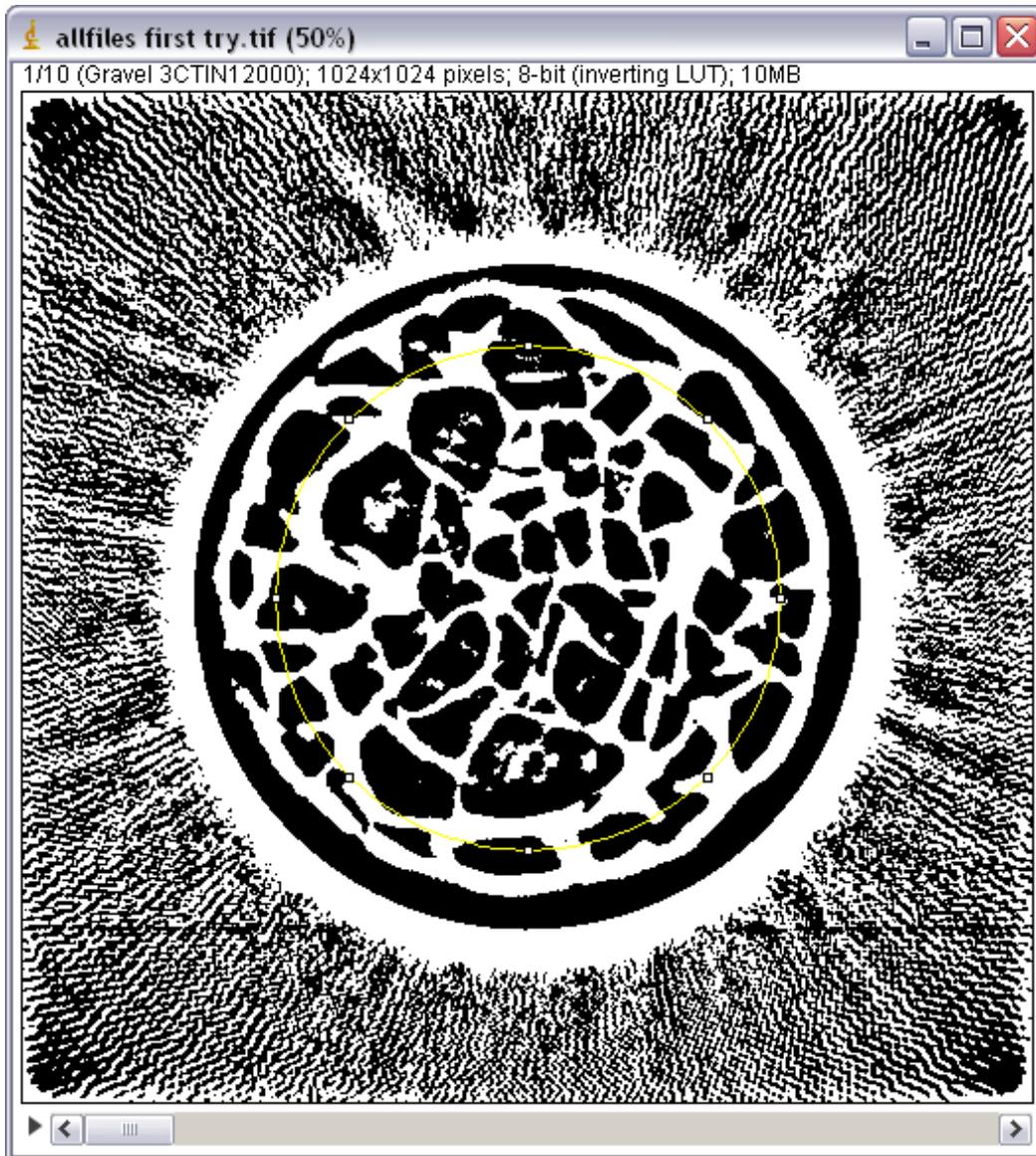


Figure 25. G-3 image after editing in ImageJ.

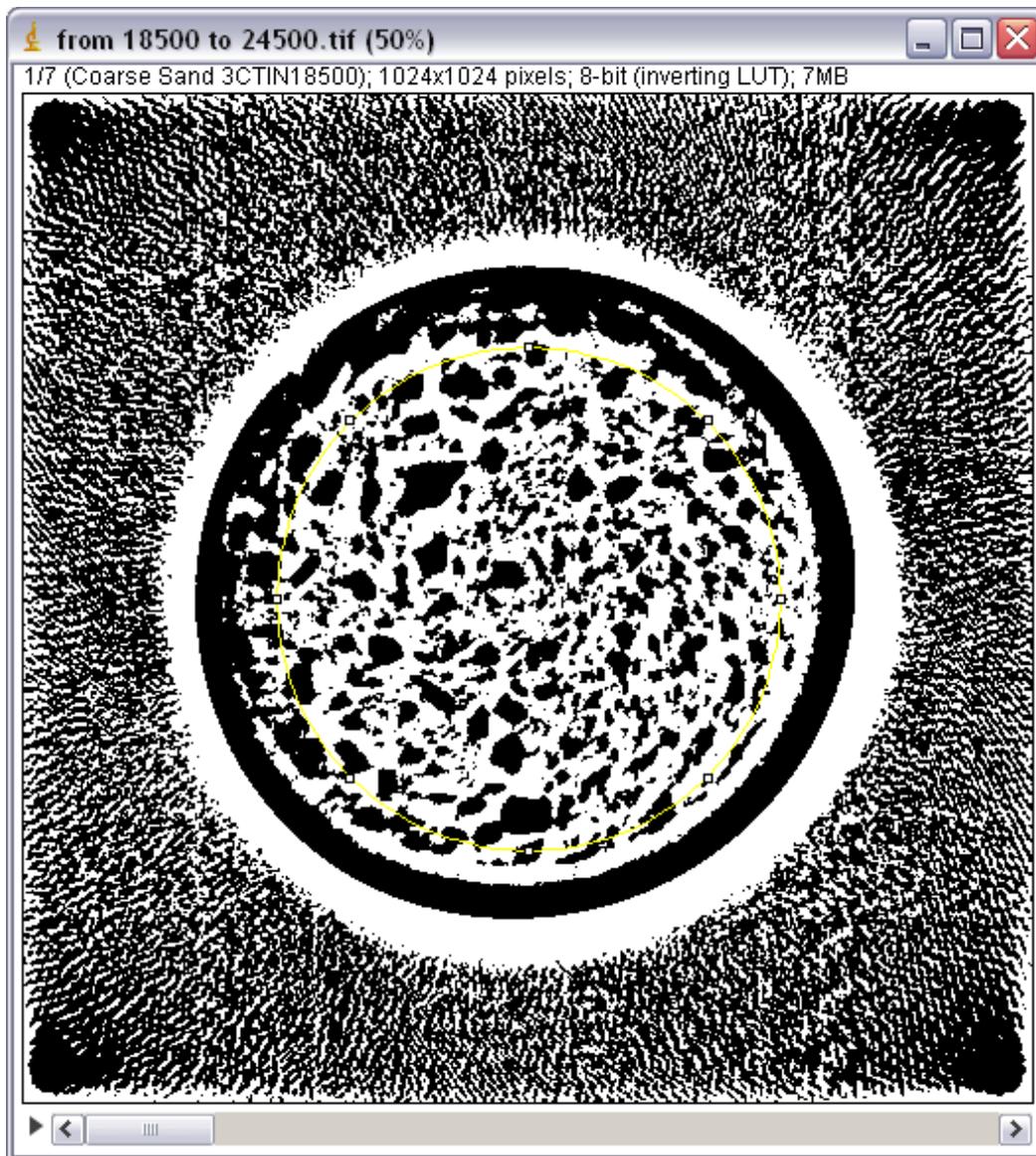


Figure 26. CS-3 image after editing in ImageJ.

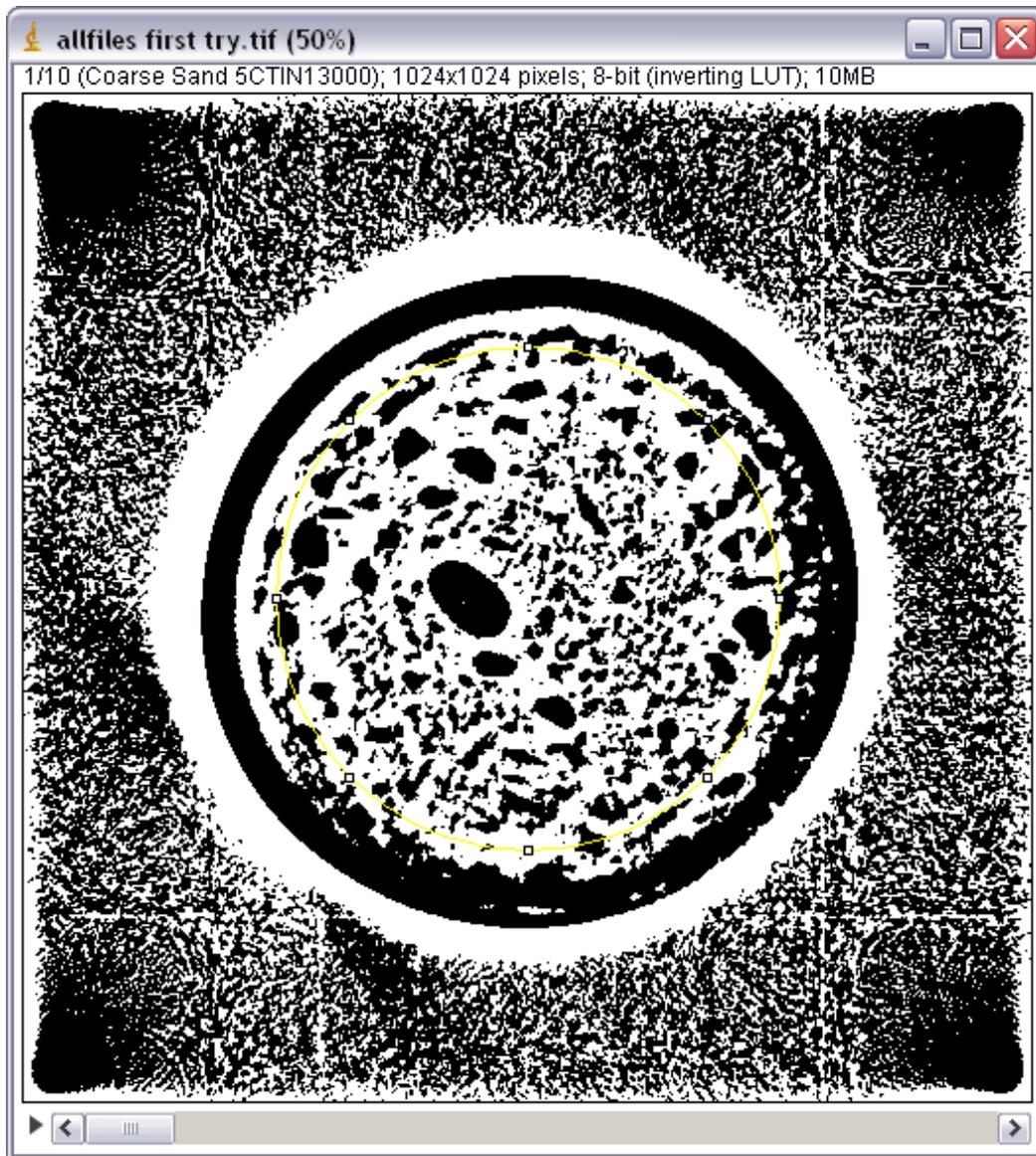


Figure 27. CS-5 image after editing in ImageJ.

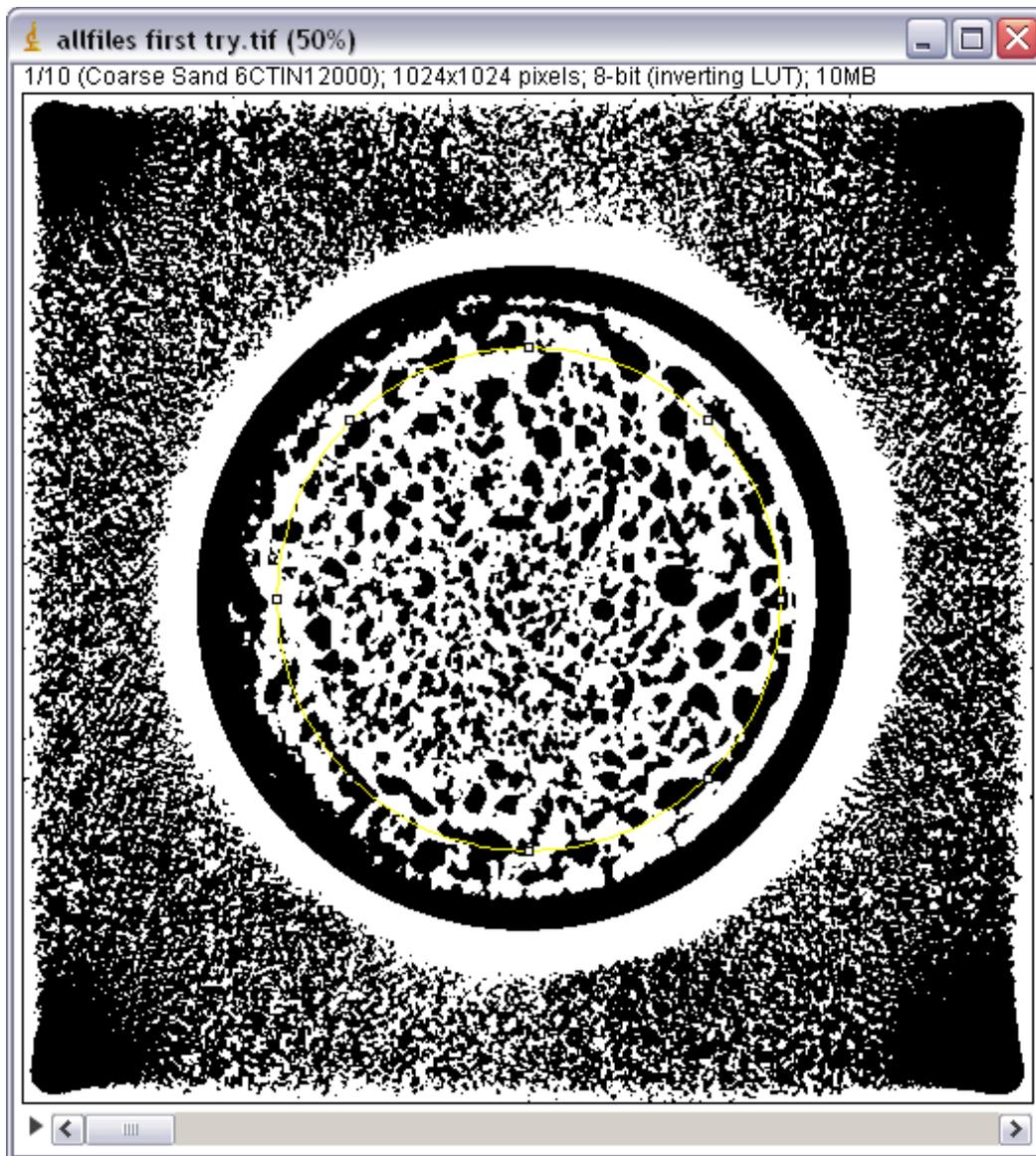


Figure 28. CS-6 image after editing in ImageJ.

## 9 REFERENCES

- Alshibli, Khalid A., and Reed, Allen H. *Advances in Computed Tomography for Geomaterials*. Hoboken: John Wiley & Sons, Inc., 2010.
- Ferreira, Tiago A., and Rasband, Wayne. *The ImageJ User Guide, Version 1.43*. Bethesda, Maryland, April 20, 2010.
- G. Zacher, J. Santillan, O. Brunke, and T. Mayer. "3D Microanalysis of Geological Samples with High-Resolution Computed Tomography." *Advances in Computed Tomography for Geomaterials*. Hoboken: John Wiley & Sons, Inc., 2010. 197-204.
- Holtz, R.D., and Kovaks, William R. *An Introduction to Geotechnical Engineering*. New Jersey: Prentice-Hall, Inc., 1981.
- Mokwa, Robert L. *Geotech Lab Manual*. Bozeman: Montana State University, 2008.
- Mokwa, Robert L., and Nielsen, Brent D. *Characterization of Soil Porosity Using X-Ray Computed Tomography*. Bozeman: Montana State University, 2006.
- Montana Department of Transportation. *Montana Materials Manual of Test Procedures*. Helena: Montana Department of Transportation, 2010.
- Nielsen, Brent D. *Non-Destructive Soil Testing Using X-Ray Computed Tomography*. Bozeman: Montana State University, 2004.
- Otani, Jun and Obara, Yuzo. *X-Ray CT for Geomaterials*. Lisse: A.A. Balkema, 2004.
- Peters, Terry. *CT Image Reconstruction*. London, Ontario, July 03, 2002.
- Robbins, Bryant, and Nichols, Josh. *X-Ray CT Imaging of Geomaterials Users Manual*. Bozeman: Montana State University, 2010.
- Rosenberg, Kevin M. *CTSim 3.5 User Manual, Version 1.0*. Albuquerque, New Mexico, September 17, 2005.
- V. Cnudde, J. Vlassenbroeck, Y. De Witte, L. Brabant, M. N. Boone, J. Dewanckele, L. Van Hoorebeke, and P. Jacobs. "Latest Developments in 3D Analysis of Geomaterials by Morpho+." *Advances in Computed Tomography for Geomaterials*. Hoboken: John Wiley & Sons, Inc., 2010. 84-92.
- Y. Kobayashi, S. Kawasaki, M. Kato, T. Mukunoki, and K. Kaneko. "Evaluation of Porosity in Geomaterials Treated with BiogROUT Considering Partial Volume Effect." *Advances in Computed Tomography for Geomaterials*. Hoboken: John Wiley & Sons, Inc., 2010. 287-294.

# **Practical and Professional Ethics**

## **Establishing an International Voluntourism Ethic**

Author:  
Shelby Rogala  
Undergraduate, Montana State University  
**Establishing an International Voluntourism Ethic**

## **Abstract**

The purpose of this paper is to discuss the ethical obligations of international volunteers and volunteer agencies. One might think that volunteers and volunteer agencies have minimal obligations to the communities they serve precisely because it is *voluntary* and *non-profit*. That is, we tend to think of volunteering as a “supererogatory act” that goes above and beyond the call of duty. However, new ethical problems have emerged, particularly in the area of short-stay volunteering, or “voluntouring.” I will argue that volunteer practices are often carried out in ways that deny the autonomy of local populations. However, this does not translate into international volunteering as an inherently unethical practice to be condemned. Rather, I will argue both organizations and volunteers have moral duties to the populations they serve. I will draw out the implications that my analysis has for developing an “international volunteering ethic.”

## **Introduction**

Due to globalization and mobilization of demographics from around the world, overseas aid is no longer a job relegated only to governmental or religious organizations. As ability to travel has increased, and a desire to participate in something more culturally relevant than cruise ship tours is spreading, the industry of voluntourism has entered the scene. I will define voluntourism as the recent phenomenon of taking travel vacations that center around a short stint of volunteering. This volunteering activity can manifest in many different services, but is most commonly one of three forms: teaching English to children, working towards women empowerment or pairing with medical organizations to improve healthcare for certain populations. These programs are typically run in developing countries, in rural or urban settings.

On one hand, voluntourism might be thought to be a good thing, insofar as it draws more people into volunteering than otherwise might be interested. When volunteering provides the opportunity to see a completely different country or have a unique cultural experience, while not requiring any long-term commitments, it can increase the appeal of volunteering. People who might otherwise take a vacation somewhere are now using their vacations to help others.

Moreover, this allows wealthy Westerners to have interaction with different cultures and populations who are less well off, which may improve Western's understanding of and compassion for, the challenges developing countries face.

On the other hand, voluntourism tends to exacerbate already existing problems in international aid. Agencies still deal with traditional problems such as ensuring sustainable aid, creating local agency and autonomy, and maintaining positive cultural relations, but instead of working with a few volunteers for long periods of time, voluntour agencies must contend with larger amounts of untrained, short stay volunteers. Due to the nature of overseas volunteering, these problems add upon each other. When volunteers are not trained, they aren't as aware of cultural norms and history, when they aren't educated on their aid area, they tend to take less into account the area's needs and wants, when they forget this, local agency is minimalized, and autonomy is marginalized.

In this paper, I will outline the ethical problems in voluntouring and explain the reasons these problems exist. I will then suggest ways to establish a voluntouring ethic and draw out the implications this has for international volunteering in general, as the problems encountered in voluntouring are also relevant to broader problems in volunteering.

### **Ethical Problems in Voluntouring**

I would like to present an example of a situation commonly encountered in overseas aid. This is the case of Cruz Che, Guatemala as outlined by Ned Breslin, CEO of the non-profit Water for People.

Well-meaning outsiders built 30 toilets but did not have enough money to help the rest of the community (35 families). The remaining 35 families want free latrines like their neighbors and have rejected Water For People and the Municipality's sanitation program because we insist on financial

contributions from the families to help ensure a sense of ownership and demonstrate the ability to cover O&M costs. The well meaning agency did not think beyond their initial investment of 30 toilets and have in the end undermined the further development of the community (Breslin).

In the case above, the outcome was an inability of organizations to co-operate with local communities after a previous organization had given what might be called a ‘handout.’ These freebies cut at the very heart of international aid—they exemplify the good intentions of organizations and volunteers, a blatant lack of evaluation of project management, and perhaps most unfortunate, a created system of dependency upon handouts rather than autonomous community building. Volunteering intensifies these problems because the volunteers are there for a shorter amount of time and are arguably less invested in the communities. I will now distinguish several aspects of this sort of situation that are ethically problematic.

#### *Lack of Autonomy and Agency*

The factors that lead to a lack of local agency is a combination of paternalistic, or “West Knows Best” ideas and the structures of volunteering non-governmental organizations (NGOs). The effect is a dependency on foreign handouts that restrict local communities from becoming agents of their own change. This is in neither the communities nor the organizations best interest. If a program was set up four decades ago to restructure the school system in southern Africa, and hasn’t changed its mission, something is going wrong: international aid should be transitory and helpful, not permanent and bogged down (Strauss, 2008). It is assumed that ineffective or inefficient aid is to be avoided, and that something must be done to maintain the integrity of both local communities as well as aid organizations.

It might be prudent to assign an ethic of ensuring local ownership to combat the problem of autonomy and agency. Many authors write on the need to get locals involved and encourage volunteers to understand the need for local communities to exhibit ownership in the projects.

Local ownership is defined as a community dictating where their aid is directed and taking an active role in the responsibility of management as well as fiscal parameters. A large part of ownership is making sure the local community understands that the NGO is not coming to do the job for them: that is, problems arise when programs are set up that “seem to suggest that young people from developed countries can solve problems that young people in developing countries cannot solve for themselves” (Fulbrook, 2008). Though avenues may not always be open for local leadership, it becomes the NGO’s responsibility to find acceptable routes. Aid organizations then work as facilitators rather than developers. This ensures projects to become self-sustaining, which leaves more resources available to develop meaningful cross-cultural relationships.

Autonomy and agency come hand in hand—sometimes promoting community independence encourages community involvement, other times autonomy grows out of active ownership of projects, and an ability to dictate what happens. Currently either autonomy or agency are mildly stressed as important roles in international aid (in respect to volunteer training). Though both are necessary, neither is sufficient on its own. Both problems are directly related to a third and perhaps fourth necessary component, volunteer training and positive volunteer motivations.

### *The Problem with Good Intentions*

In evaluating aid projects, many view charity as a step above and beyond our moral obligations. Because those volunteering have good intentions, or are motivated by an unselfish desire to help others, this is taken to be sufficient for their actions to have moral worth. This leads to problems in the aid world. Singer suggests that charity is not as effective when treated as merely an ‘extra’ rather than a duty or obligation (CITE if possible). When a person engages

in an act of charity, and feels as if they have already placed higher standards on themselves, they and others are less likely to question how much better that act could have been. Because the mere act of giving two cents a day to an African child is more than most would do, few question what could be done better. When aid workers believe that good intentions alone are sufficient to fostering positive community development, they misrepresent the difficulties of international aid.

This problem is compounded when added onto the goals of Voluntour NGOs to funnel as many volunteers through their programs as possible. Organizations take advantage of the fact that most volunteers come to the projects already feeling good about their work. There is no need in the eyes of the volunteer or the organization to provide extensive training. Though most organizations offer a week-long orientation, this generally consists of a day or two of basic language and culture education followed by sightseeing. Volunteers are thus insufficiently trained to understand the people, places and problems that they will inevitably face in the field.

Lough (2008) writes about necessary training steps for outgoing volunteers and program managers. They include role taking, reflection, intensity, support and reciprocity. Lough argues that encouraging positive and specific role taking, enough time for reflection of work, intensity in duration rather than work hours, sufficient support on the field and reciprocity with local communities are necessary conditions for any successful volunteer placement. These measures are intended to encourage a deeper understanding for the volunteers of what will be expected of them. In turn, it provides the volunteer agencies with an opportunity to ensure volunteers and managers are committed to the program. This suggests that in most precarious volunteering situations, those good intentions must be accompanied by a knowledge and capability that puts those intentions, energy and time to their best possible use.

I have argued that having good intentions are not sufficient for ethical volunteering, but this does not mean that they are not a necessary. In Kantian ethics, when good intentions are not present, it is a simple case of using people as means to an end, rather than treating them as means in themselves. When a volunteer only donates her time to a community in order to build a resume, she is treating the community members as objects to further her goal. Similarly, when an aid worker signs up for an adventure to Brazil under the guise of a volunteer trip, she is using the local culture of Brazil as a means to her end, without showing any sign of concern for the actual community. Indeed, the fact that a) the volunteer is using the locals as a means to an end and b) the volunteer is pretending to help the local community makes the ethicality even more questionable.

Some may disagree with this argument on the grounds that intentions have no impact on the work being done. No matter if a volunteer comes for their own pleasure or with the goals of helping a local community, the benefits are the same. When dealing in close contact with other cultures and individuals, however, intention comes out in a very visible way. Lucy Healey and Jenny and Jacques Bouillet write in *Volunteering: What's in a Name*, "We have seen volunteers come into the village communities to engage in 'community development' work that collapses once the volunteers have left." Presumably, if the volunteer had good intentions, vested interest beyond personal gain and correct follow-through, the volunteering experience could provide a long-lasting benefit for the communities involved, as well as the volunteers. Good intentions and proper training become two more necessary conditions for ethical volunteering.

Outlined above are the problems encountered in international voluntouring, that is, autonomy and agency threatened by poorly trained or mal-intentioned volunteers. Applying these problems to a volunteering ethic creates four necessary components. These are: ensured

autonomy, active agency (of the community), well-intentioned volunteers and properly trained volunteers. The next section of this paper will describe why these problems arise, and in what ways higher standards can be incorporated into existing voluntouring systems. It doesn't assume that problems in voluntouring agencies are inherently unethical, but rather that these problems can be addressed in order to *improve* the moral worth of volunteering, or to maximize the energy and abilities volunteers can bring to developing countries.

### **Toward a Volunteering Ethic**

In addition to the four criteria for ethical volunteering that I have argued for in the previous sections, I would like to develop a fifth ethical guideline that will support the success of the other four. This guideline deals with a need for transparency within the systems of voluntouring, as well as international aid in general. It is tied to the ideas of organizational structure and market based charity.

#### *Organizational Structure*

Shepard (1998) suggests NGOs must engage in a certain amount of "unbundling" before NGOs can operate on a sustainable level. The term unbundling in this context refers to the process of creating a more transparent system less reliant on upper management and more in tune with local cooperation. In a visual sense, it means moving from a vertically structured system to a horizontal one: to 'unbundle' leadership roles into the community as opposed to keeping them in high ivory towers.

In order to make this idea clearer, a hypothetical Voluntour NGO structure is outlined below. This representative NGO operates in India. It provides three services (or volunteer options). These are teaching English in schools, working with local daycares and creating programs for street kids. The structure begins with the International NGO organization, through

which volunteers are put in contact with the country coordinator employed by that NGO. After this layer, volunteers begin communication with the in-country coordinator, who is stationed in the country, and employed by various NGOs in a managerial position. This position is the link between the local NGOs and the international NGO. He/She may be working for various companies at once, providing similar services to each. In most organizations, this position is the host for orientation week, the airport pick up/drop off coordinator, and initial contact for the volunteers.

The local NGO has a similar function to the in-country coordinator, except that this organization has little to no contact with the international NGO, and none with the volunteers pre-arrival at the volunteer site. Like the in-country coordinator, the local NGO may be working simultaneously with various international NGO's, providing housing, food, and project orientation and support for multiple locations and volunteers. This partnership between international non-profits and local ones is mutually beneficial. Unless international NGOs have the wherewithal to place volunteers themselves, or local NGOs have the time and money to dedicate to marketing out of country, each needs the other to complete their job.

Up until this point the structure of the organization is strictly vertical. There is little horizontal branching. However, once a volunteer arrives to their project location, a small amount of branching out takes place. This is support that can be provided by individuals not necessarily tied to the international or local NGO. Currently, these roles are filled by the principals in the schools, the teachers in the daycares, and hopefully long term volunteers in the street kids programs. Keep in mind, however, that of the three projects, each has various locations: therefore, there is not only one school or one daycare location, but several in the same town. This

makes the levels of support more confusing by far, and the amount of managing on the part of the local NGO a big task.

What I recommend adding is additional support systems on the local level—unbundling leadership roles to include more local managers. The answer of the question of how to make transitions between volunteers easier, and how to utilize the high energy that short stay volunteers can offer projects will also answer in what ways programs can better serve local communities. By creating an easily accessible—transparent— support system at the local end, volunteers are better able to connect with their projects and communities.

### *Market Based Charity*

Perhaps the most important application of transparency is within the financial areas of voluntourism. The stigma that many have about higher prices meaning higher quality is taken advantage of in the volunteering realm. Higher cost doesn't necessarily translate to a better program. At times higher costs really mean greater profits for those running the “non-profit.” Many cheap, well-run organizations are overlooked and others that funnel their funds in a more efficient manner that benefits locals are regarded as ‘unsafe.’ How do costs translate?

Some organizations take increased costs and put them towards marketing or upper management. This increases the ‘viability’ of the company because the name becomes more mainstream, not due to results but to search engine popularity. This means that money for marketing isn't necessarily the result of a popular program, but rather the cause of it.

Some organizations charge extra money up front for extra activities, using the impressive list of side ventures as an explanation for where all that money is going. There are a few problems with this line of persuasion. Say yoga for one week costs 40 USD. One organization might add this charge to the volunteers original program package for each week they are there,

regardless of whether or not they will take part in this activity. However, this does not necessarily mean that if it is not included one cannot access it. As most volunteer operations are funneled down to local non-profits, and therefore local NGOs host several different international organizations, the services available to one organization are available to all. Many organizations offer a booklet of activities, outings and extras that they will charge for in addition to the program price. This makes the initial cost of the trip lower, and though volunteers may have to pay extra for yoga or side trips, they are able to do so at their discretion. Therefore, if a volunteer was interested in participating in all the extra guided activities, the more expensive program might be a better deal in some ways. However, if another volunteer is looking to do trips on their own, or only take a few extra classes, the pay-as-you-go option will prove much cheaper in the long run—they won't be subsidizing other's activities as much. Ethically speaking, transparency in rates provides a fairer opportunity for the volunteer to choose which program best fits their needs.

Asking the volunteers what they would want their extra money to go to, most of the answers, unsurprisingly, were: safety, preparation and creating local jobs. None answered, "I would like to pay an extra 500 dollars a week so that the president of the NGO can drive a BMW, or so the managers of the program can hire two maids and three chefs." Though it is understood that costs must go to those in charge, and their jobs are certainly important and deserve to be rewarded, there seems to be something not quite right about taking advantage of people's goodwill and regard for safety to charge exorbitant prices.

The more direct route to the community an organization runs, the lower the cost for the volunteer and the greater the payback to the local community. In an interview conducted in May 2010, one volunteer spoke of her conversations with coordinators regarding finances:

*“The only disappointing aspect of this experience was that the volunteer host had very limited funding. She only received 300 rupees a day per person from the coordinator, Dr. D, which barely paid for our food. We stayed at her house, and all other expenses were paid by her. I only received one meal from Dr. D, on the way from our Delhi Coordinator’s house to the volunteer host. It made me wonder where the rest of the money went (only \$30 was paid to J. Sali, the volunteer host, for my week-long stay, although I payed \$220 to the main organization for my week volunteering with her, on top of the \$320 paid for the orientation week). It seems it was pocketed by Dr. D.”*

When this volunteer wanted to complain to the organization about this discrepancy, she was asked not to, in order to not discourage other volunteers from joining the organization. This is under the assumption that most volunteer agencies operate in by catering to the highest paying international NGO and the lowest charging local NGO to create the largest profit margin, and uncovering the fiscal organization of one would not change the system. The question becomes whether or not voluntouring would be happening if these coordinators were not making a profit. It isn’t evil to make a profit, or irresponsible.

The problem perhaps becomes transparency and understanding. The idea of a middle man making taking in a large salary while local NGOs bargain to feed and house volunteers seems distasteful. As illustrated, however, a restructuring not just of one NGO would need to be made, but of all. This gargantuan task might in fact prove more disastrous to effective aid than it would benefit. Perhaps a way to manage this problem is to create an ethical code wherein NGO internal operations are made transparent to potential volunteers. Though this does not change the system, it places an awareness in the mind of the volunteer the market basis of their goodwill. Thus, in addition to ensuring local autonomy and agency, encouraging proper training

and motivations of volunteers, international aid must also include a measure of transparency within the operation of systems.

### **Conclusions: The Next Step**

While all can agree that many NGO's have the capability to promote social wellbeing we can also recognize the pitfalls and shortcomings of various organizations in practice. And yet, these problems seem to be slipping through the cracks: there is a certain amount of ignorance or oblivion in the voluntourism community as to the disastrous effects of poorly operated aid agencies. This is a result of having no established set of governing ethics. As voluntouring is a representative microcosm of international aid in general, and problems encountered in voluntouring mimic and expand problems in international aid (with respect to volunteers), the ethics defined for voluntouring can be roughly applied to international volunteering.

I have outlined the major ethical issues in regard to international voluntouring: lack of autonomy and agency, poor volunteer training, and shifting intentions of volunteering. I have tried to change these into ethics to be followed, four necessary components to international voluntouring: ensuring autonomy and agency, proper volunteer training, and good intentions. I have added a further standard of transparency within NGO operations to promote understanding of market-based charity. I then expanded these ethics to include not just international voluntouring practices, but international aid in general, as problems run parallel in both situations. These suggestions can provide a starting point for building a more comprehensive international voluntourism ethic.

**References:**

Brown, Kathleen M. Keys to Making A Volunteer Program Work: A Guide for Organizations That Use Volunteers. California: Brown, 1982.

Boullet, Jacques and Jenny; Healey, Lucy. "Volunteering: What's in a Name?" Just Change: Feb 2008: 20.

Breslin, Ned. Rethinking Hydrophilanthropy: Smart Money for Transformative Impact. Water For People.

Lough, Benjamin J. "Principles of Effective Practice in International Social Work Field Placements." Journal of Social Work Education (2009)

Kawashima, Tatsuhiko. "International Volunteer Co-operations Activities of GONGOVA: Grass Roots Programme for the Underprivileged Villages in Thailand." Gakushin Economic Papers, Vol 39, No. 2 (2002).

Musik, Mark and Wilson, John. Volunteers: A Social Profile. Indiana: Indiana University Press 2008.

O'Neil, Edward. Awakening Hippocrates. US: AMA, 2006

Oyen, Else. Best Practices in Poverty Reduction. NY: Crop, 2002

Shepard, Andrew. Sustainable and Rural Development. NY: St. Martins Press, 1998.

Strauss, Robert L. Think Again Peace Corps. Foreign Policy Web Exclusive, 2008

Szporluk, Michael. "A Framework for Understanding Accountability of International NGO's and Global Good Governance." Indiana Journal of Global Legal Studies (2009)

The Impact of Management Intensive Grazing

Jocee Stirling

Department of Animal & Range Science: Montana State University

Mentors:

Clayton Marlow, Montana State University

Chuck Coffey, Noble Foundation



THE SAMUEL ROBERTS  
**NOBLE**  
FOUNDATION

## TABLE OF CONTENTS

<u>Sections</u>	<u>Page</u>
I. ABSTACT.....	1
II. INTRODUCTION.....	1
III. METHODS.....	2
IV. EXPERIMENTAL DESIGN.....	2
V. RESULTS.....	5
VI. CONCLUSIONS.....	8
VII. MANAGEMENT IMPLICATIONS.....	9
VIII. LITERATURE REVIEW.....	10
IX. REFERENCES.....	11

### Tables & Figures

Figure 1.....	4
Figure 2.....	5
Figure 3.....	5
Figure 4.....	6
Figure 5.....	6
Figure 6.....	7
Table 1.....	7

## **ABSTRACT**

The purpose of this research project was to determine the impact of a Management Intensive Grazing system on a native warm season pasture. A nine acre native warm season pasture in Ardmore, OK, was used for this experiment. This research project was done for two consecutive summers in 2009 and 2010. The vegetation composition increased in the presence of sedges, forbs, and invasive species.

The data in this study also shows that steers can still exhibit a preference while under a management intensive grazing system. Due to the results, management intensive grazing does not appear to be a good system for preserving a native warm season pasture. The management intensive grazing system claims to reduce selectivity and increase the uniformity of grazing. This study suggests otherwise.

## **INTRODUCTION**

Management Intensive Grazing or MiG is a rotational grazing system that is becoming a widely used grazing system by livestock owners across the United States. This experiment was conducted to determine its effectiveness for use in preserving native warm season pastures while still producing a profit. This experiment was conducted in Ardmore, OK, under the supervision of the Samuel Roberts Noble Foundation. The native warm season pasture that was used in this experiment, prior to grazing for this research, had not been grazed in 20 years. The vegetative composition of the pasture was over 65% native vegetation. The grazing experiment was conducted from June through July in both 2009 and 2010.

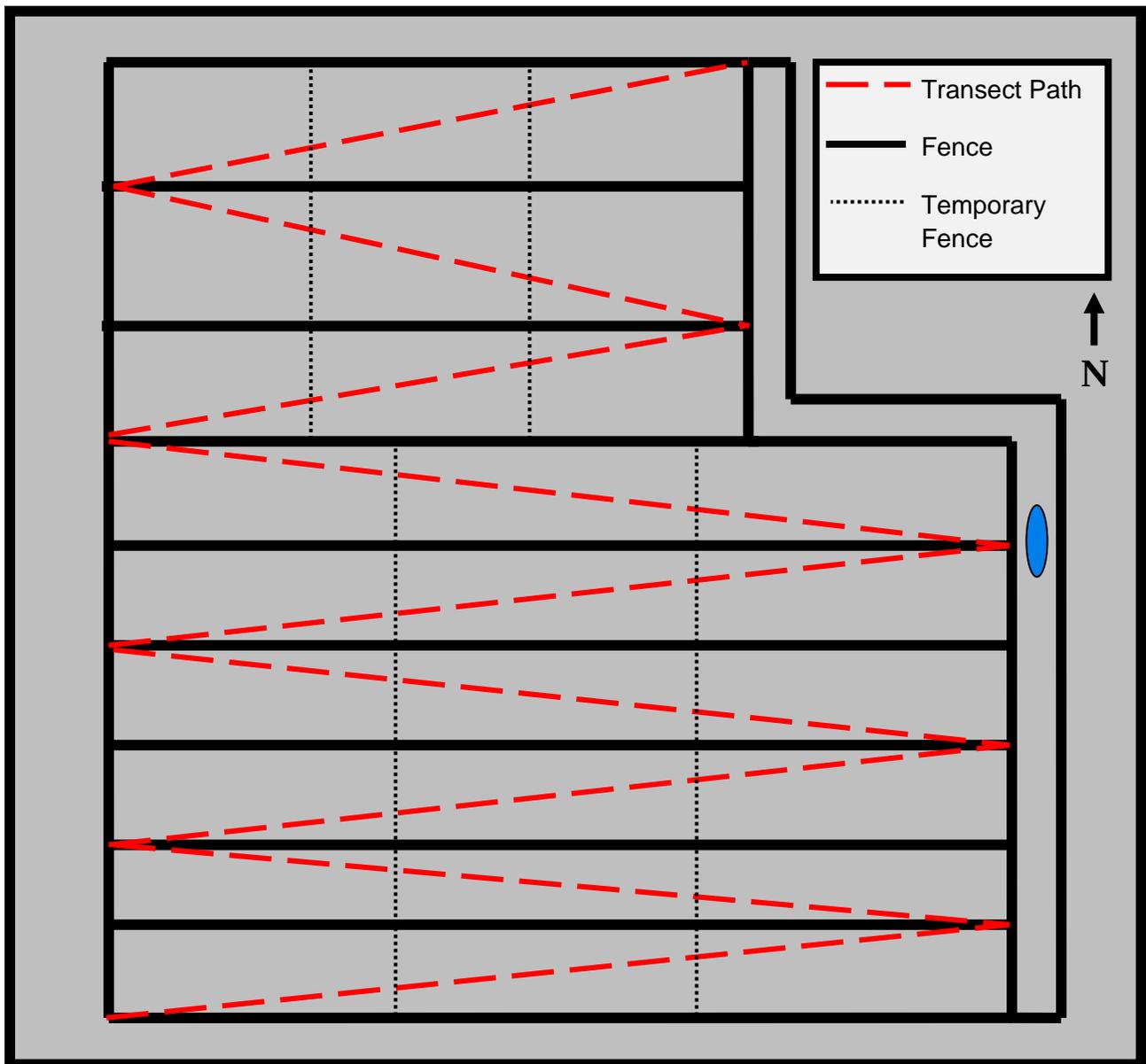
## METHODS

- 14 Steers (700lbs) grazed 0.33 acres per day in this experiment.
- Ground cover and vegetation composition data was taken by using the step-point method in a “zig-zag” pattern across all 9 paddocks.
- Grazing preference was determined while performing the after grazing step-point data collections. It was noted whether each plant recorded had been grazed by the steers or not.
- Utilization of the available forage was estimated by measuring the grass height before and after grazing.

## EXPERIMENTAL DESIGN

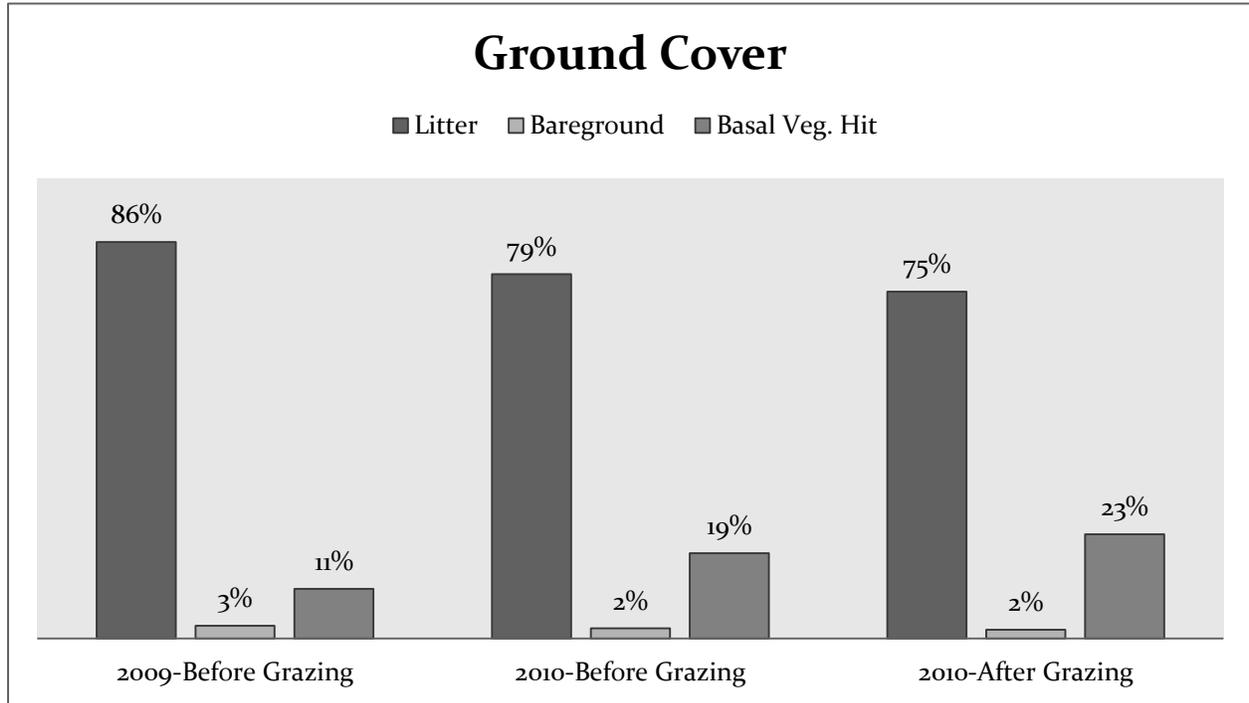
The pasture that was used for the experiment was 9 acres in size and was divided into 9 paddocks, each 1 acre in size. The vegetation in the pasture on average was composed of 19% *Andropogon gerardii* (Big Bluestem), 19% *Carex spp.*, 15% *Schizachyrium scoparium* (Little Bluestem), 11% *Panicum virgatum* (Switchgrass), 11% *Bromus japonicus* (Japanese Brome), 3% *Festuca arundinaceae* (Tall Fescue), and 22% other mixed species.

The figure below is the layout of the pasture used in this experiment. All of the pastures were not exactly the same shape, but all were 1 acre in size. The alley to the west of the paddocks was used to allow the steers access to a centrally located water tank in the alley.

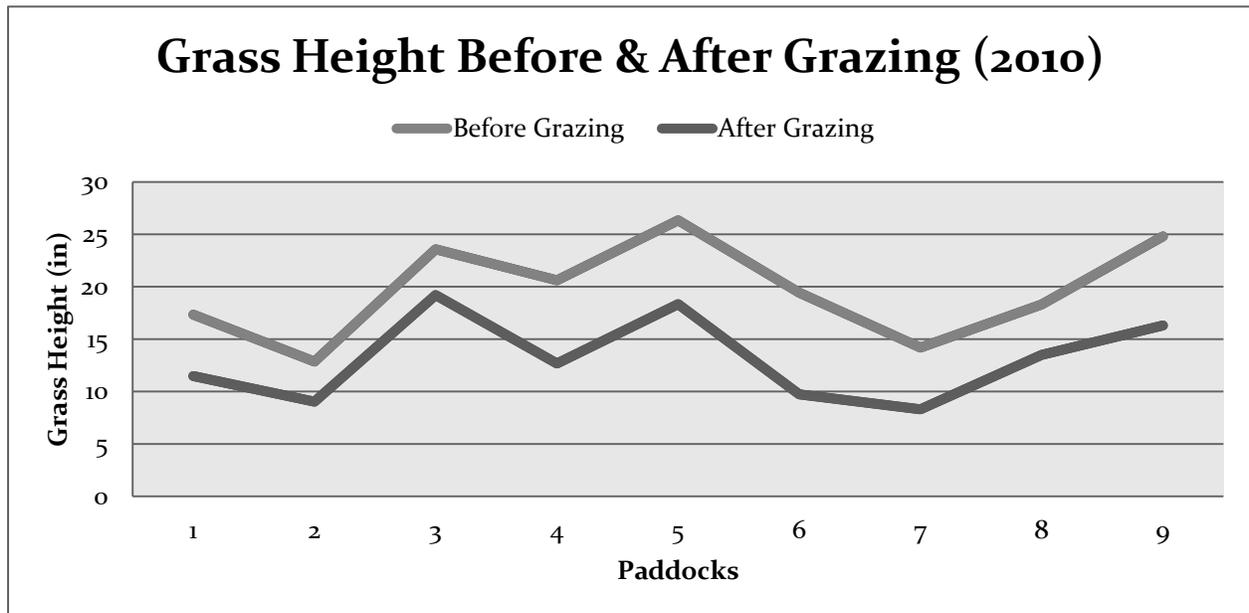


**Figure 1:** This is the pasture design used for the MiG research in Ardmore.

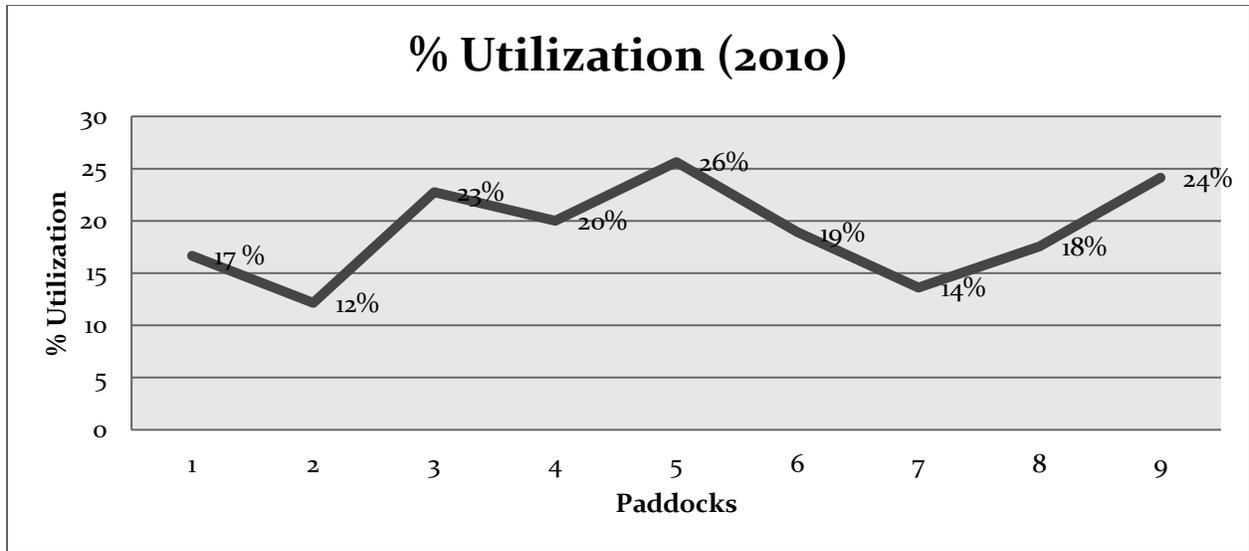
## RESULTS



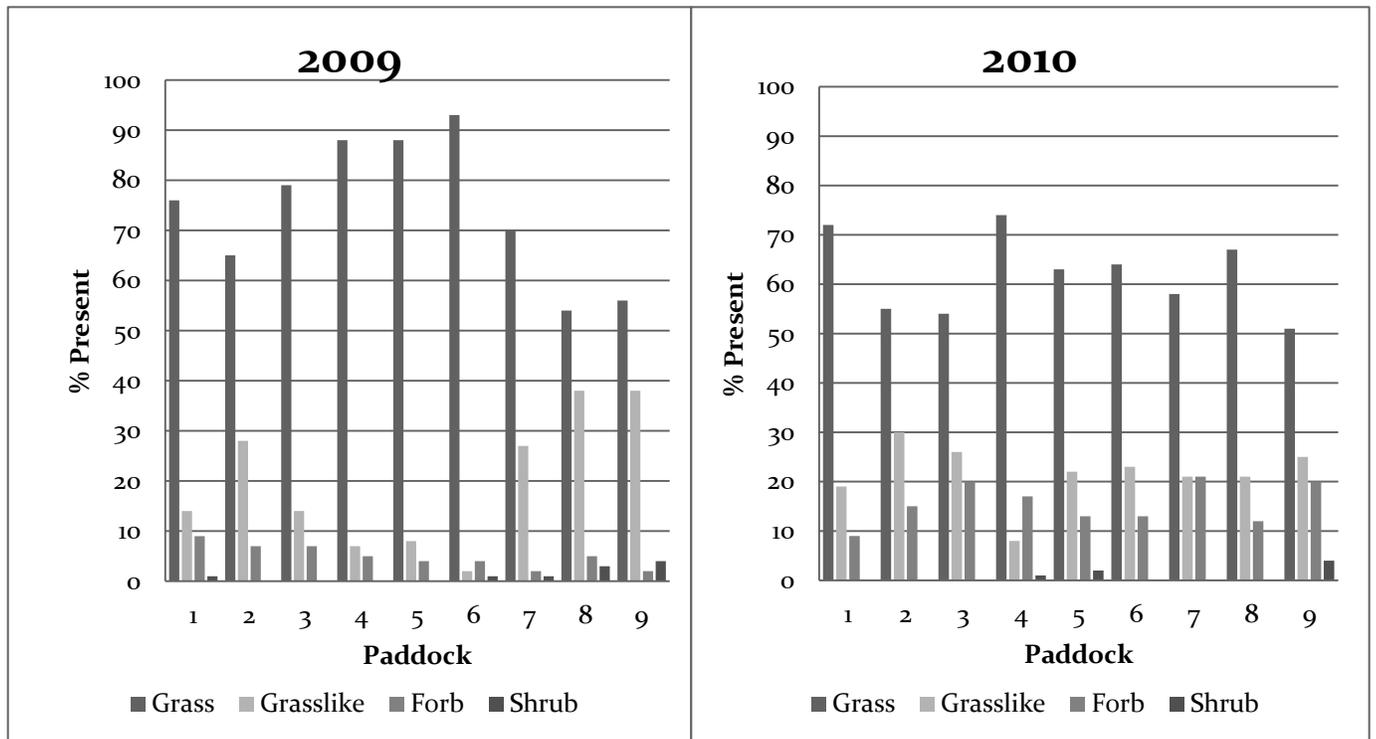
**Figure 2.** Ground cover displayed an overall increase in the amount of basal vegetation cover and a decrease in the amount of litter and bareground cover.



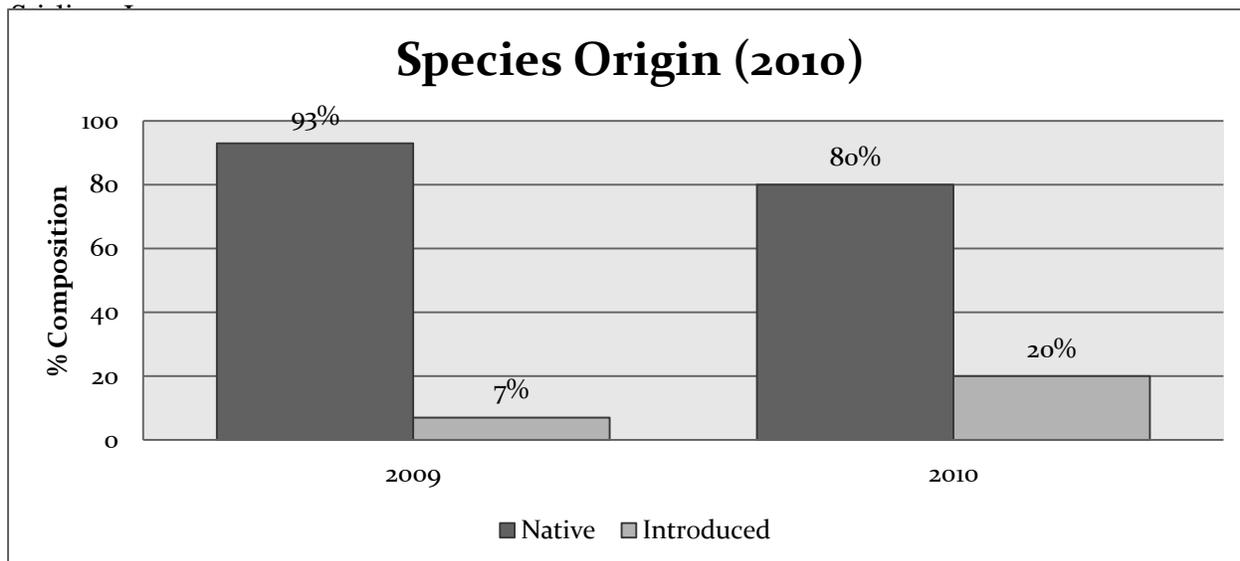
**Figure 3.** Grass heights before and after grazing. The average amount grazed per day by the 14 steers was 6.54 inches.



**Figure 4.** Percent utilization of each paddock. The average percent utilization of each paddock was 19%.



**Figure 5:** Vegetation types for the pasture from the before grazing data of 2009 and the before grazing data of 2010. These graphs show a decrease in the percent grass species and an increase in the percent grasslike species and forbs.



**Figure 6:** This graph depicts the species origin of the paddocks of the before grazing data of 2009 to the before grazing data of 2010. There was a 13% increase in the percent introduced species.

Plant	Percent Total Before Grazing	Percent Total After Grazing	Percent Grazed	Percent Ungrazed
<b>Big Bluestem</b>	18.67	24.5	63.56	36.44
<b>Sedges</b>	19.33	14.78	51.89	48.11
<b>Little Bluestem</b>	15	22.9	61.11	38.89
<b>Japanese Brome</b>	11.33	8.89	8.33	91.67
<b>Tall Fescue</b>	2.78	3.56	29.4	70.6
<b>Switchgrass</b>	11	2.33	85	15

**Table 1:** This table depicts the grazing preferences of the steers. It shows that Big Bluestem, Sedges, Little Bluestem, and Switchgrass were preferred over Japanese Brome and Tall Fescue.

## CONCLUSIONS

### 2009 vs. 2010

- There was an increase in total percent composition of Carex spp. and forbs.
- An increase was shown in total percent composition of invasive species.  
(Predominantly Japanese Brome)

### After grazing data in 2010 showed that...

- Litter decreased by 13% compared to pre-graze 2009 data.
- Bareground cover decreased by 30% in comparison to previous year's data.
- Basal vegetation cover increased by 52% in relation to the previous year's data.

**Steers exhibited a preference for the most abundant plant species, all of which were native grass or grass-like species.**

- Steers avoided grazing Japanese Brome and Tall Fescue.

## MANAGEMENT IMPLICATIONS

The data in this study shows that steers can still exhibit a preference while under a management intensive grazing system. Thus, they have a greater effect on the plants they prefer and less effect on the ungrazed plants. This gives the ungrazed plants an advantage for

Stirling, Jocee

reproduction and growth. The increase of the less palatable plants shown in the study is most likely a result of the preference and selection of more palatable plants by the steers. Due to the results, management intensive grazing does not appear to be a good system for preserving a native warm season pasture. The management intensive grazing system claims to reduce selectivity and increase the uniformity of grazing. This study suggests otherwise.

## LITERATURE REVIEW

Marriott, C. A., Hood, K., Fisher, J. M., & Pakeman, R. J. (2009). Long-term impacts of extensive grazing and abandonment on the species composition, richness, diversity and productivity of agricultural grassland. [Article]. *Agriculture Ecosystems & Environment*, 134(3-4), 190-200.

*This article described an experiment done to see the implications of extensive grazing versus intensive grazing. In conclusion, it found that extensive grazing buffered productivity better than intensive grazing in drought years. This is similar to my study, because it found that intensive grazing is not the best management strategy for the long term.*

Martz, F. A., Gerrish, J., Belyea, R., & Tate, V. (1999). Nutrient Content, Dry Matter Yield, and Species Composition of Cool-Season Pasture with Management-Intensive Grazing. *Journal of Dairy Science*, 82(7). Retrieved from <http://www.sciencedirect.com/science/article/B9887-4YS4MBF-S/2/f1282c9d3eaf1529cbc1f3d62f5d4416>. doi:10.3168/jds.S0022-0302(99)75381-6

*The objective of this study was to determine any changes in nutrient content, available pasture, and species stand counts of a cool season pasture under a management intensive grazing system. The conclusions of this study found that animal selectivity was strong enough over the grazing season to keep a constant quality in their diets. This study also found that the grazing of the pasture was uniform “enough” over the season. This study is not similar to my study in this regard. I found there was a high selectivity of the cattle and that my experimental pasture was not grazed uniformly.*

## REFERENCES

- Gerrish, J. (2004). *Management Intensive Grazing: The Grassroots of Grass Farming*.
- Marriott, C. A., Hood, K., Fisher, J. M., & Pakeman, R. J. (2009). Long-term impacts of extensive grazing and abandonment on the species composition, richness, diversity and productivity of agricultural grassland. [Article]. *Agriculture Ecosystems & Environment*, 134(3-4), 190-200. doi: 10.1016/j.agee.2009.07.002
- Martz, F. A., Gerrish, J., Belyea, R., & Tate, V. (1999). Nutrient Content, Dry Matter Yield, and Species Composition of Cool-Season Pasture with Management-Intensive Grazing. *Journal of Dairy Science*, 82(7). Retrieved from <http://www.sciencedirect.com/science/article/B9887-4YS4MBF-S/2/f1282c9d3eaf1529cbc1f3d62f5d4416> doi:10.3168/jds.S0022-0302(99)75381-6
- Savory, A. (1988). *Hollistic Resource Management*. Washington, D.C.: Island Press.

Asymmetrical Conflict:

Sleep Deprivation as a Precursor to PTSD Among Veterans

Francisco Velasco

Montana State University

Abstract

Conflicts ranging from a global scale to smaller indigenous battles have been prevalent throughout human history. Each contains unique cultural and environmental differences, but also a shared commonality-combat. The emphasis of combat and its association to Post Traumatic Stress Disorder (PTSD) is well documented, yet the preceding moments leading into combat are not understood. Are there other unknown variables that act as a primer in an individual's vulnerability to PTSD? Literature has shown that in a civilian population sleep deprivation induces cognitive abnormalities (Heon-Jeong & Kwang-Yoon, 2003). Today, combat troops engage in asymmetric warfare that sometimes requires extensive sleep deprivation to complete a mission. The purpose of this research was to evaluate the relationship between sleep deprivation during combat and a later diagnosis of PTSD. Additionally, is there a relationship between sleep deprivation and a later diagnosis of a sleeping disorder? Finally, is there a threshold at which troops can sustain themselves in combat without sleep and not succumb to either PTSD or any type of sleeping disorder? Veterans with and without a PTSD diagnosis completed a survey about sleep rotations during missions and firefights, number of missions and diagnosis of sleeping disorders. Results indicated that there was a significant relationship between sleep deprivation and a later diagnosis of PTSD and a later diagnosis of a sleep disorder. In addition, preliminary results indicated a maximum operational threshold for troops. Research focused on sleep deprivation before and during combat is crucial because it may illustrate an individual's capacity to cope while under duress in a battlefield environment. Current treatments may be refined and tailored to address these overlooked contributors to PTSD, which could lead to more efficient and successful treatment outcomes.

*Keyword:* Sleep deprivation, PTSD, combat, military operations

### **Asymmetrical Conflict: Sleep Deprivation as a Precursor to PTSD Among Veterans**

War and conflict has been a continuous signature of the human race. Disputes over territory boundaries, religious affiliation, and race are some of the most salient factors that have influenced the initiation of such conflicts. These conflicts have ranged from the most prominent countries to the most isolated tribes. Although differences in these various civilizations are apparent, they have a singular commonality—combat. The effects of exposure to these conflicts vary between individuals. Specifically, veteran populations are showing an increased maladjustment to life after combat. Some veterans do reintegrate into a civilian life whereas others develop a chronic form of post traumatic stress disorder (PTSD) or risk taking behavior (Kilgore et al., 2008). What is it about combat or the preemptive moments that enhance an individual’s susceptibility to a later diagnosis of PTSD?

Specifically, the prevalence of PTSD in the United States has become more prominent due to the current conflicts in Iraq and Afghanistan. Past and current conflicts have led to the development of research focusing on the mental impact of war. One area of emphasis was establishing the diagnosing criteria for PTSD and determining the PTSD severity in an individual.

The diagnosing criterion for PTSD is clearly defined in the DSM-IV-TR, which indicates that individuals must have encountered either a direct or indirect stressor that caused some type of trepidation. In addition, the stressor must be consistently recurring through intrusive recollection, such as a dream. Individuals must also be projecting feelings of numbness and exuding avoidant behavior related to the stressor. Some types of hyper-arousal, such as difficulty concentrating or falling asleep must also be associated

with the stressor. The duration of these problems combined with their impact on an individual's life determine whether an individual has PTSD and to what degree (American Psychiatric Association, 2000).

In the current Asymmetrical conflict in Iraq and Afghanistan, devices, such as improvised explosive devices (IEDs) and homemade explosives (HMEs) have been refined from years of war. They have been developed to blend into environments as innocuous objects to maximize their effectiveness. IEDs and HMEs currently are the current weapon of choice against American and coalition forces. This is illustrated in a congressional research service report (CRS) in august of 2007 that stated that about sixty percent of military casualties in Iraq and fifty percent of casualties in Afghanistan were due to IEDs and HMEs (Wilson, 2007).

Unfortunately these objects have catastrophic consequences not only on the body, but on the mind as well. For some returning veterans, these objects still manifest themselves in everyday items in the U.S. like loose wires in a home, electrical outlets, phone outlets, and trash on the side of a road. It is this variety and correlation of IEDs and HMEs with everyday items that causes the returning veteran difficulty in distinguishing danger from safety. In addition, some veterans engage in direct combat in both cities and rural areas for days. Although sleep rotations are attempted to be enforced by commanders, it is the boots on the grounds that must adapt to their environment. Consequently, some troops must stay up for days to maintain pressure on enemy forces.

Currently, the Department of Veterans Affairs has implemented the use of various assessments to identify potential at risk veterans for PTSD. The PTSD Checklist (PCL) is one such form. This form has been altered to address both civilian and military

populations. PCL-M is the type of PCL usually given to active military personnel and veterans. PCL-M is based on a scoring system. The higher the score the greater the severity (Weathers, 1993). The severity score, along with an individual meeting the criteria for PTSD in the DSM-IV-TR, provides a solid base to understand if an individual has PTSD and to what degree. This assessment has been a successful tool in screening veterans for PTSD.

Given the initial tools to assess PTSD how do we isolate and minimize the effect of each influencing element of PTSD among veterans? When these elements have been experienced, compounded, and projected through symptoms of PTSD in a veteran, how do we intervene or assist in coping strategies that work?

Evidence-Based psychotherapy is the main treatment employed by the Department of Veteran Affairs due to its success in reducing symptoms and improvement of lifestyle for the veteran. In Evidence-Based Therapy the therapist and patient outline significant problems together. This cohesive environment is then enhanced by the therapist guiding the patient through the problem, consequently enabling the patient to be proactive in recovery (National Center for PTSD, 2011).

There are several types of evidence-based psychotherapies. PTSD specific therapies that are utilized by the Department of Veteran affairs are Cognitive Processing Therapy (CPT) and Prolonged Exposure Therapy (PE). CPT assists the veteran by altering stress inducing thoughts or thought processes into less stressful ones. In essence this approach assists in rationalizing the occurrence of a negative event, such as accidentally killing a civilian who displayed threatening mannerism, but who in reality was just nervous. The veteran's self-blame would be rationalized by explaining to the veteran

that they reacted by the following the rules of engagement (ROE) in a hostile environment, the civilian response did not change, so you had to engage.

PE approaches a veteran's problem by having them imagine the traumatic event or threatening object in a controlled environment. This method will be continued until the veteran overcomes the hindering problem. For example, a veteran who was wounded by a land mine while crossing a clearing to assault an objective is terrified of walking across his front lawn. After imagining the environment where the injury occurred, it is hoped that the veteran will eventually understand the unique circumstance that surrounded his injury and that environment is not existent in his front lawn (Hamblen, 2010). Evidence-Based psychotherapy is empirically supported and effective between genders and across conflicts (National Center for PTSD, 2011).

Although strides have been made in coping and intervention strategies for PTSD from places, such as the National Center for PTSD, little is still known about elements that may enhance an individual's vulnerability to the development of PTSD. There are a multitude of elements that preempt battle which have not been evaluated for their association with PTSD.

Individuals who operate in combat experience a variety of physical and emotional elements other than the widely publicized firefights. They sometimes endure days of silence, sleep deprivation, sleep in combat, hypothermia, rationed food and water and the overall lack of normalcy in a civilized environment. It is these overlooked elements that must be taken into consideration to provide more empirical literature that will assist in the treatment of PTSD.

The purpose of this research was to focus on one such unknown element—sleep deprivation and its relationship to PTSD. Specifically, does extended sleep deprivation before combat impair an individual's ability to cope with a traumatic experience and make them more susceptible to a later diagnosis of PTSD? In a civilian population, deficits in cognitive functioning due to sleep deprivation have been recognized.

Heon-Jeong and Kwang-Yoon et al., (2003) conducted an experiment in which thirty students were required to take neurocognitive tests and P300 event-related potential during the morning and evening of the two day testing period. Participants underwent thirty-eight hours of continuous sleep deprivation. Results for this study suggested impairments in alertness and reaction time were due to sleep deprivation. Particularly, a decrease in alertness equates to a decrease in reaction.

Killgore, Balkin and Wesensten et al., (2006) tested the effects of sleep deprivation in judgment making; thirty four participants were given the Iowa Gambling Task (IGT) before and after forty-nine hours of sleep deprivation. Before sleep deprivation, participants chose from less risky deck of cards. However, this logical approach diminished after the implementation of sleep deprivation. Participants began choosing from more risky decks. Although sleep deprivation was conducted in a non-battlefield environment, the effects of sleep deprivation on mental functioning were established.

The effects of simulated combat on cognitive functioning during military training have been evaluated. Specifically, the United States Army evaluated soldiers during Ranger school training. Ranger school consists of approximately sixty-one days of sleep deprivation integrated with intense physical training and emphasis on successfully

conducting military operations. The overall goal of ranger school is to provide soldiers who can operate while sleep deprived and lead other soldiers in various terrains to accomplish a mission (Military Operational Medicine Research Program, 1999).

Vital statistics released by the Operational Medicine Research Program provided a closer replicated example of the effects of war in combat MOSs. Ranger candidates' average caloric intake was 4000 kcal a day while only consuming an average of 2800 kcal. The average weight loss was 26.7lbs. The Lifting strength of candidates was reduced from 170 lbs to 130 lbs at the end of the course. Ranger candidates average 3.6 hours of sleep a day (Military Operational Medicine Research Program, 1999).

The effects of sleep deprivation in Ranger school candidates were noted as in previous research utilizing a civilian population. The impairment of reasoning and pattern analysis was observed (Class 11-91). Interestingly, memory was documented as not being affected (Military Operational Medicine Research Program, 1999). The observed impairment due to sleep deprivation in participants from both civilian and military populations reiterates the impact of sleep in cognitive performance. The current study extends these lab-based findings to real world combat settings.

A crucial factor to consider when examining sleep deprivation is whether or not a relationship between sleep deprivation in combat and diagnosis of a sleeping disorder exist. In relation to sleep deprivation, is there a threshold at which individuals can sustain themselves in combat without sleep and not succumb to either PTSD or any other sleeping disorder? Finally, does sleeping while directly being engaged in combat affect the encoding of memories to such a degree that an individual's susceptibility to PTSD increases? I hypothesize that there will be a significant relationship between sleep

deprivation before combat and a later diagnosis of PTSD. It is expected that the diminished cognitive functioning observed in Heon-Jeong and Kwang-Yoon et al., (2003) and Killgore, Balkin and Wesensten et al., (2006) study will also impact individuals in combat, but to a greater degree and respective to their experience with traumatic events.

There will also be a significant relationship between sleep deprivation in a combat zone and a later diagnosis of a sleeping disorder. Although this is a novel area of research I believe that the consistent sleep deprivation will lead to a modified combat circadian rhythm, which will lead to the development of a sleep disorder.

A threshold at which individuals can sustain themselves without submitting to a later diagnosis of PTSD, sleeping disorder or both will exist. This hypothesis is derived from operational observation in Operation Iraqi Freedom.

Individuals who slept during direct engagement (while being fired upon) will have a higher susceptibility to PTSD. This is due to startled responses that were observed in soldiers after they had slept while directly being engaged during Operation Iraqi Freedom.

Uncovering the underlying mechanism of PTSD is a journey of mental excavation. Focusing on detailed components of pre/post combat may not only refine coping strategies, but also facilitate novel enhanced intervention technique for PTSD, tailored for both civilians and individuals in areas of conflict. Understanding the sleep deprivation threshold for individuals in combat could provide invaluable insight into the mind's endurance and ability to cope with traumatic events.

## **Method**

### Participants

Prospective participants were recruited at the Veteran Service Office at MSU and throughout military installations in the United States. Veterans were utilized because this study is focusing on the relationship between sleep deprivation and PTSD among veterans. There were a total of eighty-four participants. Age, gender, and ethnicity were accounted for, but did not serve any specific purpose in this study. In order to be eligible for this study, participants must have served or currently be serving in the United States Military and be a minimum of eighteen years old.

### Materials

An online questionnaire was accessed by participants through a secured online network that was password protected. No personal identifying information was collected or stored to maintain participant anonymity.

A total of twenty-one questions were asked (see Appendix). Questions focused on sleep deprivation during deployment to a combat zone. Examples of the questions that were asked are what is the longest time you stayed up consecutively during deployment? Were you ever ordered to sleep in combat during a long firefight?

Data entered by participants appeared in excel format in a secured email. A standard usb was utilized to capture and transfer data to a stand-alone computer. Data was then be analyzed by SPSS.

### Procedure

An online consent form was administered. In addition to the consent form on the same online page of the study it was emphasized that participation is voluntary and that there is no financial compensation for participating, to prevent coercion. Participants were informed of the purpose of this study in general terms. Participants acknowledged

this information before they proceeded to the questionnaire. Participants filled out an online questionnaire focusing on sleep deprivation in combat. This is an original questionnaire that was developed based on experience and observation of soldiers conducting missions in Operation Iraqi Freedom. The missions ranged from reconnaissance to direct engagement of combatants with and without the influence of sleep deprivation. Each question has been translated in a manner that is fluent with military terminology and accessible by academic analyses. This was done to minimize the misinterpretation of questions and allow for a clear understanding of the relationship between sleep deprivation and a later diagnosis of both PTSD and sleeping disorders.

I had sole access to the data and analyzed all initial data myself. A secondary check of data was done by Dr. Meade into ensure accuracy. Before the initiation of this project the appropriate Institutional Review Board (IRB) approval was obtained to ensure that precautions are adequate and congruent with present regulations. The projected time frame for this project will be four to six months to completion from the day of the IRB approval.

This is a correlational study focusing on the relationship, if any, of sleep deprivation and PTSD. A general across military service analysis was conducted to depict the affect of sleep deprivation in individuals who have served in a conflict and a later diagnosis of PTSD. The relationship between sleep deprivation and a later diagnosis of a sleep order was also evaluated. A chi-square test was employed to observe, if any, an operational threshold at which individuals can sustain themselves without sleep before succumbing to a later diagnosis of PTSD, sleeping disorder or both. Specifically, the

threshold or longest time up without sleep was analyzed in days and compared to both the diagnosis and non-diagnosis of PTSD, sleeping disorder or both.

Veterans that indicate their longest time up in an area of conflict in hours were rounded to the nearest day. The range of days that will be analyzed will be from less than twenty-four hours to the greatest participant entered amount of days up without sleep. A secondary objective was to examine the relationship between sleep deprivation and individual's later diagnosis of PTSD, sleeping disorder, or both based on military occupation skill (MOS). All MOSs regardless of their prevalence in conus or oconus missions related to conflicts were evaluated and placed into either a combat or support element category. Conus missions represent missions conducted from within the continental United States and oconus missions represent mission conducted outside the continental United States. A chi-square test was employed to observe the frequency of PTSD, sleeping disorder, or both in an individual based on MOS. The dividing of military occupation into these two categories is meant to reflect an individual's MOS interaction in a combat zone.

Veteran data that indicated they were victims of sexual assault or had exposure to chemical agents were not utilized for this study. The purpose of omitting this information is that they are apparent confounds which would inhibit accurate findings. Although this data was not utilized in this study it was maintained for possible future analysis.

The difficulty in prescribing adequate treatment and intervention for PTSD among veterans is not its abstract nature, but the accuracy of translation of wartime experiences from third person perspectives. Data gathered from veterans to researchers leaves an error gap, allowing for some variables to be overlooked. By comparing existing literature

related to PTSD with research focused on unknown variables that may enhance susceptibility to PTSD, intervention and coping treatments may be refined.

#### Ethical Considerations

Due to the nature of this study questions were asked in a manner that does not elicit any type of negative responses. However, if there were negative responses the participants had access to the Department of Veterans Affairs (VA) suicide hotline number where skilled clinicians can direct the proper course of action. I also had direct contact with the OIF/OEF case management team and a representative of the Army Wounded Warrior Program (AW2) to direct participants in need of assistance who have contacted me directly. These numbers were posted online along with the questionnaire.

### **Results**

Results are congruent with our predictions. A between-subjects independent sample t-test was conducted between sleep deprivation in a combat zone and a later diagnosis of PTSD. Participants were placed into sleep deprivation categories respective to the amount of sleep deprivation they indicated. The categories ranged from less than 24 hrs of sleep to being sleep deprived up to 11 days. There was a significant relationship  $t(64)=-1.40, p<.05$ . This relationship was expected due to a decrement in cognitive functioning influenced by sleep deprivation as previously observed in Heon-Jeong and Kwang-Yoon et al., (2003) and Killgore, Balkin and Wesensten et al., (2006) civilian study.

A between-subjects independent sample t-test was conducted between sleep deprivation in a combat zone and a later diagnosis of a sleep disorder. There was a significant relationship  $t(72)=-1.52, p<.05$ . A modified combat circadian rhythm was

anticipated due to its development in an area of conflict an observed maintain pattern of sleep in veteran's post-deployments.

A chi-square test was employed to observe the frequency of PTSD relative to the longest time an individual was up. A threshold at which individuals can sustain themselves without submitting to a later diagnosis of PTSD, sleeping disorder or both was observed. A threshold of three days was observed between sleep deprivation and a later diagnosis of PTSD. Specifically, continuous sleep deprivation in a combat zone above three days ( $M=3.76$ ,  $SD=2.82$ ) increased an individual's vulnerability to PTSD whereas individuals who were sleep deprived below three days ( $M=2.35$ ,  $SD=1.30$ ) were less likely to develop PTSD (see Table 1). Additionally, a similar threshold was observed between sleep deprivation and a later diagnosis of a sleep disorder. Individuals who were sleep deprived past three days ( $M=3.65$ ,  $SD=2.60$ ) had an increased susceptibility to a later diagnosis of a sleeping disorder than individuals who were sleep deprived below three days ( $M=2.72$ ,  $SD=2.02$ ) during deployment (see Table 2). An operational threshold was predicted due to the observed physical and mental breakdown of troops conducting missions during Operation Iraqi Freedom.

A chi-square test was utilized to observe the frequency of PTSD relative to individuals who did and did not sleep while being directly engaged. Findings indicated that seventy-five percent of individuals who slept in combat (direct engagement) were also later diagnosed with PTSD whereas forty-three percent of soldiers who did not sleep in combat were later diagnosed with PTSD (see Figure 1). This was expected because of the observed startle response in individuals who slept while being engaged during Operation Iraqi Freedom.

A chi-square test that separated MOSs also showed that individuals who served in a combat MOS were forty-eight percent more likely to be later diagnosed with a sleep disorder than individuals who served in a support MOS, who were fifteen percent likely to be diagnosed with a sleep disorder (see Figure 2). This was not a primary objective of this research, but given the MOSs interaction with enemy forces this result was expected.

### **Discussion**

The Relationship between sleep deprivation and a later diagnosis of PTSD, sleep disorder, or both were observed along with a maximum operational threshold. These findings are unique because they integrate combat experience from a first person perspective with an academic platform. The questionnaire bridges a gap between the interpretation of combat experiences and actual combat by asking operational questions typically undisclosed to the general scientific community.

The observed threshold for a later diagnosis of PTSD and a sleep disorders was interesting due to their relative similarity. This three-day marker should be reevaluated for its accuracy. A significant relationship was also observed between sleep deprivation and a later diagnosis of PTSD and sleep disorders, which supports the current threshold.

Findings illustrate possible new variables that may enhance the onset of PTSD and sleep disorders. Specifically, the impact observed in veterans by sleep deprivation may be a foot hold in understanding an individual's coping mechanism while under duress in a battlefield environment. So, what role does personal coping and rationalizing during and after the trauma of war play when influenced by sleep deprivation? Finally, how does the mind encode the surrounding environment when an individual is being

directly engaged? Is there a possible survival encoding system that is a combination of physiological enhancements and unconscious monitoring?

Although Killgore, Balkin and Wesensten et al., (2006) research was opposing to my findings, there were two significant differences that were notable. The first difference was the environment and second the length of sleep deprivation. Killgore, Balkin and Wesensten et al., (2006) research was conducted in a controlled environment whereas veterans were under duress due to the battlefield environment. Sleep deprivation was also longer in the veteran population. However, Killgore, Balkin and Wesensten et al., (2006) study does provide a good baseline to test future differences in individuals before and after deployments.

The effects of sleep deprivation and cognitive functioning are well established and illustrated in Killgore, Balkin and Wesensten's (2006) research and Heon-Jeong & Kwang-Yoon's (2003) research. These apparent deficits in cognitive functioning among a civilian population may also indicate impairment in rationalizing and coping with a traumatic experience.

Uncovering the underlying mechanism of PTSD is a psychological journey of mental excavation. Focusing on detailed components of pre/post combat may not only refine coping strategies, but also facilitate a novel enhanced intervention technique for PTSD, tailored for both civilians and individuals in areas of conflict.

Findings from this study suggest that there is a threshold of three days of sleep deprivation. This threshold currently is titled the Percussion Threshold and should be maintained specifically as a possible theoretical premise for individuals directly participating in military operations that require sleep deprivation (see Figure 3). The

Percussion Threshold holds that there is a three day limit of continuous sleep deprivation an individual can endure before becoming susceptible to PTSD, sleeping disorder or both. Future replications of this study are needed to determine the longevity of this threshold.

One limitation of this study was that the overall number of participants was small respective to military branch of service and MOS. Future research should increase the participants for each branch of service and MOS. Due to the vast number of MOSs this increase should reveal the sub-population of veterans that is most susceptible to the effects of sleep deprivation.

By understanding the effects of Sleep Deprivation related to MOS logistical preparation could be refined to minimize the sometimes-lifelong battle of PTSD. This can be done by increasing the size of a combat force respective to the size of its area of operation (AO). This should allow adequate time for rest. The discrepancy between the conclusions of supported research related to the effects of sleep deprivation and war is that the mission and its environment will always override a conus mandate from military command related to scientific findings. How do we integrate scientific findings with combat operations?

A possible solution to this unique problem would be to identify a full spectrum of variables that have been supported to be identifiers of later diagnosis of PTSD. Specifically, by identifying the questions that have a high probability of enhancing PTSD ratings among current assessments used and condensing these question into a form can be a better determinant of whether PTSD exist or will exist at a later time. Future variables that show similar accuracy in depicting a veteran's susceptibility to PTSD should be

incorporated to maintain a linear evolution with combat. Probability of successfully diagnosing PTSD earlier may be improved.

This research was also limited due to the inadequate documentation of exposure to explosion by veterans. These blast injuries can lead to traumatic brain injury (TBI), which have been associated with PTSD. The difficulty lies in distinguishing the onset of PTSD due to combat experience and the influence of physiological induced PTSD like symptoms due to a TBI. The Department of Defense in conjunction with the Veterans Brain Injury Center has stated that casualties from Iraq and Afghanistan with brain injuries because of combat are approximately 22% (Summerall, 2007). In the high pace environment of war each mobile individual who can shoot, move and communicate is vital to the mission. Temporary impairment or headaches because of explosions can and will be brushed off by individuals to accomplish the mission. In some cases to “fall out” in the midst of battle can be fatal to the individual in the fight or the man or woman next to them. How do we document these regular occurrences?

Mitigating the conflict of ideas in a civil manner between diverse cultures is a complex matter, which requires enormous amount of endurance. PTSD will continue to be a growing and significant problem among civilians and military personnel around the globe. Continued research into the specific facilitating elements of PTSD and refinement in strategies for coping and intervention in populations of high susceptibility must and should be continued.

## References

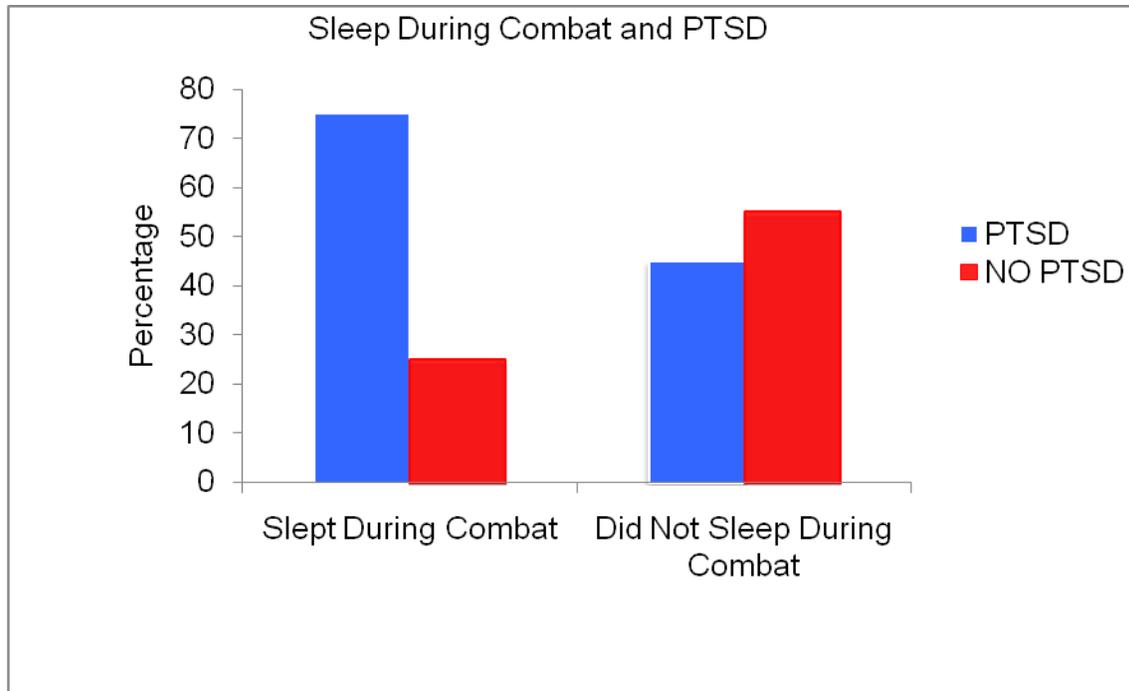
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (Revised 4th ed.). Washington, DC: Author.
- Hamblen. (2010). *Treatment of PTSD*. Retrieved from [http://www.ptsd.va.gov/public/pages/handoutspdf/handout\\_TreatmentforPTSD.pdf](http://www.ptsd.va.gov/public/pages/handoutspdf/handout_TreatmentforPTSD.pdf)
- Heon-Jeong, L., Lee, K., & Kwang-Yoon, S. (2003). Cognitive deterioration and changes of P300 during total sleep deprivation. *Psychiatry & Clinical Neurosciences*, 57, 490. doi:10.1046/j.1440-1819.2003.01153.x
- Killgore, W. D. S., Balkin, T. J. & Wesensten, N. J. (2006). Impaired decision making following 49 h of sleep deprivation. *Journal of Sleep Research*, 15, 7-13.
- Kilgore, W. D., Cutting, D. I., Thomas, J. L., Cox, A. L., McGurk, D., Vo, A. H., Castro, C. A. & Hoge, C. W. (2008). Post-combat invincibility: Violent combat experiences are associated with increased risk-taking propensity following deployment. *Journal of Psychiatric Research*, 42, (13), 1112-1121.
- Mellman, (1995). Sleep events among veterans with combat-related posttraumatic stress disorder. *The American Journal of Psychiatry*, 152(1), 110.
- National Center for PTSD. (2011). *Understanding PTSD Treatment*. Retrieved from [http://www.ptsd.va.gov/public/understanding\\_TX/booklet.pdf](http://www.ptsd.va.gov/public/understanding_TX/booklet.pdf)
- Summerall. (2007). *Traumatic Brain Injury and PTSD*. Retrieved from <http://www.ptsd.va.gov/professional/pages/traumatic-brain-injury-ptsd.asp>
- U.S. Army Medical Operational Medicine Research Program. (1999). *Biomedical Studies of U.S. Army Ranger Training (Fact Sheet Number 5)*. Retrieved from <http://www.momrp.org/publications/Rangers.pdf>

Velasco, Francisco

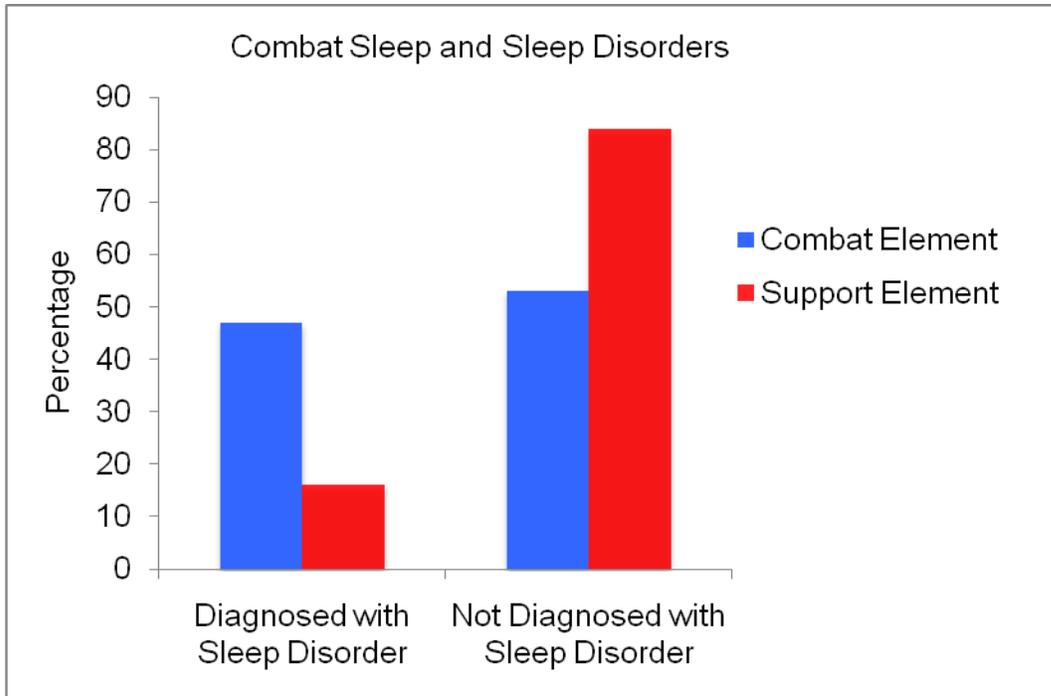
Wilson. (2007). *Improvised explosive devices (IEDS) in Iraq and Afghanistan: Effects and countermeasures* (CRS Report No. RS22330). Retrieved from

<http://www.fas.org/sgp/crs/weapons/RS22330.pdf>

Weathers, F., Litz, B., Herman, D., Huska, J., & Keane, T. (October 1993). The PTSD Checklist (PCL): Reliability, Validity, and Diagnostic Utility. Paper presented at The Annual Convention of the International Society for Traumatic Stress Studies, San Antonio, TX.



*Figure 1.* Relationship between sleeping in combat and a later diagnosis of PTSD. Data suggests that Individuals who sleep in combat are more likely to be later diagnosed with PTSD.



*Figure 2.* Comparison of military occupational skill (MOS) to a later diagnosis of a sleep disorder. Military occupational skill was divided into combat and support elements. Data suggest that individuals in a combat MOS were more likely to be later diagnosed with a sleep disorder than individuals in a support element.

Table 1

*Relationship between longest time up during deployment and a later diagnosis of PTSD.*

*Numbers represent the mean days up in each category.*

	PTSD (N= 37)	NO PTSD (N= 29)
LTUPDD	3.76 (2.82)	2.35 (1.30)

Table 2

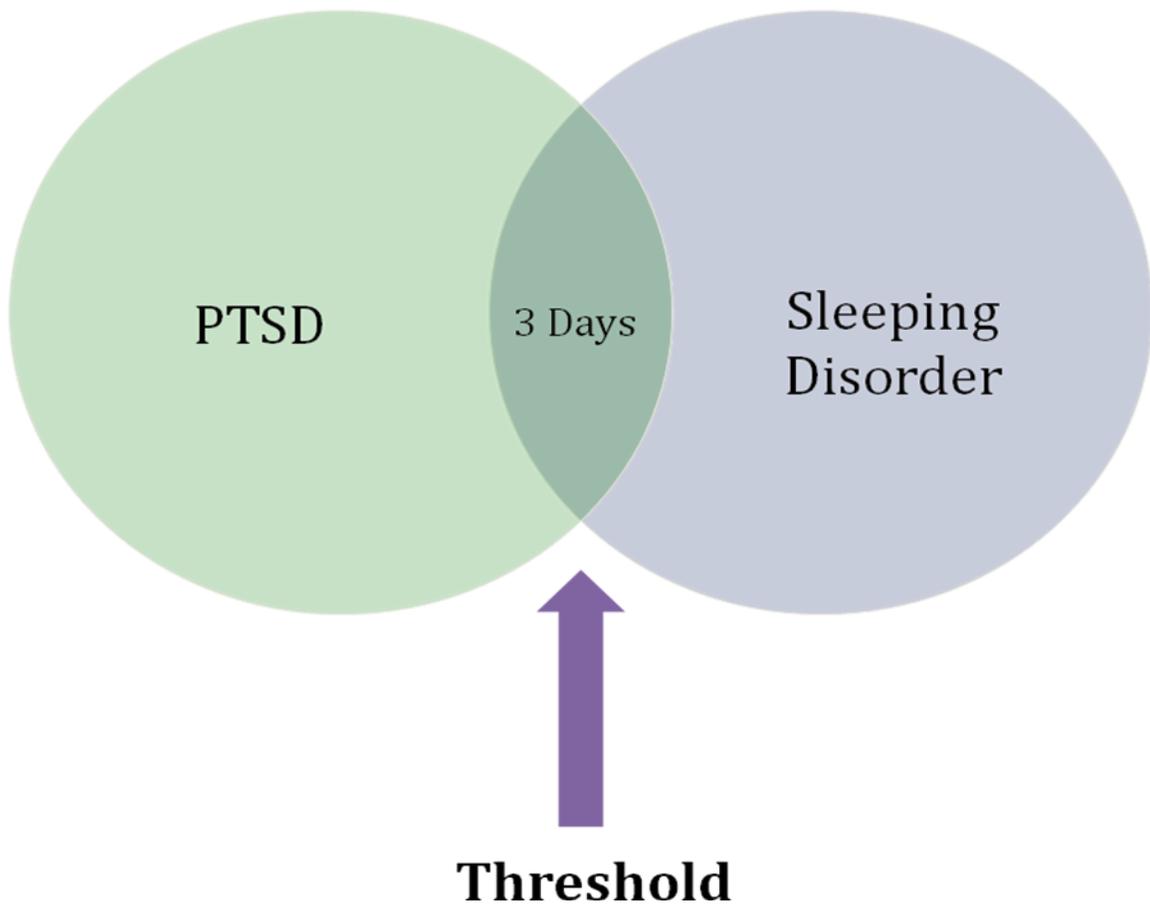
*Longest time up during deployment (LTUPDD) compared to later diagnosis of a sleep disorder.*

*Numbers represent the mean days up in each category.*

---

	Sleep Disorder (N=17)	No Sleep Disorder (N=50)
LTUPDD	3.65 (2.60)	2.72 (2.02)

---



*Figure 3.* Refers to a possible threshold of three days of continuous sleep deprivation in a combat zone which may increase an individual's vulnerability to PTSD, sleep disorder or both.

Appendix

**1. Gender**

Male  Female

**2. Age**

**3. Ethnicity**

Caucasian  African American  
 Asian  Alaskan Native  
 Hispanic  Native American/American Indian  
 Native Hawaiian  Other (please list)

**4. Are you a veteran?**

No  Yes

**5. If so, which conflict did you serve in?**

**6. Which branch of the service were you in?**

**7. What was the duration of your tour?**

Years  Months  Days

**8. How many deployments have you been on?**

**9. What was your Primary Military occupational skill during deployment?**

**10. After discharge from military service, did you attend school?**

No  Yes

**11. Before combat missions, how many consecutive hours did you typically sleep?**

- 0 hours
- 1-5 hours
- 6-10 hours
- 11-15 hours
- 16-20 hours
- 21-25 hours
- 26-30 hours
- 31-35 hours
- 36-40 hours
- 41-45 hours
- 46-50 hours
- 51-55 hours
- 56-60 hours
- 61-65 hours
- 66-70 hours
- 71-75 hours
- 76-80 hours
- Other (please specify in space provided)

**12. During combat missions, how many consecutive hours did you stay awake on average?**

- 0 hours
- 1-5 hours
- 6-10 hours
- 11-15 hours
- 16-20 hours
- 21-25 hours
- 26-30 hours
- 31-35 hours
- 36-40 hours
- 41-45 hours
- 46-50 hours
- 51-55 hours
- 56-60 hours
- 61-65 hours
- 66-70 hours
- 71-75 hours
- 76-80 hours
- Other (please specify in space provided)

**13. How many missions did you go on during your deployment?**

**14. What is the longest amount of time you stayed up consecutively during deployment?**

Days  Hours

**15. Did you use a sleep rotation? (for example 1 hour up, 1 hour down)**

- No  Yes

**16. If so, what was your sleep rotation?**

**17. Were you ever ordered to sleep in combat during a long firefight?**

- No  Yes

**18. If so, did you fall asleep for any length of time?**

- No  Yes

**19. After returning from deployment, were you diagnosed with a sleeping disorder by the military, VA, or any doctor?**

- No  Yes

**20. If so, what type of sleeping disorder?**

**21. After returning from deployment, were you diagnosed with Post Traumatic Stress Disorder (PTSD) by the military, VA, or any doctor?**

- No  Yes