
Journal of Undergraduate Research and Scholarly Excellence

Spring 2014

Volume V
Issue I



Colorado State University

Journal of Undergraduate Research
and Scholarly Excellence



JUR Press
Office for Undergraduate Research and Artistry
The Institute for Learning and Teaching
Colorado State University
Campus Delivery 1052
200 W. Lake Street
Fort Collins, CO, 80521-4593
Phone: (970) 491-4156
jur.colostate.edu

Designers: Matt Gotlin-Sheehan, Deanna Cox, and Hailey Misheff

Cover Art: *Bones of the Earth (past)* by Krystin Gutierrez

Copyright ©2014 JUR Press. All rights reserved.

Reproduction or translation of any part of this work beyond that permitted by Section 107 or 108 of the United States Copyright Act without the permission of the copyright owner is unlawful. The copyright of each article is held by the author. Requests for permission or further information should be addressed to the Operations Department of JUR.

ISSN: 2156-5309

Printed in the United States of America

Advertising information: If you are interested in advertising or any other commercial opportunities, please contact the Director of Operations for JUR at jurpress@gmail.com.

Author Inquiries: For inquiries relating to the submission of articles please visit jur.colostate.edu.

EDITORIAL STAFF

Editor in Chief
Deanna Cox

Managing Editor
Audrey Reuter

Associate Editors

Danielle Cole
Benjamin Fisk
Andres Flores
Poppie Gullett
Ryan Henderson
Michaela Koretko
Elizabeth Linxwiler
Thomas Luckie
Emily Ward
Katherine Watts

Copy Editors

Kathryn Hancock
David Hinson
Nicole Smith
Jordan Vlieger
Christopher Vanjonack

Satellite Editors

Scheriner University, Texas
Jake Crawley
Claire Real

University of New Haven, Connecticut

Alyssa Abraham
Alexis Kellogg
Kayla Maciejewski
Michael Parlato

Universidad Autónoma de Yucatán, Mexico

Martha Carreño
Alicia Córdova
Arely Lara
Edwin Rodriguez

Affiliate Editors

Bliss Chang, University of Alabama at Birmingham
Billie Dashah Chen, University of Queensland, Australia
Stuti Das, Stella Maris College, India
Katherine Liang, University of Hong Kong, China
Tommaso Portaluri, University of Turin & Collegio Carlo Albeto, Italy
Renato Santos, Universidade Estadual Paulista, Brazil
Nikunj Sharma, Amity University, India
Andreea Silaghi, Babes-Bolyai University, Romania

OPERATIONS STAFF

Director of Operations
Keaton Sloan

Operations Associates

Victoria Dixie Crowe
Elizabeth Linxwiler
Nicholas McGlashen
Tysha Medeiros
Erin Oppenheim
Quintn Parker
Abbey Pizel
Steven Poling
Jaime Pritchard

ADVISORY BOARD

Faculty Advisor

Dr. Mark Brown
Veterinary Medicine and Biomedical Sciences
Director of the Office for Undergraduate
Research and Artistry

Graduate Advisor

Kate Wilkins
Graduate Degree Program in Ecology,
Colorado State University

Industry Liaison and Contributing Editor

Jessica Egner
CBR International Corp.®

Faculty Advisory Board

Dr. Susan Athey
Business
Dr. Ken Blehm
Veterinary Medicine and Biomedical Sciences
Dr. John Didier
Liberal Arts
Dr. Chris Myrick
Natural Resources
Dr. Matt Hickey
Health and Human Sciences
Dr. Nancy Irlbeck
Agricultural Sciences
Dr. Don Mykles
Natural Sciences
Dr. Tom Siller
Engineering

A Letter from the Editor

JUR Press is proud to present Volume V of the Journal of Undergraduate Research and Scholarly Excellence. With published work in the sciences, creative writing and literature, history, and art, this issue of the Journal is uniquely interdisciplinary and represents authors from around the world. The breadth of undergraduate work featured here is truly remarkable, and our organization feels fortunate to be a part of its showcasing.

In my first year as editor in chief, I have watched the JUR team grow in countless ways. Starting with an almost entirely new staff in September, this year was a chance to mold the Journal of Undergraduate Research and Scholarly Excellence into the best organization it could be. We took the opportunity to connect more meaningfully with our audience and further build our team into the cohesive unit it is today.

We embarked on a complete rebranding of our organization, increased our social media presence fourfold, improved our community service and involvement, and expanded internationally. While we are still a journal for undergraduates and by undergraduates, our new mantra – linking the global undergraduate community – better captures our mission to serve the interests of worldwide undergraduate thinkers, tinkerers, experimenters, writers, and artists. To our published authors, I congratulate each of you on your accomplishment and wish you the best of luck as you move forward in your careers.

While JUR does provide a platform for students to publish and showcase their work, we also give students the opportunity to learn about the publication process from start to finish through internships as editors, operations associates, and referees. Our undergraduate network has grown to include not only international authors, but also affiliate and satellite editors in four U.S. states and the countries of Australia, Brazil, China, India, Italy, Mexico, and Romania. We are truly committed to enhancing the undergraduate experience, and we continually seek to engage undergraduate students in our organization as much as possible.

Beyond all that we have accomplished this year, I want to say how incredibly proud I am of each member of the JUR staff both at home and abroad. You are exceptional individuals with a wide range of talents, and this team was better because you were a part of it. Publishing this journal has been the culmination of a year's hard work, and I applaud you. I am honored to be your editor in chief and even more thankful to be your friend.

Yours truly and truly yours,



Deanna J. Cox
Editor in Chief
The Journal of Undergraduate Research and Scholarly Excellence
JUR Press



Special Thanks

This publication would not have been possible without Colorado State University and the contributions of numerous advocates and benefactors.

JUR Press would like to thank our Faculty Supervisor, Dr. Mark Brown, the Faculty Advisory Board, and our Graduate Advisor Kate Wilkins. We would also like to thank our partners at the Autonomous University of the Yucatan in Mexico, Schreiner University in Texas, and the University of New Haven in Connecticut. Finally, thanks to Jessica Egner, JUR's first editor in chief, for her past and ongoing support.

Congratulations to our graduating seniors Alyssa Abraham, Matt Gotlin-Sheehan, Ryan Henderson, Katie Hancock, Alexis Kellogg, Thomas Luckie, Kayla Maciejewski, Hailey Misheff, Tysha Medeiros, Steve Poling, Jaime Pritchard, and Claire Real.

TABLE OF CONTENTS

TITLE	AUTHOR AND INSTITUTION	PAGE
Barriers and perceptions related to cataract surgery in Ghana	Michael Celone Tulane University, Louisiana	1
Lifestyle indicators for health care vs. non-health care students	Jaclyn Collins, Susan Burda, Brittany Crawford, Randi Gregoire, Alicia Heinrich, Amera Nelson, Caitlin Prunty, Katie Pullar, Kayla Wahlin, and Desiree L. Tande, PhD University of North Dakota, North Dakota	5
The effect of the Wannsee Conference on Mischlinge experiences	Anne Tabb, Thomas Pegelow-Kaplan, PhD, and Scott Denham, PhD Davidson College, North Carolina	11
Walking through the valley: Margaret Gower's grief journey in Gail Godwin's <i>Father Melancholy's Daughter</i>	Courtney Bidwell Indiana Wesleyan University	16
Who Is Uriah Heap?	Katie Hancock Colorado State University, Colorado	19
An Appeal to Anyone Writing Anything	Quintn Parker Colorado State University, Colorado	20
The Geology of Who You Share Your Bed With	Kasey Broscheit Colorado State University, Colorado	21
Frankenstein Animal Farm	Kaitlyn Chasarik Colorado State University, Colorado	23
Bones of the Earth	Krystin Gutierrez Colorado State University, Colorado	25
My Pietà His Affliction	Bethanie Pack Colorado State University, Colorado	27
Poise Id	Donald Watts Colorado State University, Colorado	29
Effects of barley extract on the growth of <i>Spirogyra</i> , <i>Synedra</i> , and <i>Ankistrodesmus</i> algae	Brooke Burmeister, Emily Deaver, PhD, and Thomas Dille, PhD Southwest Minnesota State University, Minnesota	31
Foraging frequency of juvenile Mountain Plovers (<i>Charadrius montanus</i>) among three Colorado habitat types	Alan H. Harrington and Paul F. Doherty, PhD Colorado State University, Colorado	35
Arsenic concentration and flood discharge in Southern California	Thomas W. Luckie Colorado State University, Colorado	39
The importance of accounting for overdispersion in site-occupancy estimations	Adam Eric Miller Colorado State University, Colorado	44
Discovery of the tallest redwoods in the Santa Cruz Mountains – their distribution and ecology	Zane Moore and Steven W. Singer, MS Colorado State University, Colorado	49
Creation of a single-vector I-SceI-based allelic exchange system	Faith M. Robison, Brian H. Kvitko, PhD, Herbert P. Schweizer, PhD, and RoxAnn Karkhoff-Schweizer, PhD Colorado State University, Colorado	54
Climate change and energy efficiency: An analysis of the President's Climate Action Plan and public opinion	Kristen Bailey University of Richmond, Virginia	62
Unique spaces, unique states of mind: the Thai forest monks and the Abhidhamma method of conscious states and meditation	Billie Dashah Chen University of Queensland, Australia	70
Judging emotion in reason: the effect of emotion in the Anglo- American legal system	Diana Kontsevaia McGill University, Canada	73

Barriers and perceptions related to cataract surgery in Ghana

BY MICHAEL CELONE

TULANE UNIVERSITY

Abstract

Cataract is a significant contributor to vision loss and blindness in low-income countries, especially Ghana. However, even when treatment is available, many patients will forego a sight-restoring cataract surgery. The aim of this study was to analyze the perception of cataract among cataract patients and to discern possible barriers to a free sight-restoring surgery. In depth interviews were used to explore the opinions of 152 cataract patients in Ghana during the months of June and July 2012. The mean age of participants was 72.1 years with a nearly equal distribution between male and female. A majority of participants (94.5%) were aware that something could be done to help their vision prior to attending the outreach, but only 45.0% were aware that surgery was an option. Some patients (10.7%) indicated that their family would not support them in having the surgery and 39.9% of patients stated that they would need the permission of a family member. Most participants (95.2%) with a mature cataract indicated that they wanted the free cataract surgery; among the six who declined, the most common reason was fear. This study suggests that further education may be necessary to increase awareness of the benefits of cataract surgery. However, more research is needed to determine how many participants will actually attend the surgery and ascertain the potential barriers that may appear on the scheduled surgical date.

Introduction: Rationale and specific aims

Cataract is a significant contributor to vision loss and blindness in low-income countries; “up to 75% of blindness (visual acuity below 20/400) is due to cataract, and cataract remains the most common treatable cause of blindness.”¹ Although cataract is ubiquitous globally, populations in remote regions of low-income countries are disproportionately burdened.² Such areas have inadequate medical infrastructure to diagnose and treat cataract, and individuals with operable cataracts often go untreated. Reported surgical coverage for cataract in developing countries is low,¹ and in countries including India, Brazil, and Malawi, 33–92% of cataract-blind patients remain blind, despite the availability of surgery.³

Despite the increased availability of diagnostics and treatment, many patients with operable cataracts decide to forego a sight-restoring operation. Past research demonstrates several reasons for patient refusal to attend cataract surgery, including cost,^{1, 2, 3, 4, 5, 6, 7} fear,^{3, 5} a lack of knowledge about cataract,^{1, 3, 6, 7} concerns about the quality of local services,^{1, 6} lack of desire to improve vision,^{2, 7} shortage of trained personnel,¹ cultural and social reasons,³ religious reasons,² and distance to a hospital.³ This study intends to analyze patient perception of cataract surgery and discern causes for the failure of rural Ghanaian patients receiving eye care from a local eye clinic to undergo surgery. It is anticipated that knowledge regarding cataract will be

high but fear will still remain a significant barrier to the uptake of surgery.

Methods

Approval for research on human subjects was granted by the Tulane University Institutional Review Board, project number 323613-1. A waiver of written informed consent was granted due to the language barrier and illiteracy of the patient population. Verbal consent was obtained for all participants.

This study was conducted in rural villages throughout Ghana, primarily in the Ashanti, Brong-Ahafo, and Greater Accra regions. The researcher was a volunteer with Unite For Sight, a “501(c)(3) non-profit global health delivery organization that empowers communities worldwide to improve eye health and eliminate preventable blindness.”⁸ Unite For Sight’s partner eye clinics’ outreach teams visit different villages daily to provide eye care and return to each village on a monthly basis, making eye care available to those living in extreme poverty throughout the country. Those who present with operable cataracts are referred to the clinic to receive a sight-restoring surgery free of charge.

Local Ghanaian eye doctors affiliated with local eye clinics examined patients during eye care outreaches. Based on the status of the cataract, patients were identified as candidates for surgery by the local ophthalmologist. Those who presented with mature cataract were eligible for a free surgery at local health facilities, with the surgical cost funded by

Unite For Sight. Candidates for this study were limited to adults (over 18) with an operable cataract. The cataract patients who met these criteria were directed to the researcher and were given the opportunity to participate in the study. Eligible participants were presented with a series of open-ended questions, read aloud with the assistance of a local translator coordinated by the Unite For Sight partner eye clinic’s ophthalmic staff. Staff members associated with the eye clinic were able to assist in translation at various times, but when they were not available, it was necessary to find a translator amongst the patients who was competent in English and willing to assist with the study. Each interview was approximately 15 to 20 minutes in length. Questions offered insight into participant knowledge of and willingness to pursue cataract surgery, and assessed the socioeconomic status of eligible patients using the Poverty Scorecard⁹. Participants were free to exclude any question they did not feel comfortable answering. No identifying information was recorded to maintain the confidentiality of responses. Descriptive statistics were used to summarize participant responses.

Results

One hundred and fifty two patients were interviewed over a six-week period in 18 villages in Ghana. Patient gender was fairly evenly distributed with 78 females and 74 males. The mean age of interviewed patients was 72.1 years with a standard deviation of 11.6 years. One hundred and twenty-

five patients (82.2%) were diagnosed with a mature cataract while 27 patients (17.8%) were diagnosed with an immature cataract (Figure 1a). 34.1% of patients presented with bilateral cataracts while 65.9% presented with a unilateral cataract (Figure 1b). Eighty four and five tenths percent of patients stated that their vision interferes with their daily life.

Of the 125 patients with a mature cataract (i.e. requiring immediate surgical intervention), 119 patients (95.2%) wanted the free surgery, while only six patients (4.9%) said they would not attend (Figure

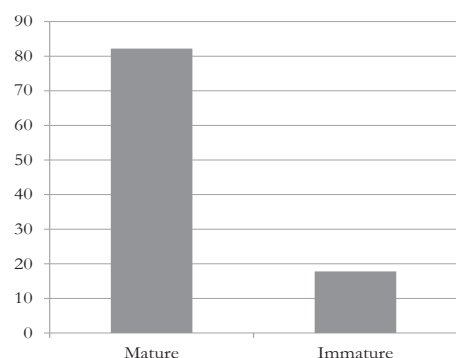


Figure 1a: Percentage of patients presenting with a mature vs. immature cataract

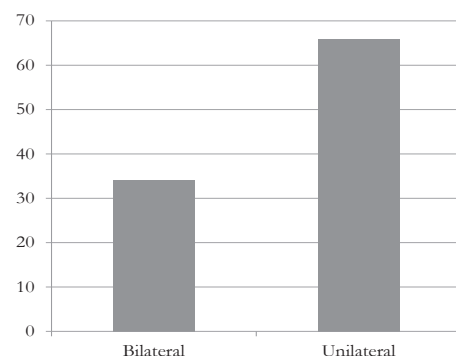
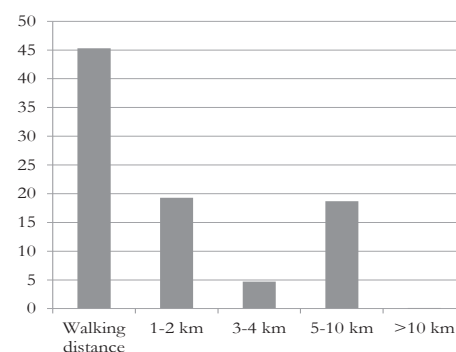


Figure 1b: Percentage of patients presenting with a bilateral vs unilateral cataract



Supplemental Figure 1. How far did you travel to reach the outreach?

2a). The most common reason for declining the surgery was fear, as indicated by three individuals. One patient cited transportation barriers as a reason for not attending the surgery while two patients said that their children were not present and thus they could not get permission to attend surgery (Figure 2b). Of the 27 patients presenting with an immature cataract, 24 (88.8%) said they would want the surgery should their cataract get worse in the future.

The survey assessed the impact of family member involvement in the decision to pursue surgery: 77.2% of patients indicated that they believed their family would support their decision to have the cataract surgery, while 10.7% of patients said that their family would not support them. Twelve and one tenth percent of patients were unsure of their family's position regarding the surgery (Figure 3a). In addition, 39.9% of patients indicated that they would need the permission of a family member before having the surgery (Figure 3b). Of those who required family permission, 57.9% said that they would consult their children, while 26.3% said they would consult a spouse (Figure 3c).

More than half of patients (59.2%) indicated that they had attempted something to improve their vision in the past (Figure 4a). Of those who had done so, the most common remedy was eye drops (46.9%). Only 3.1% of patients had tried a traditional remedy to improve their vision (i.e. rubbing a leaf in the eye) (Figure 4b). Patients who had attempted to improve their vision in the past had done so with varying results: 55.6% of patients stated that past treatment helped their vision, while 43.2% stated that it did not.

Some of the patients were returning for a second cataract surgery: 19.7% of the patients had been offered a cataract surgery in the past, and 69.0% of those patients had accepted the surgery (Figure 5a and 5b). Of the nine patients who did not accept surgery

in the past, four (44.4%) cited financial reasons as a barrier.

Data regarding patient knowledge of cataract treatment were collected: 94.5% of patients indicated that they believed something could be done to help their vision before attending the outreach; however, before attending the outreach, only 45.4% of patients were aware that surgery could help them (Figure 6a). A majority of patients with relatives or acquaintances who had undergone the surgery indicated that the surgery was beneficial: 30.9% of patients knew someone who had undergone cataract

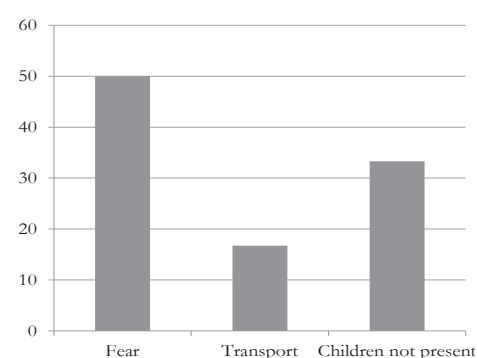


Figure 2b: If no, why do you refuse surgery?

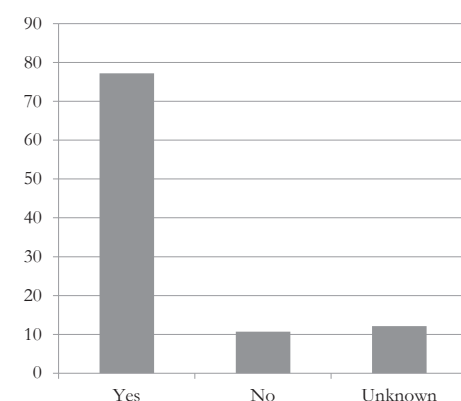


Figure 3a: Will your family want you to have the surgery?

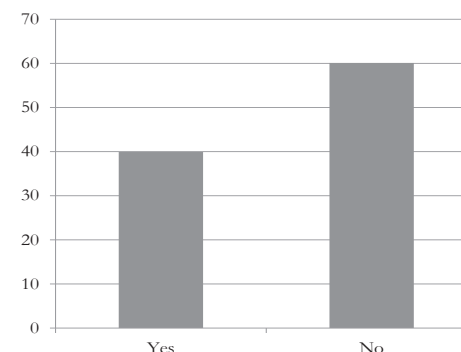


Figure 3b: Do you need permission to have surgery?

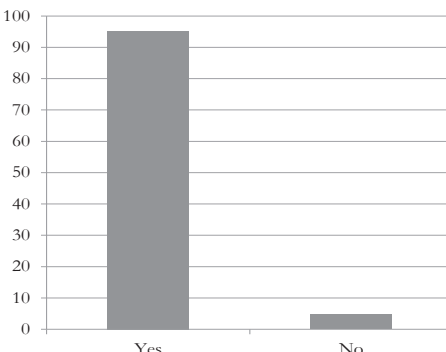


Figure 2a: If your cataract is mature will you want the surgery?

surgery, and, of that group, 88.4% stated that the surgery helped their relative or acquaintance.

Sixty four and four tenths percent of patients had not attended any form of schooling, while 14.8% had attended primary school and 20.1% had attended high school. Only one patient had attended university. The most common patient occupation was farming (56.9%), with unskilled labor following at 13.9%. Sixteen and seven tenths percent of patients had no occupation.

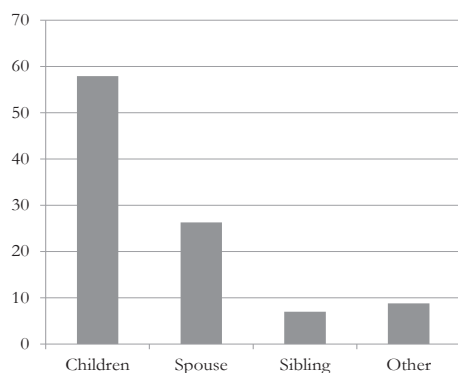


Figure 3c. If yes, whom will you ask?

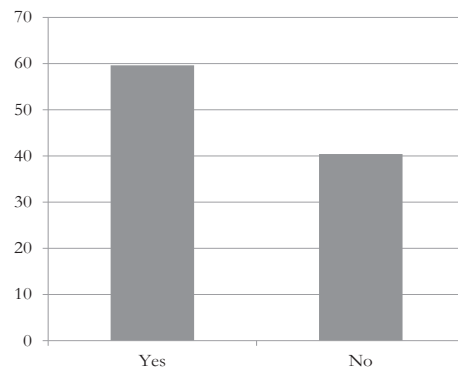


Figure 4a. Have you previously attempted to correct your vision?

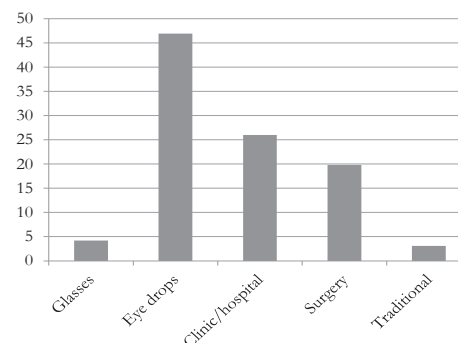


Figure 4b. If yes, what methods did you use to attempt to correct your cataracts?

Discussion

This research has many implications for the provision of cataract care to rural Ghana. More than 95% of patients with a mature cataract expressed a desire to undergo the free surgery, suggesting that there may be relatively few barriers to the uptake of surgery when the patient is initially informed of the need for surgery. However, the validity of this statistic is questionable; the clinic staff (one ophthalmologist and three nurses) expressed the opinion that this statistic is misleading and that the number of patients actually attending surgery may be

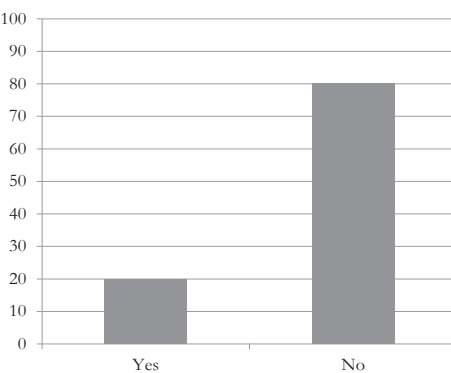


Figure 5a. Have you been offered cataract surgery in the past?

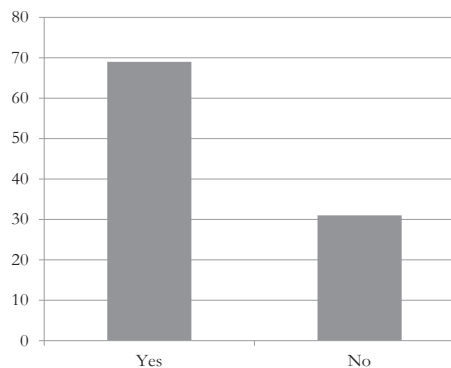


Figure 5b. If yes, did you accept the surgery?

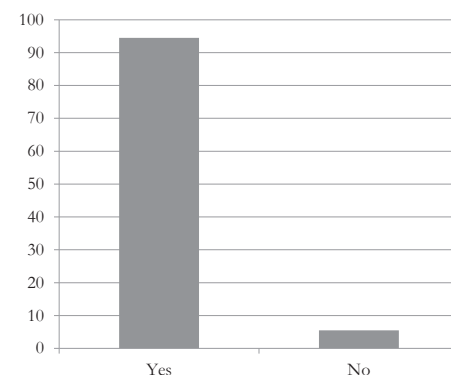


Figure 6a. Did you know something could be done to help your cataracts?

lower. This idea is supported by the fact that only 69.0% of patients previously offered surgery had attended. Several factors may be at play:

- **Patients were not honest in their responses to the researcher.** The researcher's status as a Caucasian-American may have automatically introduced an insurmountable cultural barrier. Local ophthalmic staff suggested that patients may have provided answers that they assumed were expected of them, i.e. they desired cataract surgery. It is evident that social research introduces an 'insiders' and 'outsiders' dynamic, whereby differences in race, language, socioeconomic status, and education between researchers and participants may impede research.¹⁰
- **Transportation Barriers.** Barriers related to transport are possible but not likely. Transportation to the cataract surgery is arranged by local Community Health Workers affiliated with Unite for Sight, and patients are expected to contribute to the cost of transport, unless it is determined to be a barrier for that particular patient. If the local Unite for Sight doctors determine that the patient is unable to fund the cost of transport, they will cover this expense. However, one patient did refuse surgery, citing transportation issues as the reason.
- **Duty to provide for family.** The cataract surgery is a two-day process involving one day of surgery and one day of recovery, both occurring at the clinic. Some members of the ophthalmic staff felt that patients may be reluctant to miss two days of work. This sentiment was echoed in South Africa, where the socioeconomic costs of missing work emerged as a barrier to

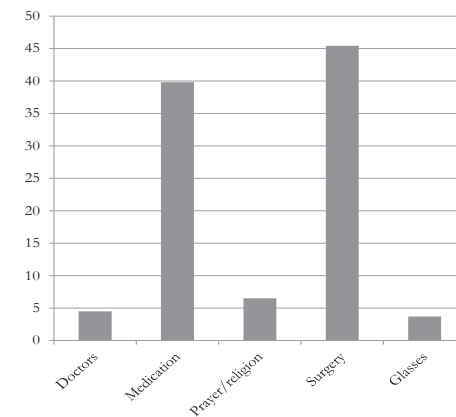


Figure 6b. If yes, what did you think could be done to help your cataracts?

cataract surgery.¹¹

- **Fears about surgery.** Misconceptions regarding surgery persist in Ghana. Despite education, some patients believe that their eye will be replaced with a cat's eye during surgery, or that doctors will remove their eye during the operation. These misconceptions were discussed repeatedly by the clinic nurses and doctors. Such misconceptions lead to fears that may manifest prior to surgery, prompting the patient to avoid the operation.

Based on these considerations, the researcher proposes a follow-up study to better assess the barriers to the uptake of cataract surgery in rural Ghana. It is evident that some patients who are referred for cataract surgery do not ultimately proceed with surgery. In order to properly assess the reasons for not attending surgery, a retrospective study should be conducted after the scheduled surgery date. Future researchers should examine clinic data to identify cataract patients who did not attend their scheduled surgery. By comparing the list of referred patients and the list of those attending surgery, researchers can easily determine the patients who declined surgery from a given town. Those who were referred but declined to attend should be interviewed to determine the specific reasons for declining surgery. This method reduces the possibility of patient dishonesty. It also allows the researcher to document barriers that emerged prior to surgery.

It is also important to mention the language barrier and associated complications. The majority of cataract patients involved in this study were speakers of a local Ghanaian dialect. As a result, a translator was required to interpret the responses of study participants. The languages encountered throughout the course of this study prominently included Twi, and to a lesser extent, Ga and Ewe. The presence of a translator may have introduced bias to the study and should be considered when interpreting results.

Regardless of the limitations of this study, valuable information was revealed that could be useful during the implementation of an eye health program in Ghana and other low-income regions. Health education campaigns may increase awareness of cataract surgeries and reduce misconceptions. Before coming to the outreach, only 49 patients (32.2%) were aware that surgery could help them; this suggests that awareness of surgical intervention as a treatment for cataract is low. Based on the researcher's observations, those patients who were returning for a second cataract surgery were very effective in reducing misconceptions and easing

the fears of first time patients. Increasing dialogue between those who have undergone the surgery and those who are considering it could alleviate fears.

Overall, the number of patients who indicated a desire to undergo surgery was higher than expected; of the 125 patients presenting with mature cataracts, only six rejected surgery. While half of the mature cataract patients who rejected surgery cited fear as the reason, this only constituted three patients. Additionally, it appears that the patient population could benefit from increased education regarding the benefits of surgery: while a majority of participants (94.5%) were aware that something could be done to help their vision prior to attending the outreach, only 45.0% were aware that surgery was an option. Furthermore, family dynamics may impact surgical uptake, based on the percentage of patients (39.9%) who stated that they would need the permission of a family member and the percentage of patients (10.7%) who indicated that their family would not approve of surgery. More research is needed to determine the true proportion of patients who ultimately attended surgery as well as the possible barriers that may emerge prior to surgery.

References

- ¹Tabin, G., Chen, M. and Espandar, L. (2008) "Cataract surgery for the developing world." *Current Opinion in Ophthalmology*. 19.1. Pg 55-9.2Rabiu, M M. (2001)
- ²"Cataract blindness and barriers to uptake of cataract surgery in a rural community of northern Nigeria." *The British Journal of Ophthalmology*. 85.7. Pg 776-80.
- ³Lewallen, S. and Courtright, P.H. (2000) "Recognising and reducing barriers to cataract surgery." *Community Eye Health Journal*. 13.34. Pg 20-21.
- ⁴Zhang, M., Wu, X., Li, L., Huang, Y., Wang, G., Lam, J., Lam, D.S., Gao, Y., Griffiths, S. and Congdon, N. (2011) "Understanding barriers to cataract surgery among older persons in rural China through focus groups." *Ophthalmic Epidemiology*. 18.4. Pg 179-186.
- ⁵Athanasiov, P.A., Casson, R.J., Newland, H.S., Shein, W.K., Muecke, J.S., Selva, D. and Aung, T. (2008) "Cataract surgical coverage and self-reported barriers to cataract surgery in a rural Myanmar population." *Clinical and Experimental Ophthalmology*. 36.6. Pg 521-5.
- ⁶Yin, Q., Hu, A., Liang, Y., Zhang, J., He, M., Lam, D.S., Ge, J., Wang, N., Friedman, D.S., Zhao, J. and Congdon, N. (2009) "A two-site, population-based study of barriers to cataract surgery in rural china." *Investigative Ophthalmology and Visual Science*. 50.3. Pg 1069-1075.
- ⁷Athanasiov, P.A., Edussuriya, K., Senaratne, T., Sennanayake, S., Selva, D. and Casson, R. J. (2009) "Cataract in central Sri Lanka: cataract surgical coverage and self-reported barriers to cataract surgery." *Clinical and Experimental Ophthalmology*. 37.8. Pg 780-4.
- ⁸N.A. (2011) "Immense Impact and Quality." *Unite for Sight. Unite for Sight.* <<http://www.uniteforsight.org/volunteer-abroad/impact>> (Accessed 04/01/2012).
- ⁹Schreiner, M. and Woller, G. (2010) "A Simple Poverty Scorecard for Ghana." *Microfinance. Microfinance Risk Management.* <<http://www.microfinance.com/#Ghana>> (Accessed 10/18/2013)
- ¹⁰Rabe, M. (2003) "Revisiting 'insiders' and

'outsiders' as social researchers." *African Sociological Review*. 7.2. Pg 149-161.

¹¹Shah, A. (2005) "Barriers to the uptake of cataract surgery for women in urban Cape Town." *Community Eye Health*. 18.52. Pg 80.

Lifestyle indicators for health care vs. non-health care students

BY JACLYN COLLINS, SUSAN BURDA, BRITTANY CRAWFORD,
RANDI GREGOIRE, ALICIA HEINRICH, AMERA NELSON, CAITLIN PRUNTY,
KATIE PULLAR, KAYLA WAHLIN, AND DESIREE L. TANDE, PhD
UNIVERSITY OF NORTH DAKOTA

Abstract

Healthy lifestyle behaviors have the potential to reduce rates of chronic disease and improve the quality of life among college students. Eating a healthy diet, limiting alcohol consumption, and maintaining a healthy weight are important behaviors for health among young adults. Identifying disparities in health behaviors among student and developing education programs, course requirements, or policies to reduce disparities could improve current and future health among college students. This paper explores whether health indicators such as dietary intake, alcohol intake, Body Mass Index (BMI), smoking, sleep, and physical activity vary between undergraduate students who are enrolled in health-related majors compared with non-health-related majors. Further, we studied sex differences in these health indicators among college undergraduate students.

Introduction

Many Americans desire quick, easy food choices due to their busy schedules.¹ Fast food is convenient but is more likely to be high in fat, sodium, and calories. College students, like non-college-going Americans, frequent fast food establishments for constraints of time and also because fast food is relatively inexpensive.² The alternative to the typical American diet—a prudent or healthy diet—has been related to decreased cardiovascular disease³ and mortality risk.^{4,5} According to Yang, Cogswell, Flanders, Hong, Zhang, Loustalot, Gillespie, Merritt, and Hu cardiovascular disease continues to be the leading cause of death among U.S. adults.⁵

Undergraduate students are expected to be healthy because most of them are young adults. However, this is not necessarily the case. Obesity rates among adolescents and adults have increased dramatically from the early 1990s.^{6,7} Further, Fernandes and Lofgren (2011) reports that metabolic syndrome, is present among a high number of college students.⁸ Metabolic syndrome is a condition with at least three of the following characteristics present: abdominal obesity, insulin resistance, elevated blood pressure, low HDL-C, and high triglyceride levels.⁹ More than a quarter of the study sample met at least one criteria for the diagnosis of metabolic syndrome.⁸ This syndrome that leads to increased risk of heart disease is associated with poor dietary quality. This study exemplifies the

importance of evaluating lifestyle factors among college students for the purpose of identifying risky behaviors and planning targeted interventions to help them inculcate health habits and reduce their chances of developing ailments in the future.

Eating a healthy diet, limiting alcohol consumption, and maintaining a healthy weight are all important behaviors for heart health among young adults.¹⁰ During the first three years of college there are often changes in these behaviors,¹¹ so identifying disparities in health behaviors among students and developing education programs or policies to reduce disparities among college students could impact their future health. Sex differences in health-related behaviors^{2,12} and disease incidence^{13,14} have been reported among college students. Previous researchers have found that college students are more likely to eat poorly when not enrolled in a nutrition-related curriculum² and alcohol intake varies across major area of study among males in India.¹⁵ These differences in health indicators by area of study may translate to the work world and have long-term implications. Among working adults, poor health status is related to unskilled or low skilled occupations¹⁶ and obesity is related to working more hours each week.¹⁷

Obesity has been identified as a major public health concern requiring attention on college campuses.¹⁸ Among U.S. adolescents and young adults, obesity predicts cardiovascular mortality.¹⁹ Additional research is needed to examine whether

health indicators vary across major areas of study. Students' knowledge and experience gained through a major area of study may influence their lifestyle choices. Shah, Amirabdollahian, and Costa reported better dietary intake for junior and senior students compared with freshman students and for dietetic majors compared with non-dietetics majors.²⁰ Several academic programs are training students to work in the field of health care and wellness but most studies are limited to medical, nursing, or dietetics students.^{12,15,19,20} We don't currently know if these students benefit from more favorable lifestyle behaviors compared to other college students.

The purpose of this study was to investigate whether health indicators, including dietary intake, alcohol intake, smoking, sleep, physical activity, and BMI vary between undergraduate students at an upper Midwest university who are enrolled in a health-related area of study compared with those enrolled in other areas of study. Students enrolled in health-related majors may be perceived as following a healthier lifestyle than their peers; however, this has not been reported in the literature. Thus, the current study was employed to learn whether differences in health indicators exist between students in health-related majors compared with non-health-related majors. A secondary purpose was to examine differences between males and females in health-related and non-health-related majors because sex differences have been reported for health indicators and

disease prevalence. The ability to identify differences between groups is important for screening students and identifying those at risk for early intervention.

Healthy lifestyle behaviors have the potential to reduce rates of chronic disease and improve the quality of life among college students. Perhaps all students would benefit from taking health-related courses as part of their Bachelor's degrees but first we must establish whether differences exist between groups of students in health care related majors compared with those enrolled in other major areas of study. We hypothesize that on average students majoring in health-related disciplines report more favorable dietary intake, alcohol intake, and BMI compared with their counterparts majoring other disciplines. We also hypothesize that on average females will have more favorable dietary intake, alcohol intake, and BMI status when compared with males.

Methods

The present study was reviewed and approved by the University of North Dakota's Institutional Review Board. The cross-section study design was carried out at a mid-sized public university. Participation was open to undergraduate students across all disciplines. Study participants reviewed and signed informed consent forms prior to study entry. A self-administered survey was provided to a convenience sample. Data collection was carried out in February, 2012.

On the basis of their area of study, student participants were divided into two groups: health care and non-health care. Health care areas of study were selected based on the likelihood of graduates working in the field of health care or wellness as well as the undergraduate requirements for wellness and health courses at the university. Non-health care areas of study were identified as all other undergraduate majors offered at the university. Health care students were identified by self-reported majors or minors in the following areas of study: (1) anatomy and cell biology, (2) athletic training, (3) biochemistry and molecular biology, (4) biology—pre health science, (5) communication and speech disorders, (6) community nutrition, (7) dietetics, (8) gerontology, (9) health education, (10) kinesiology, (11) medical laboratory science, (12) nursing, (13) physical education, exercise science, and wellness, (14) physical therapy, (15) social work, and (16) pre-health science. Students with majors and minors in disciplines different from the ones mentioned or those who had not yet declared their area of study were classified under non-health care. Undergraduate class status was defined based on the university

definitions: freshman (0 through 23 credits), sophomore (24 through 59 credits), junior (60 through 89 credits), senior (90 through 125 credits). Graduate and distance students were excluded from the study.

Measures

The survey measured the following lifestyle indicators: smoking status, physical activity, alcohol consumption, sleep duration, height, weight, and dietary intake. Physical activity items measured weekly participation in moderate and vigorous activities. The MEDFICTS (meats, eggs, dairy, fried food, fat in baked goods, convenience foods, fats added at the table and snacks) dietary assessment questionnaire measured dietary fat and cholesterol consumption. This questionnaire was designed to measure adherence to the National Cholesterol Education Program for heart health and provides a dietary quality score based on dietary fat and cholesterol consumption. The MEDFICTS scores range from zero to 216 and were categorized into three groups: "Need for Dietary Changes" (score of greater than 70), "Heart-Healthy" (score of 40 through 70), and "Therapeutic Lifestyle Changes" (score of less than 40). The MEDFICTS tool used in this study is described in detail elsewhere.^{23,24} BMI was calculated from self-reported heights and weights. BMI categories were defined as underweight (less than 18.5), normal (18.5 to 24.9), overweight (25.0 to 29.9), and obese (greater than or equal to 30.0).²⁵ The underweight and normal categories were grouped due to the small number of students in the underweight category. The following BMI groups were utilized for statistical analysis: (1) less than 25.0, (2) 25.0 to 29.9, and (3) greater than 29.9.

Data analysis

Statistical Package for Social Sciences (SPSS) software was utilized for data analysis version 18.0.²⁶ Means, standard deviations, and frequencies were utilized to describe the data. Pearson correlations, independent t-tests, analysis of variance (ANOVA) with Tukey post hoc tests, and chi square were utilized for statistical analysis. Two data points were identified as extreme outliers—one for BMI and another for a MEDFICTS score. The outliers were not data entry errors so completely removing them is not advisable. These outliers were identified by reviewing histogram charts and confirmed by a score beyond 3.0 times the H-spread (BMI > 41.7; MEDFICTS score > 180). The extreme outliers distort statistical estimates for sample means and variance, and therefore, the values were changed to be the largest value in each variable but no

longer an extreme outlier by changing the data points to values that were equal to the mean value plus two standard deviations.^{27,28}

Results

Study participants were undergraduate college students (N = 158) from an upper Midwest university. The participation rate for the study was 89.2%. A total of 177 students participated in the study with 158 completing the study. Nineteen surveys were incomplete or non-qualifying surveys (e.g., graduate students). The majority of study participants were non-health care students (57%) with the mean age of 20.9 years (SD, 2.8). Most study participants were white (93%), female (61.4%), and non-smokers (94.3%). The distribution across undergraduate class status was the following: 25.3% freshman, 19.6% sophomores, 22.2% juniors, and 32.9% seniors. Detailed information about sample characteristics and comparisons between health care and non-health care students is provided in Table 1.

Sex differences were found in some lifestyle characteristics. Seventy five percent of males (46 of 61 male participants) and 56% (54 of 97 female participants) of females reported weekly alcohol consumption. Male participants were shown to consume more servings of alcohol per week than women (mean \pm SD, 8.3 ± 8.0 and 2.2 ± 3.0 , respectively, $t = 5.74$, $p < 0.001$). Dietary intake of fat and cholesterol was higher for males than females (mean \pm SD, 60.3 ± 30.2 and 39.4 ± 26.1 , $t = 4.62$ respectively; $p < 0.001$), and more females than males fell into the optimal intake level for fat and cholesterol based on MEDFICTS scores (score of less than 40; $\chi^2 = 16.9$, $p < 0.001$, effect size = 0.327).

The majority (63% or 100 of 158 participants) of students reported weekly alcohol intake, with a higher average weekly intake for non-health care students compared to health care students ($t = 3.97$, $p < 0.001$). The number of students consuming alcohol on a weekly basis was also higher for non-health care (71% or 64 of 90 participants) compared with health care students (53% or 36 of 68 participants) ($\chi^2 = 5.50$, $p = 0.019$, effect size = 0.187) and male (75% or 46 of 61 participants) compared with female (56% or 54 of 97 participants) ($\chi^2 = 6.281$, $p = 0.012$, effect size = 0.119). Positive relationships were found between alcohol use and smoking status ($r = 0.27$, $p < 0.01$) and MEDFICTS score (lower scores indicate a heart healthy diet) ($r = 0.26$, $p < 0.01$; refer to Table II). MEDFICTS scores were higher among students that reported weekly alcohol intake (mean \pm SD, 52.7 ± 32.1) compared to those who did not consume alcohol weekly (38.5 ± 21.7) ($t = -3.32$, $p = 0.001$).

Smoking was inversely related to physical activity ($r = -0.18$, $p = 0.02$) and daily sleep duration ($r = -0.17$, $p = 0.03$) and directly related to alcohol ($r = 0.27$, $p < 0.01$) and MEDFICTS score ($r = 0.26$, $p < 0.01$). Smokers participating in this study were less likely to report weekly moderate or vigorous physical activity. Smokers also reported drinking more alcohol per week and fewer hours of daily sleeping, on average. Pearson correlations for participant characteristics are presented in Table 2.

BMI was higher for non-health care students (mean \pm SD, 25.2 ± 4.1) than health care students (23.4 ± 3.7) ($t = 2.75$, $p = 0.007$). Fewer health care students fell into the overweight and obese groups (Figure 1). BMI also varied between sexes with a higher BMI for men (mean \pm SD, 25.5 ± 3.7) than women (23.8 ± 4.1) ($t = 2.60$, $p = 0.01$). Further, BMI was positively related to undergraduate class status (freshman, sophomore, junior, and senior) ($r = 0.17$, $p \leq 0.05$), sex ($r = -0.20$, $p \leq 0.05$) and age ($r = 0.34$, $p \leq 0.01$) (refer to Table 2). MEDFICTS scores varied across BMI groups among males ($F(2,58) = 4.59$, $p = 0.014$). Males in the overweight group (BMI $\geq 25.0 - 29.9$) had a significantly lower MEDFICTS score ($M = 47.7$, 95% CI [38.7, 56.6]) than men in the < 25.0 group ($M = 71.6$, 95% CI [58.9, 84.2], $p = 0.011$), but MEDFICTS scores did not vary across BMI groups for women.

Discussion

The study found differences in lifestyle characteristics between sexes as well as between students who study health-related disciplines and those who don't. Dietary fat and cholesterol intake varied by sexes with more women than men falling into the optimal "Therapeutic Lifestyle Changes" category based on the MEDFICTS scores. These findings are consistent with previous research reporting that female students eat a lower percentage of energy from fat than male students.²⁹

According to this study, male college students engaged in less healthy eating habits than women independent of their major area of study. Males consume a higher percentage of energy from fat, using food labels less often, and consuming fast food more frequently.^{2,29} These habits may contribute to more cholesterol and saturated fat in men's diets as reflected in the MEDFICTS score in the present study. The higher MEDFICTS scores for men may be partially attributed to a higher total caloric intake among men or underreporting by women. Underreporting energy intake is more common among women than men.³⁰ The lack of ability for MEDFICTS to discriminate between sexes is a limitation of the tool noted in

previous research²⁴ and our findings confirm the difference between men and women in this area. Sex differences found in this study provide further evidence that the MEDFICTS tool may benefit by adding a sex question to the tool, so respondents can report this characteristic.

Non-health care students are more likely to fall into the overweight or obese groups. BMI is correlated with excessive adipose tissue which places individuals at risk for multiple diseases, such as heart disease, hypertension, type 2 diabetes mellitus, sleep apnea, and some forms of cancer.³¹ The prevalence of obesity among participants in this study was lower at 12.7% than the

national rate of 35.7% recently reported among adults.³² However, this is expected because obesity rates increase from younger to older age groups and the average age in our study was 20.9 years.³² Nonetheless, the higher rate of obesity among young men in the present study may indicate an increased risk for chronic diseases later in life.

Dietary scores varied by BMI group for males. The results unexpectedly indicated that the MEDFICTS scores were lower for men in the overweight group than men with a BMI of 24.9 or less, suggesting poorer dietary choices by those with more favorable BMI values. This finding may be due to increased awareness of nutrition

	Health care (n = 68)	Non-health care (n = 90)	p - value	Combined (N = 158)
Age (mean \pm SD) years	20.4(2.7)	21.3(2.8)	0.032	20.9(2.8)
Gender (%)			<0.001	
Male	16.2	55.6		38.6
Female	83.8	44.4		61.4
*Ethnicity (%)			—	
White	92.6	93.3		93.0
Black or African American	1.5	0		0.6
Asian	1.5	3.3		2.5
Native Hawaiian or other Pacific Islander	1.5	0		0.6
American Indian, Alaska Native	2.9	3.3		3.2
Smoking (%)			—	
Yes	2.9	7.8		5.7
No	97.1	92.2		94.3
Sleep (mean \pm SD) hours/day	7.1(1.2)	7.2(1.0)	NS	7.2(1.1)
Alcohol (mean \pm SD) drinks/week	2.6(3.8)	6.1(7.3)	<0.001	4.6(6.2)
Leisure-time physical activity (%) (weekly participation)			NS	
Moderate	7.4	7.8		7.6
Vigorous	25.0	28.9		27.2
Moderate and Vigorous	67.6	63.3		65.2
BMI (mean \pm SD)	23.4(3.7)	25.2(4.1)	0.007	24.4(4.0)
*BMI categories (%)			<0.001	
Underweight	1.5	3.3		2.5
Normal	76.5	46.7		59.5
Overweight	11.8	35.6		25.3
Obese	10.3	14.6		12.7
MEDFICTS score (mean \pm SD)	42.5(28.6)	51.3(29.7)	NS	47.5(29.5)
MEDFICTS categories (%)			NS	
Category 1 (Score < 40)	51.5	42.2		46.2
Category 2 (Score 40-70)	35.3	34.4		34.8
Category 3 (Score > 70)	13.2	23.3		19.0

Table 1. Descriptives and differences for undergraduate study participants

MEDFICTS: dietary questionnaire assessing fat and cholesterol intake; NS: non-significant.

*Chi-square tests: (1) ethnicity: white was compared with all other ethnic groups combined; (2) BMI categories: underweight and normal BMI groups were combined and compared to overweight and obese groups. Smoking and ethnicity lacked sufficient numbers in some groups for chi-square tests.

	Status	Age	Gender	Ethnicity	Smoking	BMI	Physical Activity	Sleep	Alcohol	MEDFICTS Score	Area of Study
Status	1										
Age	0.51**	1									
Gender	-0.10	-0.18*	1								
Ethnicity	-0.07	-0.05	-0.10	1							
Smoking	-0.08	-0.02	-0.20*	-0.01	1						
BMI	0.17*	0.34**	-0.20*	0.07	-0.06	1					
Physical Activity	0.03	-0.05	-0.08	0.02	-0.18*	0.01	1				
Sleep	0.02	-0.11	0.06	-0.17*	-0.17*	-0.08	-0.01	1			
Alcohol	0.21**	0.09	-0.48**	-0.03	0.27**	0.05	0.07	-0.09	1		
MEDFICTS Score	-0.06	-0.01	-0.35**	-0.01	0.26**	-0.01	-0.03	-0.11	0.32**	1	
Area of Study	-0.19*	-0.17*	0.40*	0.01	-0.10	-0.22**	0.04	-0.04	-0.28**	-0.15	1

Table 2. Pearson correlation for participant characteristics

Status: freshman (0), sophomore (1), junior (2), senior (3); Gender: men (0), women (1); BMI, Body Mass Index; Physical activity (leisure) : weekly moderate (0), vigorous (1), or both activities (2); Area of study: non-healthcare (0), healthcare (1).

**Correlation is significant ≤ 0.01 level (2-tailed).

*Correlation is significant ≤ 0.05 level (2-tailed).

and food choice or underreporting energy intake and therefore a lower MEDFICTS score for overweight men. Excess weight has been associated with underreporting energy intake.³¹ Men with a BMI of less than 25.0 may also be less concerned with dietary intake because they are not in a weight category associated with high health risk. Notably, MEDFICTS scores did not vary across women's BMI groups. However, overweight women have been reported to have a higher rate of underreporting their energy intake as well as fat and cholesterol intake,^{30,33} which may contribute to the lack of dietary difference between BMI groups of women. Because a diet low in saturated fat and cholesterol can decrease the risk for cardiovascular disease and mortality, male students may benefit from education on how to improve the quality of their diets.^{3,4,5}

Alcohol intake is an important health concern for the collegiate population. Gore and colleagues³⁴ reported alcohol consumption as a key risk factor for incidental disability-adjusted life years or years lost due to premature morbidity or mortality based on data from children and young adults, aged 10 – 24 years (WHO's 2004 Global Burden of Disease study). Approximately 62% of U.S. men report drinking alcohol compared to only 47% of U.S. women.³⁵ The rates in the present study were higher for both men and women, which is a concern that demands additional attention and resources. Non-health care students and male students were more likely to indulge in higher weekly consumption of alcohol. Students who consumed more fat and cholesterol, of which excessive amounts are indicative of poor dietary quality, also consumed more alcohol in the present study.

These findings support previous research reporting that dietary quality is inversely related to alcohol intake.³⁶ Research indicates that alcohol intake may compromise dietary quality. Strategically marketing wellness interventions that aim to improved dietary intake and reduce alcohol intake to male and non-health majors may be an efficient use of limited resources on college campuses.

Significant relationships were found between dietary intake and smoking status and are useful to consider for future related research. However, the small number of smokers in our sample greatly limits the generality of these results. Nineteen percent of U.S. adults were smokers in 2010, with 18% of women and 21% of men identifying as current smokers.³⁷ The present study found that only 5.7% (n = 9) of the sample were self-reported current smokers, while the 2013 estimated cigarette smoking rate is 9.3% among U.S. adults with a Bachelor's degree.³⁸ The small subsample of smokers limits the generality of the smoking-related findings of this study and requires future research with a larger sample or oversampling of smokers to confirm relationships found in the present study. Therefore, further investigation is needed to determine if smokers are more likely to eat a high fat and cholesterol diet and drink more alcohol as our results indicate. Furthermore, smokers in the current study reported fewer hours of sleep, on average, and were less likely to report moderate or vigorous physical activity than their non-smoking counterparts. A recent, larger study reported an inverse relationship between smoking and fruit and vegetable intake among adults.³⁹ The results of this study are consistent with our findings that smokers have less healthy diets

compared with nonsmokers.

The transition to college is a critical time of change for young adults. Many college students are in a time marked by adjustment and instability in their lifestyles and behaviors.⁴⁰ Developing healthy habits at this stage in the life cycle may lower the risk of common chronic diseases later in life. Many preventable chronic diseases are the result of cumulative unhealthy lifestyle behaviors over decades. Thus, early intervention is key for the prevention of these conditions. Most college students experience increased autonomy and decision making with the transition from home to college, so this is a period of opportunity to learn about healthy behaviors and make independent lifestyle choices.⁴¹ Previous research has reported successful interventions that have helped students to improve short-term health-related behaviors.^{20,42} Additional research is needed to identify interventions that result in long-term beneficial changes in health-related behaviors and to identify the college students at greatest health risk.

Limitations of the study

The study has several limitations. The data was self-reported and therefore our original data and subsequent results are prone to response bias. The sample included primarily white undergraduate students, which represents the targeted university's student population but limits generality of the results. Although MEDFICTS is a reliable dietary assessment questionnaire that has been evaluated in a variety of adult groups, it does not account for caloric intake or sex differences. The results related to smoking should be interpreted with caution, because only 9 participants (5.7%)

represented this group in our study.

Conclusion

Non-health care students were more likely to drink alcohol and be overweight or obese when compared with health care students. Increased alcohol intake was related to increased dietary intake of fat and cholesterol, thus unhealthy behaviors often coexist among college students. Sex differences place men at a higher risk for chronic disease, including a less favorable fat, cholesterol, and alcohol intake, as well as BMI status. Students who major in a healthcare-related field may benefit from required courses that educate students about wellness and lifestyle choices that are associated with prevention of diseases. According to the results of this study, non-health care students and male students reported less favorable lifestyle characteristics and may benefit from targeted education programs, course requirements, or policies designed to teach students about the benefits of healthy lifestyle choices. Future research should explore whether these types of interventions are equally beneficial for both health care and non-health care students as well as both sexes. Additional research is also warranted to study relationships between smoking, sleep, diet, alcohol, and physical activity in a large college population. The American College Health Association's National College Health Assessment data could be utilized for this purpose.

References

- ¹Tillotson, J. (2009) "Americans' food shopping in today's lousy economy (part 2)." *Nutrition Today*. 44.5. Pg 218-221.
- ²Morse, K., and Driskell, J.A. (2009) "Observed sex differences in fast-food consumption and nutrition self-assessments and beliefs of college students." *Nutrition Research*. 29. Pg 173-179.
- ³Miller, E.R., Erlinger, T.P., and Appel, L.J. (2006) "The effects of macronutrients on blood pressure and lipids: An overview of the DASH and OmniHeart trials." *Current Atherosclerosis Reports*. 8.6. Pg 460-465.
- ⁴Anderson, A.L., et al. (2011) "Dietary patterns and survival of older adults." *Journal of the American Dietetic Association*. 111.1. Pg 84-91.
- ⁵Yang, Q., et al. (2012) "Trends in cardiovascular health metrics and associations with all-cause and CVD mortality among US adults." *Journal of the American Medical Association*. 307.12. Pg 1273-1283.
- ⁶U.S. Department of Health and Human Services. (2013) "Nutrition, Physical Activity, and Obesity." <<http://healthypeople.gov/2020/lhi/nutrition.aspx?tab=data>> (Accessed: 11/30/2013)
- ⁷U.S. Department of Health and Human Services. (2013) "Health Risk Factors" <<http://www.cdc.gov/nchs/hsu/healthrisk.htm#elevated>> (Accessed: 11/30/13)
- ⁸Fernandes, J., and Lofgren, I.E. (2011) "Prevalence of metabolic syndrome and individual criteria in college students." *Journal of American College Health*. 59.4. Pg 313-321.
- ⁹Grunday, S.M., Brewer, H.B., Cleeman, J.I., Smith, S.C., Lenfant, C. (2004) "Definition of

metabolic syndrome. Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition." *Circulation*. 109. Pg 433-438.

¹⁰Lui, K., et al (2012). "Healthy lifestyle through young adulthood and presence of low cardiovascular disease risk profile in middle age: The Coronary Artery Risk Development in (Young) Adults (CARDIA) Study." *Circulation*. 125. Pg 996-1004.

¹¹Lau, R.R., Jacobs Quadrel, M., and Hartman, K.A. (1990). "Development and Change of Young Adults' Preventive Health Beliefs and Behavior: Influence from Parents and Peers." *Journal of Health and Social Behavior*. 31.3. Pg 240-259.

¹²Huang, T.T., Harris, K.J., Lee, R.E., Nazir, N., Born, W., and Kaur, H. (2003) "Assessing overweight, obesity, diet, and physical activity in college students." *Journal of American College Health*. 52. Pg 83-86.

¹³Dasgupta, K. (2008) "Sex differences in the development of higher systolic blood pressure during adolescence." *Cardiology Review*. 25.5 Pg 54-57.

¹⁴Thoits, P.A. (2010). "Stress and health: major findings and policy implications." *Journal of Health and Social Behavior*. 51(S). Pg S41-S53.

¹⁵Gupta, S., Singh Sarpal, S., Kumar, D., Kaur, T., and Arora, S. (2013). "Prevalence, pattern and familial effects of substance use among the male college students – a north India study." *Journal of Clinical Diagnostic Research*. 7.8 Pg 1632-1636.

¹⁶Tjepkema, M., Wilkins, R., and Long, A. (2013). "Cause-specific mortality by occupational skill level in Canada: a 16-year follow-up study." *Chronic Diseases and Injuries in Canada*. 3.4. Pg 195-203.

¹⁷Park S., Pan L., and Lankford T. (2013 Nov 7). "Relationship between employment characteristics and obesity among employed U.S. adults." *American Journal of Health Promotion*. [epub ahead of print].

¹⁸Sparling, P.B. (2007). "Obesity on campus." *Preventing Chronic Disease: Public Health Research, Practice, and Policy*. 4.3. (Accessed 11/22/13: www.cdc.gov/pcd/issues/2007/jul/06_0142.htm.)

¹⁹Saydah, S., McKeever Bullard, K., Imperatore, G., Geiss, L., and Gregg, E.W. (2013). "Cardiometabolic risk factors among US adolescents and young adults and risk of early mortality." *Pediatrics*. 131.3 Pg e679-e686.

²⁰Shah, N., Amirabdollahian, F., and Costa, R. (2011). "The dietary and physical activity habits of university students on health and non-health related courses." *Journal of Human Nutrition and Dietetics*. 24. Pg 277-278. [abstract]

²¹Sakamki, R., Toyama, K., Amamoto, R., Liu, C.-J., and Shinfuku, N. (2005). "Nutritional knowledge, food habits and health attitude of Chinese university students – a cross sectional study." *Nutrition Journal*. 4.4 (Accessed 11/22/13: <http://www.nutritionj.com/content/4/1/4>.)

²²Wengreen, H.J., and Moncur, C. (2009) "Change in diet, physical activity, and body weight among young-adults during the transition from high school to college." *Nutrition Journal*. 8. Pg 32. <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2720988/?tool=pubmed>> (Accessed 4/25/12).

²³Kris-Etherton, P., Eissenstat, B., Jaax S., Srinath, U., Scott, L., Rader, J., and Pearson, T. (2001) "Validation of MEDFICTS, a dietary assessment instrument for evaluating adherence to total and saturated fat recommendations of the National Cholesterol Education Program Step 1 and Step 2 diets." *Journal of the American Dietetic Association*. 101.1. Pg 81-86.

²⁴Mochari, H., Gao, Q., and Mosca, L. (2008) "Validation of MEDFICTS dietary assessment questionnaire in a diverse population." *Journal of the American Dietetic Association*. 108.5. Pg 817-822.

²⁵U.S. Department of Health and Human Services. "Healthy Weight- it's not a diet, it's a

lifestyle!" <http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html> (Accessed: 2/10/2012.)

²⁶SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.

²⁷Pallant, Julie. (2007) *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Window (Version 15): 3rd Edition*. McGraw-Hill Companies, Inc.

²⁸Van Selst, M., and Jolicoeur, P. (1994). "A solution to the effect of sample size on outlier elimination." *The Quarterly Journal of Experimental Psychology*. 47A.3. Pg 631-650.

²⁹Li, K., Concepcion, R., Lee, H., Cardinal, B., Ebbeck, V., and Woekel, E. (2012) "An examination of sex differences in relation to the eating habits and nutrient intakes of university students." *Journal of Nutrition Education and Behavior*. 44.3. Pg 246-250.

³⁰Brifel, R.R., Sempos, C.T., McDowell, M.A., Chien, S., and Alaimo, K. (1997) "Dietary methods research in the Third National Health and Nutrition Examination Survey: underreporting of energy intake." *American Journal of Clinical Nutrition*. 65.4. Pg 1203S-1209S.

³¹U.S. Health and Human Services. (1998). "Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults – The evidence report." *Obesity Research*. 98.6. Pg 51S-209S.

³²Ogden, C., Carroll, M., Kit, B., and Flegal, K. (2012). "Prevalence of obesity in the United States, 2009-2010." U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics Data Brief Web site. <http://www.cdc.gov/nchs/products/databriefs.htm>. (Accessed 5/10/2012).

³³Braam, L.A.J.L.M., Ocké, M.C., Bueno-de-Mesquita, H.B., Seidell, J.C. (1998). "Determinants of obesity-related underreporting of energy intake." *American Journal of Epidemiology*. 147.11 Pg 1081-1086.

³⁴Gore, F.M., Bloem, P.J., Patton, G.C., Ferguson, J., Joseph V., Coffey, C., Sawyer, S.M., and Mathers, C.D. (2011) "Global burden of disease in younger people aged 10 – 24 years: as systematic review." *Lancet*. 377.9783. Pg 2093-2102.

³⁵U.S. Health and Human Services. Centers for Disease Control, Division of Population Health Website. "Excessive alcohol use and risks to men's health." <<http://www.cdc.gov/alcohol/fact-sheets/mens-health.htm>> (Accessed 4/28/12).

³⁶Breslow, R., Guenther, P., and Smothers, B. (2006) "Alcohol drinking patterns and diet quality: The 1999-2000 National Health and Nutrition Examination Survey." *American Journal of Epidemiology*. 163.4. Pg 359-366.

³⁷U.S. Department of Health and Human Services. Centers for Disease Control and Prevention National Center for Health Statistics Web site. "Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2010." <http://www.cdc.gov/nchs/data/series/sr_10/sr10_252.pdf> (Accessed 4/24/12)

³⁸U.S. Department of Health and Human Services. (2013) Adult Cigarette Smoking in the U.S.: Current Estimate. <http://www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/index.htm#national> (Accessed 12/01/13)

³⁹Haibach, J.P., Homish, G.G., and Goirino, G.A. (published online ahead of print May 12 2012) "A longitudinal evaluation of fruit and vegetable consumption and cigarette smoking." *Nicotine & Tobacco Research*. <http://www.ncbi.nlm.nih.gov/pubmed/22614546>. (Accessed 5/29/12)

⁴⁰Lenz, B. (2001) "The transformation from adolescence to young adulthood: a theoretical perspective." *Journal of School Nursing*. 17.6. Pg 300-306.

⁴¹National Center for Education Statistics Web

site. "Fast Facts." <<http://nces.ed.gov/fastfacts/index.asp?faq=FFOption6#faqFFOption6>> (Accessed 5/29/12)

⁴²Ha, E.J., and Caine-Bish, N. (2009) "Effect of nutrition intervention using a general nutrition course for promoting fruit and vegetable consumption among college students." *Journal of Nutrition Education and Behavior* 41.2. Pg 103-109.

The effect of the Wannsee Conference on Mischlinge experiences

Understanding the impact of the Wannsee Conference through Mischlinge testimonies

**BY ANNE TABB, THOMAS PEGELOW-KAPLAN,
PHD, AND SCOTT DENHAM, PHD
DAVIDSON COLLEGE**

Infamous for the coordination of the Final Solution of the Jewish Question, the Wannsee Conference of January 20, 1942 spent significant time probing the issue of Mischlinge. The latter third of the Wannsee Conference discussed the "...solution of the problem of mixed marriages [Mischehen] and mixed parentage [Mischlinge]." The Reich Citizenship Law of September 15, 1935, one of the Nuremberg Laws, officially defined a Mischlinge as "one who is descended from one or two grandparents who were racially full Jews."² Despite this legal classification, the status of Mischlinge remained a significant debate throughout the Third Reich. At the Wannsee Conference, Reinhard Heydrich, Head of the Reich Security Main Office (RSHA), cited a letter from Hans Heinrich Lammers, the Chief of the Reich Chancellery, as the foundation of this discussion. Heydrich proposed that first-degree Mischlinge, with exceptions, now be treated as "full Jews" and included in the measures of the "Final Solution."³ Dr. Wilhelm Stuckart of the Reich Ministry of the Interior led the opposition to this proposal, pointing out that inclusion with full-Jews would "constitute endless administrative work."⁴ Stuckart instead proposed forced sterilization of Mischlinge of the first degree and the immediate dissolution of mixed marriages. In the end, the Wannsee Conference postponed the decision about what to do to several follow-up meetings. The officials in attendance at these follow-up conferences, however, ultimately further deferred the solution of the Mischlinge debate to after the war.⁵

What did this indecision mean for policy towards Mischlinge? Most historians have argued that little change occurred as a direct result of the Wannsee Conference. Mark Roseman argues policy changes were a result of "signs that Wannsee had indeed changed the climate."⁶ He points to the decision of the "Ministry for the Occupied Eastern Territories ... to treat Soviet Mischlinge as Jews" as the first indication of a "changed climate."⁷ However, he recognizes that the arguments of the Wannsee Conference hardly applied to Russian citizens as they did to half-Germans. James Tent's argument is con-

sequently stronger, identifying actions taken in 1942 against Mischlinge as "evidence ... that Hitler was starting to make common cause more frequently with the Party's fanatical elements from 1942 onward."⁸ Tent identifies this evidence as harsher measures taken against Mischlinge after the Wannsee Conference: "Already in July 1942, Martin Bormann ordered Party officials to take a much tougher line with their political assessments of Mischlinge when the latter applied for exemptions such as marriage, military service, or public employment. Other Party officials such as Hans Heinrich Lammers at the Reich Chancellery and Wilhelm Frick, who headed the Interior Ministry, immediately followed suit, issuing orders to government officials to enforce all regulations against Mischlinge strictly."⁹ These changes, parallel to many of the restrictions imposed upon full-Jews earlier in the Third Reich, were reflective of the shift in policy of 1942 after the debates of the Wannsee Conference. This paper seeks to contribute to the understanding of a changed climate by tying the experience of Mischlinge to the "harsher climate" and the debates at the Wannsee Conference.

Another significant question remains: what did indecision at the Wannsee Conference and follow-up conferences mean for the experience of Mischlinge? Scholars such as Peter Monteath, James Tent, Beate Meyer, and Cornelia Essner have extensively examined the remaining records on Mischlinge to contribute the voices of these victims to the history of policies against half-Jews in the Third Reich. Meyer first looked to oral history as a way to understand the reality of the Mischlinge experience. Scholars after her followed this trend; for example Monteath notes that oral history is crucial to understand what cannot be "recounted adequately by following the paper trail of official documentation alone."¹⁰ Tent agrees on the importance of oral history in his study of the Mischlinge experience, seeking to use testimonies to "expose the sufferings of a category of victims that has largely gone unnoticed in investigations of the Holocaust."¹¹ However, while these studies help explain the Mischlinge experiences follow-

ing the Wannsee Conference, further use of oral testimonies helps specifically explain these experiences in conjunction with the "changed climate" of 1942. The experiences of Mischlinge survivors, recounted in oral history, help us understand the experiences of half-Jews in the wake of the Wannsee Conference. It most often directly affected Mischlinge in cases where they attained special knowledge about high-level discussions, or were, in a very rare case for 1942, affected by a deportation order in the aftermath of these discussions. For others, changes they felt were determined by the Nazi state's fanatical wave of measures instituted after the Wannsee Conference. Finally, many continued to live "unaware that the Wannsee Conference had taken place," and were unaffected by its indecisive discussions.¹²

It is important to consider first the discussions at the Wannsee Conference and follow-up conferences in order to understand the conversations, attitudes, and proposed policies that influenced their tangible experiences. Stuckart's suggestion of sterilization indicated a radicalization of his position. He represented the comparatively cautious Interior Ministry, which had been fighting for a relatively moderate approach to the Mischlinge problem since the Nuremberg Laws and the creation of the Mischling as a legal category. Stuckart's expert on Jewish affairs, Bernhard Lösener, provided him with a document to this effect for the Wannsee Conference "outlining the reasons why the Mischlinge should be protected."¹³ Thus when Stuckart proposed sterilization, Heydrich, in light of the position of the Reich Main Security Office (RSHA), considered this a great victory over the Interior Ministry. Although the Interior Ministry had not conceded that Mischlinge should be classified as so-called full-Jews, the proposal of sterilization appeared to indicate a diminishing of their economic, administrative, and legal qualms with restricting the rights of Mischlinge.¹⁴ Heydrich's organization of the Conference, from the location to the invitation to the opening remarks and follow-up letter, had been created with the goal of once and for all asserting the authority of the RSHA.¹⁵ After Stuckart's

proposal of sterilization, Heydrich felt that he had succeeded.¹⁶

Although Heydrich left the Wannsee Conference proud of a victory over government officials, the issue of so-called Mischlinge was still considered a “theoretical” discussion according to the protocol of the meeting.¹⁷ The participants reached no formal decision and there were many obstacles in the way of official policy, which officials returned to at two follow-up conferences later in 1942. On March 6, members of the RSHA, Party Chancellery, and Reich Chancellery met at the Reich Security Main Office to continue the controversial debate. On the agenda were the administrative obstacles of sterilization, including the “700,000 hospital days” this would allegedly entail for Mischlinge, when these beds were needed for wounded soldiers.¹⁸ Sterilization was deemed unrealistic by the participants unless it was ordered by the Führer, in which case they proposed Mischlinge be concentrated in a special part of a city as had been done with elderly Jews.¹⁹ The issue remained unsettled and thus another conference was called on 27 October in Eichmann’s office (Amt IV B4) of the Reich Security Main Office.²⁰ Here, “voluntary” sterilization was reintroduced as a realistic solution while compulsory sterilization was debated as an issue.²¹ The members of the RSHA, Party Chancellery, and Reich Chancellery decided that in order to create the appearance of voluntary sterilization, Mischlinge would have the “choice” of sterilization or deportation. Making sterilization a requirement for remaining in the Reich and avoiding deportation, they decided, achieved the goal of sterilization without the appearance of force.²² At the conclusion of this meeting, however, the participants had still not settled on any measures and once again deferred to later discussions.

For one group of Mischlinge, the Wannsee Conference and follow-up discussions meant the difference between life and death. After the Conference, on June 8, 1942 Heinrich Himmler, with Hitler’s approval, assumed the role of head of the RSHA.²³ German historian Michael Wildt describes Himmler as “an active director who was able to use the RSHA to realize one of the institution’s genuine objectives: the final solution the Jewish question in Europe.”²⁴ Informed of the discussions at the Wannsee Conference and the recipient of a personal plea for the further delay of Mischlinge sterilization from Lösener on September 10, 1942, Himmler was aware of the harsher climate that had developed.²⁵ Thus, Himmler’s order that German concentration camps achieve the status of “judenfrei” in November 1942 included first-degree Mischlinge.²⁶ Driven by this principle of making Germany free from

Jews, Heinrich Müller, Reich Security Main Office Head of Department (Amt) IV and head of the Secret State Police (Gestapo), sent this decree on to the Gestapo offices in each camp whose officials would organize deportations, making sure to include first-degree Mischlinge in his deportation order. This group constituted the first and “only” Mischlinge killed in the destruction process.²⁷ The inclusion of Mischlinge in the deportations aimed at making concentration camps “free of Jews” indicated that Himmler agreed with Heydrich’s conflation at the Wannsee Conference of Mischlinge with “full-Jews” and sought to take steps towards ridding Germany of any Jewish blood.²⁸

For others living in Germany at the time, official indecision did not mean death, yet they did face increased difficulties. Born in Frankfurt am Main to a so-called Aryan father and Jewish mother, Gerda Leuchtenberg experienced new struggles throughout the Third Reich with her status as a Mischling.²⁹ The Wannsee Conference resulted in Gerda Leuchtenberg’s father, well informed by connections through financial advising for government and industry leaders, sending her to work in a small town in hopes of anonymity.³⁰ In return for his much-needed services, these officials provided Leuchtenberg’s father with relevant and updated information on the Nazi Party’s anti-Jewish policies. This allowed her father to “forewarn his Jewish wife and Mischling daughter of trends that might affect them.”³¹ Thus, in 1942 Gerda Leuchtenberg’s father was informed that the “persecution of Jews and Mischlinge would only worsen.”³² Gerda Leuchtenberg was consequently sent by her father to work as a chemist’s assistant in a small city near the Swiss border, where her status as a Mischling was not known. The Wannsee Conference, thus, ironically changed Leuchtenberg’s life for the better, at least for the time being, by giving Leuchtenberg’s father the foresight to send her to a place out of grips of the authorities.

Awareness of the discussions at the Wannsee Conference and follow-up conferences was rare and required privileged connections, as in the case of Gerda Leuchtenberg. Most German citizens at the time, however, witnessed the fate of “full-Jews.” On July 2, 1942 Victor Klemperer, a convert to Christianity whom the regime had deemed a “full Jew,” recalled in his diary, “the removal of the old people’s home to Theresienstadt brutal. Truck with benches, crowded together, only the tiniest bundle could be taken, cuffs and blow.”³³ The awareness of the fate of Jews was even more prevalent among their Mischlinge relatives. One Mischling, Jutta Rose, recalled in an interview “I hid behind my mother” as they beat her

father and dragged him away from their family living room for deportation to Buchenwald.”³⁴ Marian Kaplan examines the recollection of a Mischling who discussed, as did many Mischlinge throughout the war, how he coped with awareness of the deportation of relatives with denial: “... later we said, ‘Well, they don’t write, but let’s hope they are well.’ But everybody knew they weren’t being sent to a work camp. Everybody was lying to each other and nobody admitted the truth. But everybody knew.”³⁵

This awareness meant that throughout 1942 so-called Mischlinge were frightened by the harsher measures implemented against them. Scholars thus far confirm what Tent describes as “a series of ominous government directives circulated periodically after Wannsee about Mischlinge that, despite objections from the Interior Ministry, set them on the same downward spiral that had led to the isolation, incarceration, and murder of full Jews.”³⁶ Raul Hilberg agrees with Tent, stating that although “Mischlinge were neither deported nor sterilized,” the months after the Wannsee Conference showed that “the anti-Mischling restrictions were somewhat intensified. For example, in the fall of 1942, the Education Ministry issued some elaborate regulations for the admission of Mischlinge to schools.”³⁷ Jeremy Noakes affirms the statements of the other two scholars, “the increasingly hard line toward the Mischlinge, which Hitler adopted in the spring and summer of 1942, was quickly reflected in a stream of official measures which added to the restrictions under which they suffered.”³⁸

This wave of measures made exemptions, education, and some forms of employment more difficult for Mischlinge to obtain in the months immediately following the Wannsee Conference. Although neither Heydrich nor Stuckart succeeded in implementing their proposed measures, Nazi officials, based on the discussions at Wannsee, instituted more restrictive measures against Mischlinge. The first of these appeared in June 1942. On June 22, a decree from the Ministry for Science, Education, and Public Instruction required Mischlinge to submit a special application for admittance to universities.³⁹ This was the first update by the Ministry for Research and Education to standing guidelines on “admission of Jewish-Mischlinge to University studies” from October 25, 1940.⁴⁰ State Secretary Werner Zschintzsch opened the memo with the statement that these new post-Wannsee guidelines are “in agreement with the leader of the Party Chancellery.”⁴¹ The leader of the Party Chancellery, Martin Bormann, was represented by his deputy for the Party Chancellery, Nazi Party Chancellery Permanent Secretary Dr. Gerhard Klop-

fer, at the Wannsee Conference.⁴² The next day, June 23, another notice from Martin Bormann made exemptions for those remaining in the Wehrmacht increasingly difficult to obtain, now requiring recommendations from the Party.⁴³

In the following month, this wave of measures continued. On July 1, in a notice from Hitler, Mischlinge in the municipal police (Schutzpolizei) were required to retire.⁴⁴ The following day, a decree from Reich Education Minister Bernhard Rust stated, "Mischlinge of the first degree are no longer to be enrolled in basic schools, training schools, and other advanced secondary schools."⁴⁵ Trade schools now required special permission for acceptance.⁴⁶ The measure also noted that it remained "in agreement with the leader of Party Chancellery and the Reich Minister of the Interior."⁴⁷ The Party Chancellery and the Reich Ministry of the Interior were represented at the Wannsee Conference by Klopfer and Stuckart, respectively.⁴⁸ This decree was distributed widely, to the education administration officials in the former Reich and into the new territories in the East including Austria, Bohemia and Moravia.⁴⁹ On July 3, a memo from Party Chancellery head Bormann explicitly stated, "viewing Mischlinge as having equal rights as German-blooded people must be avoided. In the future each case will be decided by the Führer."⁵⁰ Two men with Mischlinge status, Horst Hartwich and Ludwig Joseph, discussed in oral testimonies the influence of the July 2, 1942 measure from the Minister of Education, Bernhard Rust, on their lives.

Hartwich was born in Berlin to a Jewish pharmacist father and an "Aryan" mother.⁵¹ In the summer of 1942, 15-year old Hartwich was giving a presentation for Dr. Ratloff's class on Goethe and after fumbling his words, his teacher told him to not speak "with Jewish hastiness."⁵² Although Hartwich offers few details on this incident, he alleges that his teacher did not intend to offend. In fact, according to Hartwich's recollection, this teacher apologized after class for forgetting the student's partially Jewish background. This recognition of his then-non-Jewish status in 1942 was one of his last interactions with a teacher in his secondary school. A few weeks after the incident, the director of his school informed Hartwich of his expulsion from Lessing Gymnasium. The July 2 measure abruptly ended Hartwich's education at the age of 17.

Ludwig Joseph's education was also abruptly halted after the July 2, 1942 measure. Ludwig Joseph was born February 24, 1927 to a Jewish orthopedic surgeon father, Ernst Joseph and Protestant Mother, Herta Joseph.⁵³ Joseph recalled that "I went to school until July 1942; at the end of that school

year there was a new directive from the Nazi Education Department that anybody who is half Jewish can no longer attend a secondary or high school, in fact, any school—not even grade school." It is unclear from his 1996 interview if Ludwig Joseph was aware of this directive from Bernhard Rust at the time of his expulsion. Notwithstanding, at the time of his interview, Joseph identified the measure of July 1942 as the cause of his removal from school. Upon leaving school Joseph wondered—"what do I do for the rest of my life when I need an education?" Then he realized he had no options, that the Ministry of Education had closed the doors of his dreams. Like Horst Hartwich, Ludwig Joseph's fate had been decided in the directives in 1942.

Two half-Jewish women who saw no immediate change after the Wannsee Conference were Cecile Hensel and Jutta Rose. Both these women completed their formal secondary education by 1942, escaping the July 2, 1942 measure which resulted in Hartwich and Joseph's expulsion. Without access to privileged knowledge, like Leuchtenberg's father, they remained unaware of the discussions at the Conference. These two women, outside of the categories affected by the follow-up measures of 1942, and without privileged knowledge, continued living unaware and unaffected.

Cecile Hensen was born to a Jewish mother and Protestant father, a local bureaucrat in the town of Laden.⁵⁴ Hensen, an auditing student, managed to escape the influence of the measures. According to the Zschintzsch memo of June 22, 1942, which overturned earlier guidelines allowing auditors who were Mischlinge of the first and second degree, Hensen should have been removed from school.⁵⁵ However, her experience shows that not all Mischlinge were immediately affected by the measures implemented against them. That year, Hensen wrote a paper for Professor Baron Polnitz on the resistance fighter Wallenstein in the play by the German classicist Friedrich Schiller. Her professor asked if it was wise for her to write a paper on this topic considering her Mischling status. Aware of the Third Reich's anti-Mischling policies, Hensen stated "if the Nazis win the war it will not matter because they will kill me, and if they lose it will not matter, because I will no longer be a second-class citizen."⁵⁶ As a result of this awareness, Hensen continuously attempted to conceal her identity and make friends who could use connections in the local Gestapo to aid her in a compromised situation.

Jutta Rose was born in Hanover, Germany on January 17, 1918 to a mixed marriage between a Protestant mother, Franziska Rose and Jewish father, Fritz Rose. Despite their

religious affiliation, she received little formal religious exposure.⁵⁷ In 1942, Rose was 24 and successfully finished with her secondary education. Rose continued her life in a Berlin apartment she shared with friend, Hilde. Rose's aunt was able to help support her economically, allowing Rose freedom from the necessity of employment while living in Berlin. Rose met a young art student, Henri Nannen while he was visiting Berlin in the summer of 1939 and carried on a romantic relationship throughout the war. They corresponded continuously between Berlin and his home in Munich despite Rose's statement, "I gave witness to him that he was an ardent Nazi."⁵⁸ Henri Nannen famously founded Stern in 1948, becoming an important figure in the media of the Federal Republic after the war. Moishe Postone discussed an editorial after the war in which Henri Nannen condemned "himself for knowing and not acting, and even continuing to wear a Luftwaffe uniform with pride."⁵⁹ Although this does not confirm Rose's statement that he was in fact a member of the Nazi Party, he reflected after the war his own role as involved with the Nazi government from the Luftwaffe and furthermore an aware bystander. Rose recalled that throughout their relationship she felt comfortable talking to him about politics, even telling him that she would not visit him in Munich where she might encounter that "bastard Hitler."⁶⁰ In addition to this risky relationship with an alleged Nazi, Jutta took private lessons with a music teacher, Professor Elke, at his home in Wannsee twice a week in 1942. Despite this ironically disturbing proximity to the location of the Wannsee Conference, Jutta Rose's experience from 1942 remained unaffected by the Conference's debate.

Scholars on the whole conclude that most Mischlinge owe their survival to Hitler's indecision, although the Mischlinge experience shows that this survival often constituted considerable hardships. Tent points out that in a letter to Himmler on the final solution of the Mischlinge issue, Stuckart discussed the effect of public morale of "Aryan" relatives and option of sterilization, and "concluded by proposing that Hitler alone should decide the issue."⁶¹ This mention of Hitler was meant to deliberately delay the issue, based on knowledge that "Propaganda Minister Goebbels continued to worry about public morale."⁶² These concerns fueled Hitler's unwillingness to decide upon the fate of Mischlinge in regards to the Final Solution. Roseman agrees that the Mischlinge matter remained in abeyance partially because of the indecision between officials at the Wannsee Conference, but above all, "Hitler's unwillingness to tackle the matter in wartime that decided the matter."⁶³ Meyer confirms

this hypothesis, arguing that in regard to Mischlinge "Hitler was asked to find a solution, but he postponed making a decision until after the war. The majority of people in mixed marriages owe their lives to the fact that this decision was deferred."⁶⁴ Despite this agreement by scholars, the Mischlinge experiences expose that although Hitler did not decide to include Mischlinge in the Final Solution in 1942, many were directly, or indirectly, affected by the measures that followed the Conference, with an overall continuum of varied degrees of change.

Survival after the Wannsee Conference, as the integration of oral testimonies expose, was manifest in a wide variety of tangible experiences of Mischlinge. For Mischlinge imprisoned in concentration camps in 1942, the "changed climate" led to their inclusion in deportation to extermination camps. For Gerda Leuchtenberg, it meant fleeing to a small town where her Mischlinge status was unknown. For Horst Hartwich and Ludwig Joseph, the wave of fanatical measures after the Wannsee meeting meant expulsion from not only secondary schools, but options for future employment, which rested on the foundation of education. Fortunately for Cecile Hensen and Jutta Rose, survival after Wannsee meant a cautious continuation of their lives. For all Mischlinge, however, survival was constantly plagued by fear. Witnessing the fate of their Jewish relatives, like Jutta Rose, or observing the fate of Jews and Mischlinge, like Victor Klemperer, created a suffocating atmosphere of fear for those aware their Jewish ancestry. As Cecile Hensen wrote in a poem during the years of the Third Reich: "They did not arrest me. They did not beat me. I made it through. I know, I was lucky. It was the naked fear that I could hardly bear. It ate me up. Bit by bit."⁶⁵ After the Wannsee Conference, "lucky" Mischlinge survived due to the indecision of the Nazi leaders. However, the reality of this constantly fearful survival ranged a wide spectrum of experiences. Understanding this spectrum of experiences exposes the ominous Mischlinge debate at the Wannsee Conference and the tangible changes it meant for those living with follow-up measures, awareness of debates, or for others, ignorance.

Acknowledgments

I am grateful to the German Academic Exchange Service, the Davidson Research Initiative, and the Dean Rusk International Studies Program of Davidson College, NC, for financing the archival research in Germany on which my paper is based. I owe much appreciation to my two Professors, Dr. Pegelow-Kaplan and Dr. Denham for assisting me through this research project. Additional thanks to Dr. Denham for his translation

work. My classmates in History 433 were a great help in their extensive commentary on various drafts of this piece. I am also grateful for the assistance of Robert Dalton, Assistant Head, Research and Instructional Services, Davis Library, University of North Carolina, Chapel Hill and Martina Böhm of the Hauptstaatsarchiv Stuttgart.

References

- ¹"Protocol of the Wannsee Conference." Haus der Wannsee Konferenz. <<http://www.gwhk.de>>. (02/06/2012).
- ²Noakes, J. and Pridham, G. (1998). *Nazism, 1919-1945*. University of Exeter Press. Pg 344.
- ³Ibid.
- ⁴Ibid.
- ⁵"Translation of Document No. NG-2586 from the Foreign Office (21 March 1942) DIII 294 g Rs." Printed in Mendelsohn, J. (1982). *Legalizing the Holocaust: The Early Phase, 1933-1939*, Vol. 11. Garland Publishing. Pg 223.
- ⁶Roseman, M. (2003). *The Wannsee Conference and the Final Solution: A Reconsideration*. Picador/Metropolitan Books. Pg 146.
- ⁷Ibid.
- ⁸Tent, J. (2003). In the shadow of the Holocaust: Nazi persecution of Jewish-Christian Germans. University Press of Kansas. Pg 146.
- ⁹Tent offers these examples: "Any applications by Mischlinge seeking exemptions from the Reich Citizenship Law were to be terminated immediately. It was at this time that the Party banned Mischlinge from attending Gymnasiums and other elite secondary schools." Ibid. Pg 146-47. Tent's claim that these changes began in July is not exactly accurate, however. In the Education Ministry memo of 22 June 1942, state secretary Werner Zschintzsch remarked on an "agreement with the leader of the Party Chancellery" Bormann. Clearly the climate was changing already in mid-June. The distribution notes on the copy received by the Ministry of Culture and Education in Karlsruhe demonstrate that the new guidelines were distributed already by July 3. Werner Zschintzsch (Reichsministerium für Wissenschaft, Erziehung und Volksbildung. (22 June 1942) "Memo to State Ministries of Education and Research Administration Offices (Betrifft Zulassung von jüdischen Mischlingen zum Hochschulbesuch)." Hauptstaatsarchiv Stuttgart. EA 99/ 001 Bu 250.
- ¹⁰Monteath, P. (2008). The "Mischling" Experience in Oral History. *The Oral History Review* 35.2. Pg 140.
- ¹¹Tent. Pg 1.
- ¹²Tent. Pg 145.
- ¹³Roseman. Pg 142. Additionally, Thomas Pegelow-Kaplan cites a statement by the Lösener-Knost 1942 commentary on the Nuremberg Laws that racial legislation up to that point had "once and for all" drawn the line between Jew and Mischlinge. Yet Pegelow-Kaplan comments that this was an unsuccessful attempt by the racial experts of the Interior Ministry to establish finality in the debate when in reality they could not "encompass the myriad different cases of people's imagined racial descent." Pegelow, T. (2009). *The Language of Nazi Genocide: Linguistic Violence and the Struggle of Germans of Jewish Ancestry*. Cambridge University Press. Pg 172.
- ¹⁴Noakes, J. (1989). The development of Nazi policy towards the German-Jewish "Mischlinge" 1933-1945. *The Leo Baeck Institute Yearbook* 34.1. Pg 313.
- ¹⁵Tent. Pg 121.
- ¹⁶Sterilization was a familiar tactic to those present at the Wannsee Conference. Hitler introduced compulsory sterilization of those with hereditary diseases just months after taking the position of chancellor. Friedländer, S. (2007). *The Years of Extermination: Nazi Germany and the Jews, 1939-1945*. Harper Collins Publishers. Pg Leading up to the Conference, steriliza-

tion had been discussed in conjunction with the Mischlinge issue in 1941 between the Reich Chancellery and the Ministry of Justice. Dr. Heinrich Gross stressed to Reichsminister Lammers the "necessity for sterilizing persons of mixed blood of the 1st degree" to prevent a new generation of second degree Mischlinge. Dr. Walter Gross reported that Lammers was "positively in favour" of this sterilization proposal. Office of Chief Counsel for War Crimes. U.S. Army APO 696-A, Document NG-978. (2 October 1941) Minutes of the Consultation with Reichsminister Lammers. Printed in Mendelsohn. Pg 284-5.

¹⁷"Protocol of the Wannsee Conference."

¹⁸Summary of measures to be taken against partly Jewish people. (March 6, 1942; June 11, 1942) Conference at the Reich Main Security Office. Printed in Mendelsohn 11. Pg 193.

¹⁹Theresienstadt was an example of ghettos for the elderly.

²⁰This second follow-up conference was not the next time the Mischlinge issue was discussed in 1942. For example, on March 16, the Reich Minister of the Interior discussed how the Führer could in some cases reclassify "valuable" Jews as Mischlinge and valuable "half-Jews" as "persons of German blood." The letter goes on to say in cases where the Führer did not reclassify half-Jews as "persons of German blood," they should be given the option of sterilization in order to remain in the Reich. (March 16, 1942) Letter from the Reich Minister of the Interior dated 16 March, 1942. Printed in Mendelsohn 11. Pg 197-200.

²¹Noakes attributes this reintroduction as a result of the "experiments with X-rays which were being carried out in concentration camps." Noakes. Pg 347.

²²(October 27, 1942) Minutes of a meeting of Amt IV B4 (Eichmann's office) in the Reich Security Main Office on the treatment of partly Jewish people. Printed in Mendelsohn, 11. Pg 129-133.

²³Wildt, M. and Lampert, T. (2009). *An Uncompromising Generation: The Nazi Leadership of the Reich Security Main Office*. University of Wisconsin Press. Pg 341.

²⁴Ibid. Pg 347.

²⁵Raul Hilberg discusses this plea: "Lösener wrote his letter around September 10, 1942, and addressed it to Himmler. He repeated all the arguments that Stuckart had enumerated... Lösener admitted that sterilization was not feasible during the war. After all, he consoled Himmler "one cannot rectify errors and sins committed during the last 200 years in one day." But after the war the sterilizations could be carried out easily." Hilberg, R. (1985). *The Destruction of the European Jews*. Holmes & Meier Publishers. Pg 242.

²⁶Ibid. Pg 454.

²⁷Ibid.

²⁸Heydrich was shot by Czech resistance fighters on May 27, 1942 outside of Prague and died of injuries on June 4, 1942. Himmler and Heydrich worked closely together in 1942. For example, they communicated about Operation Zeppelin, "Heydrich approved Gräfe's plan and forwarded it to Himmler, who in turn decided to present it to Hitler on January, 1942." Wildt. Pg 335-340.

²⁹Ibid.

³⁰(28 June 1994) Interview with Gerda Leuchtenberg by James Tent. Printed in Tent. Pg 93-94.

³¹Ibid.

³²Ibid.

³³Klemperer, Victor. (2001). *I Will Bear Witness: A Diary of the Nazi Years 1942-1945*. Random House Press. Pg 90.

³⁴Pozzi-Tha, Elisabeth. (March 26, 1998) "Interview with Jutta Rose." *Survivors of the Shoah Visual History Foundation*.

³⁵Kaplan, M. (1998). *Between Dignity and Despair: Jewish Life in Nazi Germany*. Oxford University Press. Pg 196.

³⁶Tent. Pg 146.

³⁷Hilberg. Pg 425.

³⁸Noakes. 349.

³⁹Werner Zschintzsch (Reichsministerium für Wissenschaft, Erziehung und Volksbildung). „Memo to State Ministries of Education and Research Administration Offices, 22 June 1942, Betrifft Zulassung von jüdischen Mischlingen zum Hochschulbesuch.“ Hauptstaatsarchiv Stuttgart, EA 99/ 001 Bü 250. Translated by Scott Denham.

⁴⁰Ibid.

⁴¹Ibid.

⁴²“The Participants of the Conference.” Haus der Wannsee Konferenz. <<http://www.ghwk.de>> (February 6, 2012).

⁴³Walk, Joseph (1981). Das Sonderrecht für die Juden im NS-Staat: Eine Sammlung der gesetzlichen Massnahmen und Richtlinien, Inhalt und Bedeutung. Müller Juristischer Verlag. Pg 378-79. These exceptions parallel exceptions for university students from Zschintzsch’s memo on June 22, 1942, which stated that those Mischlinge who were granted exceptions to be in the Wehrmacht were allowed to study. This indicates coordination between the Party Chancellery and the Ministry of Education on exceptions for Mischlinge. Translated by Scott Denham.

⁴⁴Ibid.

⁴⁵Bernard Rust (Reichsministerium für Wissenschaft, Erziehung und Volksbildung). (2 July 1942). “Memo to State Ministries of Education, Education Administrators of the Reichsgaue and the new territories of Danzig-West Prussia, the Wartheland, and Sudetenland, including Prussian Education Offices, as well as for information to the Reichsprotektor in Bohemia and Moravia. Betrifft Zulassung jüdischer Mischlinge zum Schulbesuch.” Hauptstaatsarchiv Stuttgart. EA 99/001 Bü 250. Translated by Scott Denham.

⁴⁶Ibid.

⁴⁷Ibid.

⁴⁸“The Participants of the Conference.”

⁴⁹Bernard Rust. (2 July 1942) Memo to State Ministries.

⁵⁰Ibid.

⁵¹Horst Hartwich. “Unpublished memoir of his youth.” Cited with permission of the author in Tent. Pg 35.

⁵²Ibid.

⁵³Averick, Leah. (December 17, 1996). Interview with Ludwig Joseph by Leah Averick. Survivors of the Shoah Visual History Foundation.

⁵⁴Gelbi, Cathy. (1990) “Interview with Cecile Hensen” Recording held in the Yale Fortunoff Archive, accessed at The Memorial to the Murdered Jews of Europe. Translated by Scott Denham.

⁵⁵Werner Zschintzsch. (June 22, 1942) Memo.

⁵⁶Interview with Cecile Hensen.

⁵⁷Interview with Jutta Rose.

⁵⁸Ibid.

⁵⁹Postone, M. (1980) “Anti-Semitism and National Socialism: Notes on the German Reaction to ‘Holocaust.’” *New German Critique* 19. Pg 99.

⁶⁰Ibid.

⁶¹Tent. Pg 146.

⁶²Tent. Pg 146.

⁶³Roseman. Pg 147.

⁶⁴Beate Meyer. (2000) “The Mixed Marriage: A Guarantee of Survival or a Reflection of German Society during the Nazi Regime?” from David Bankier. *Probing the Depths of German Antisemitism: German Society and the Persecution of the Jews, 1933-1941*. Berghahn Books, 2000. Pg 62-63.

⁶⁵Interview with Cecile Hensen.

Walking through the valley: Margaret Gower's grief journey in Gail Godwin's *Father Melancholy's Daughter*

By COURTNEY BIDWELL

INDIANA WESLEYAN UNIVERSITY

Before Elisabeth Kübler-Ross's 1969 seminal work, *On Death and Dying*, most people knew very little about the mental, psychological, emotional, and spiritual effects of impending death on terminally ill patients. Her years of research and subsequent publications gave the world one of the first models of grief that did not attempt to oversimplify the complex process. She noted that many patients went through the same five phases when they found out they were dying: denial, anger, bargaining, depression, and acceptance. Shortly before she died, Kübler-Ross co-authored *On Grief and Grieving*, a book that relates the five stages of dying she establishes in *On Death and Dying* to those grieving the loss of a loved one. The same stages of grief terminally ill patients experience (denial, anger, bargaining, depression, and acceptance) also apply to the people they leave behind. Depending on the individual and the circumstances of the loss, some skip stages, some change the order, some keep returning to certain stages, some move quickly, some take years.¹ Kübler-Ross's work quickly became a constructive text for understanding the dying and forced a culture that would rather avoid thinking about death to confront common fears and misconceptions about dying.

Gail Godwin may have been familiar with Kübler-Ross's work with dying patients, but when she published *Father Melancholy's Daughter* in 1991, *On Grief and Grieving* was fourteen years away from publication. Although Godwin could not have read Kübler-Ross's last book before writing her novel, her protagonist, Margaret Gower, experiences each of the five stages of grief after her mother deserts her. While the stages of grief that Margaret undergoes are typical, the circumstances that surround and affect each stage are unique to her situation. By showing both the universality and individuality of Margaret's grief journey, Godwin both presents a picture of grief with which readers can identify and respects the unique and personal nature of every grief process.

When Margaret Gower is six years old, her mother Ruth leaves the family for a short vacation, which becomes an extended absence, which becomes a semi-permanent living situation, which does not end until she dies in a car accident. After a living through a year of her absence, her husband and

child are left to wonder whether she would have ever returned to them. To keep Ruth's memory alive, Walter and Margaret share stories, relive moments from the past, visit her grave every Sunday, and rely on each other for companionship.

Margaret's immediate reaction to the news that her mother has gone on vacation corresponds to the first stage of grief: denial. As a "temporary defense," denial is natural and healthy, so it is understandable that Margaret cannot initially believe her mother is gone.² Thinking "she hadn't heard him right," she asks Walter for clarification: "You mean she's not in the house?"³ One manifestation of denial is questioning the reality of the situation.⁴ Even after Margaret's father explains when Ruth left, why Ruth left, with whom Ruth left, and where Ruth is going, Margaret can still picture what Ruth would see if she were watching them from the upstairs window, where Margaret had assumed she was. Although Margaret is intelligent enough to realize that her mother cannot be in two places at once, she still thinks, "It was as though she, who was 'past Washington by now, depending on the traffic,' was also still here."⁵ Her inability to picture her mother as gone is a normal part of the denial stage. Kübler-Ross distinguishes between denying the event happened and the inability to fully realize the significance of the event.⁶ She argues that the denial stage of grieving is focused more on the latter.⁶ Margaret fits this definition because she is unable to completely comprehend the consequences of the information her father gives her.

But because the grieving process is not always simple, Margaret's next actions defy the easy explanation of denial. Godwin introduces her readers to the fluidity of the grieving process by describing Margaret's temper-tantrum-like actions following Walter's news. Margaret's actions are a perfect example of anger, the second of Kübler-Ross's grief stages. She is shocked at the news of Ruth's departure, but becomes angry that Walter withheld the news for as long as he did: "all the time he had been walking along mouthing those 'ah's and 'nnn's and 'ow's so enthusiastically, he had been saving up this thing to say."⁷ According to Walter, Margaret "turned into a little whirling fiend and started slinging [her] backpack at him and hitting his Legs."⁸ She "tore up [her] phonetics paper,"

which she had so proudly been showing off only minutes before, "and stamped on the pieces."⁹ Margaret acts out in anger only moments after her initial feelings of denial, illustrating that grief is not a simple, orderly process; she experiences the stages of denial and anger almost simultaneously. When Margaret reacts violently against her father and her paper, she is expressing her anger at "this unexpected, undeserved, and unwanted situation."⁷ According to Kübler-Ross, "anger is a necessary stage of the healing process" even though in Margaret's situation it proves uncomfortable for her father.⁷

By the time Margaret narrates another flashback of her past, the reader has learned that Ruth dies in a car accident before returning to her family. Even though the reader is aware of the devastation looming in young Margaret's future, the young Margaret herself is unaware of this impending doom. Thus, her feelings and actions must be understood as her response to Ruth's abandonment, not Ruth's death. Margaret is aware only of the desertion, which she continues to believe is temporary—another manifestation of denial.⁴ Even though she has already acted in anger, Margaret retreats again to a state of denial later that same evening. To reassure herself of the temporariness of Ruth's absence and to justify her denial, Margaret eavesdrops on her father as he admits the vestry into their house for their monthly meeting. In the hopes of learning more about her mother's disappearance and deciphering whether she should be alarmed, Margaret carefully listens to and analyzes the way Walter greets "each vestry member at the front door and how he would explain about Ruth's Vacation."⁸ After being "somewhat reassured by the vestry's reaction," Margaret begins searching her mother's room for more calming evidence.⁹ When she finds Ruth's favorite dress still hanging in the closet, she reassures herself that "the trip to New York couldn't be that important to her if she'd left her best dress at home."¹⁰ According to Kübler-Ross, the way Margaret "explore[s] the circumstances surrounding the loss" and allows "the finality of the loss" to begin to sink in represents a movement away from the denial stage of grief.¹¹

Margaret's conversations with Ruth over the phone also help to move her away from the denial stage of grief, but the lack of

communication between her and her mother becomes a source of anger. Although Margaret had previously “been able to receive [the tone of] these latent communications... in another medium than words,” she now cannot understand her mother’s subtextual messages.^{12,13} Ruth still tries to communicate with Margaret “on more than one level,” but Margaret can no longer understand.¹² Margaret buckles under the pressure of her mother’s demands for forgiveness and permission, only visible in “the tone behind her words.”¹² During the first few phone calls, Margaret admits that she “had broken down... and asked her when she was coming back.”¹² Ruth cannot give the concrete answers Margaret desires; instead, she says she “wished [Margaret] were a little older” so they could “talk about all this better.”¹² Although Margaret does not understand why, this statement makes her nauseous and eventually leads her to stop asking Ruth when she is coming back. Ruth and Margaret’s failure to effectively communicate after Ruth leaves is a circumstance specific to Margaret’s situation and affects the way she grieves.

The first phone call between mother and daughter begins a pattern of frustration and anger that many of their later conversations follow: Ruth tries to please Margaret but speaks in a subtextual language her daughter cannot understand, and Margaret makes futile attempts to find the words that will bring her mother home.¹³ In this first long-distance conversation, Margaret cannot talk to her mother, even though a part of her wants to. When Ruth asks her a question, Margaret feels “very constricted in [her] chest” and is “suddenly very angry.”¹⁴ Margaret does not fully understand her anger, but she knows it makes her and her mother uncomfortable. During most of the conversation, she feels that “a contrary demon” prevents her from speaking.¹⁴ Even though Walter tries to make up for his daughter’s sullen quietness, Ruth can sense Margaret’s anger.

This anger does not abate in subsequent conversations. Margaret is torn between her need for her mother and the anger she feels at being abandoned: “As much as I needed for her to come back, I dreaded our sessions on the phone; I grew to hate them.”¹² The unresolved anger and tension between Ruth and Margaret continue to escalate, Ruth growing “colder and more impatient” and Margaret becoming “more sullen and resentful and monosyllabic.”¹² Margaret resigns herself to the idea that Ruth is not coming back right away and stops begging her to come home. She is now fully entrenched in the anger stage of grief.

Like many who are grieving, Margaret again begins to experience two stages at once.

Although she still feels angry, her actions show that she has also entered the bargaining stage. Bargaining is a helpful coping method because it “allows us to believe that we can restore order to the chaos that has taken over.”¹⁵ The strongest examples of Margaret’s bargaining occur on the first two major holidays Ruth misses— Christmas and Easter. When Ruth sends Margaret and Walter Christmas presents from New York, Margaret leaves them sitting under the tree as part of the “magic bargain” she makes “when the presents started to arrive.”¹⁶ According to this bargain, if Margaret does not open her presents early, but instead leaves “them lying untouched in their sinister out-of-town papers, right up until Christmas morning... until Christmas *AFTER MASS*, then [Ruth] would have to come back.”¹⁶ Because she has not yet left the magical thinking of her youth behind her, Margaret holds herself responsible for everything that happens in her world, including whether or not her mother will come back.¹⁷ For this reason, she feels “a pang” when Walter starts to unwrap his gift early.¹⁶ Margaret worries that his “inability to hold out until Christmas morning, Christmas morning *after Mass*” would “cancel [her] bargain.”¹⁶ Although Margaret firmly holds to her resolution and does not open her Christmas presents early, she does not tell either of her parents about her secret bargain. Therefore, Margaret is appalled and embarrassed when Walter guesses her secret and tells Ruth, “She hasn’t opened them yet. I think she’s been having a little game with herself. You know, hoping you’d be back in time to open them with her.”¹⁸ Margaret immediately responds “I was not!” and wonders “How had he known this? And, even if he had guessed it, why had he betrayed me?”¹⁸ In this instance, Margaret is angry at the failure of her bargain and at her father for exposing her to Ruth.

Margaret’s first bargain not only fails to bring Ruth home, but also alienates her further. Despite this unsuccessful outcome, Margaret again thinks in bargain language when Easter approaches. While trying to convince Ruth to make the Golden Easter Egg, a duty that has always belonged to the rector’s wife, she holds herself responsible for Ruth’s actions.^{19,20} After months of tense phone conversations, anger, and confusion, Margaret still believes her words have the power to make Ruth come home: “It was like in a fairy tale. If I came up with the right password, the magic kingdom was mine. If I didn’t, I would lose everything.”²¹ But even though Margaret finds the right words and keeps her side of the bargain, Ruth does not return home. Finally, Margaret stops making bargains, stops trying to convince her mother to come home, and starts realizing how much

she misses her. For example, she describes a “dull ache” that has become inseparable from the corner where she said goodbye to her mother.²² Margaret describes this ache as “always there, even when I was preoccupied with other things.”²² The sadness that surrounded a Christmas without Ruth slowly gives way to the solemnness of the Lenten season. Margaret appreciates this time of the year because “it was okay to be sad, it was *comme il faut* to go around looking pensive and downcast.”²² Even a child as resilient and precocious as Margaret is not immune to the stages of grief. From the time Ruth deserts Margaret until Walter dies sixteen years later, Godwin gives the reader no indication that Margaret has begun to accept her mother’s abandonment. Margaret remains in the first four stages of grief, primarily depression, for over sixteen years.

After Ruth left, Margaret took over the duty of helping Walter fight his bouts of clinical depression, and as she gets older, Margaret often finds herself fighting the “absence of all energy and desire” and feeling “pregnant with nothing, angry at nothing; simply impotent and without desire.”²³ Ultimately, Margaret begins to wonder if she herself will eventually succumb to the Black Curtain of depression: “I breathed in and out and waited for the feeling to pass. It always did. Though maybe as I got older it would last longer, and one morning I would awake to find myself behind the Black Curtain like my father.”²³ Had Margaret looked at the statistics of motherless daughters, she would have been further disappointed: psychologists have now proven that “the loss of a mother before the age of 17, by death or separation [is] highly associated with clinical depression.”²⁴ Margaret struggles with feelings of depression into her early adulthood.

Walter’s sudden death and her renewed relationship with Madelyn Farley are the catalysts that force Margaret to confront and cope with the emotions she has repressed since Ruth’s abandonment. According to Zlater, this kind of delayed mourning is normal for motherless daughters. Walter’s death is “another traumatic event in the life of the mourner” that triggers “a release of feelings that have been repressed or denied or both for many years.”²⁵ When her father dies, Margaret spends weeks alone in the house, reflecting on her life and the lives of her parents. During this time, readers see Margaret beginning the process of grieving her father, but also moving forward in grieving her mother. For example, before Walter died, he and Margaret had often read Ruth’s letters in an attempt to keep her memory alive, to keep themselves an intact family. While this may have been helpful for Margaret at the

time, she now needs to remove herself from their story and realize that she is a separate person. When Margaret now reads the love letters from Ruth to Walter, she feels she is “finished with something.”²⁶ She recognizes that these letters represent “their story,” not hers, because she has finally reached the stage in the grief journey where she can detach herself from her parents’ story enough to realize that it does not have to define her.

The other catalyst that triggers Margaret’s move toward acceptance is her reunion and frank conversations with Madelyn Farley. Margaret acknowledges that she and her father had “hollowed out a place for [Ruth] and kept it raw and deep with... unanswered questions.”²⁷ When Margaret meets Madelyn again for the first time since she left with Ruth, Margaret is determined to “get everything [she] could out of Madelyn Farley concerning this complex woman who had been [her] mother” because there were yet “knots to be untied” and “secrets to be revealed.”²⁸ She openly asks the questions she and Walter had long pondered, to which Madelyn responds, “Look, I have the uncomfortable feeling I’m going to be breaking down some illusions, but you’ve been asking straight questions and I’m going to give you straight answers.”²⁹ Talking with Madelyn allows her to accept her mother as a complex individual, capable of both good and bad, which in turn enables her to accept Ruth’s abandonment in a way she was previously unable to do.

The sense of “emotional detachment and objectivity” that Margaret exhibits in regards to her parents’ relationship and her new knowledge about Ruth is specific to the acceptance stage, the final stage of the grieving process.³⁰ This stage does not mean that Margaret likes the situation; rather, acceptance is “about acknowledging all that has been lost and learning to live with that loss.”³⁰ At the end of the novel, Margaret is just beginning to accept the loss of her parents. As Kübler-Ross is careful to point out, “[a]cceptance is a process that we experience, not a final stage with an end point.”³¹ Margaret is not finished grieving the loss of her mother or her father, but she is finally able to recognize her losses for what they are and admit the reality of her life.

Elisabeth Kübler-Ross, while affirming that most people move through the same five stages of grief, is also clear that these five stages are not always experienced in a uniform, methodical way: “People often think of the stages as lasting weeks or months. They forget that the stages are responses to feelings that can last for minutes or hours as we flip in and out of one and then another. We do not enter and leave each individual stage in a linear fashion. We may

feel one, then another, and back again to the first one.”³² *Father Melancholy’s Daughter* is the story of one individual character, her specific situation, and the growth that results from her journey through the grieving process. The brilliance of Godwin’s portrayal of grief is that she does not oversimplify Margaret’s progression through Kübler-Ross’s stages. Instead, she carefully depicts a nuanced grief journey shaped by the complex and specific circumstances of Margaret’s situation. As Father Melancholy himself said, “[a] vivid story can be far more illuminating than a dreary fact.”³³ Godwin’s unique characters make her story vivid, and in doing so illustrate a difficult and often ignored subject better expressed in story than textbook.

References

- ¹Kubler-Ross, E. and Kessler, D. (2005). *On Grief and Grieving: Finding the Meaning of Grief Through the Five Stages of Loss*. Scribner. Pg 7. Pg 8.
- ²Kubler-Ross, E. (1997) *On Death and Dying: What the Dying Have to Teach Doctors, Nurses, Clergy, and Their Families*. Simon & Schuster/Touchstone Book. Pg 53.
- ³Godwin, G. (1991) *Father Melancholy’s Daughter*. William Morrow and Co. Inc. Pg 51.
- ⁴Kubler-Ross, E. and Kessler, D. Pg 10.
- ⁵Godwin, G. Pg 52.
- ⁶Kubler-Ross, E. and Kessler, D Pg 8.
- ⁷*Ibid*. Pg 12.
- ⁸Godwin, G. Pg 71.
- ⁹*Ibid*. Pg 77.
- ¹⁰*Ibid*. Pg 78.
- ¹¹Kubler-Ross, E. and Kessler, D. Pg 11.
- ¹²Godwin, G. Pg 117-119.
- ¹³Xie, L. (1995) *The Evolving Self in the Novels of Gail Godwin*. Louisiana State University Press. Pg 202.
- ¹⁴*Ibid*. Pg 81.
- ¹⁵Kubler-Ross, E. and Kessler, D. Pg 20.
- ¹⁶Godwin, G. Pg 120.
- ¹⁷Jarrati, C. (1994) *Helping Children Cope with Separation and Loss*. Harvard Common Press.
- ¹⁸*Ibid*. Pg 121.
- ¹⁹*Ibid*. Pg 160.
- ²⁰Kubler-Ross, E. and Kessler, D. Pg 17.
- ²¹Godwin, G. Pg 161.
- ²²*Ibid*. Pg 155.
- ²³*Ibid*. Pg 106.
- ²⁴Signman, M. and Wilson J. (1998) “Traumatic Bereavement: Post Traumatic Stress Disorder and Prolonged Grief in Motherless Daughters.” *Journal of Psychological Practice* 4.1 Pg 34-50.
- ²⁵Zlatar, G. (2009) *Discovering Mother: Embracing the Feminine: An Imaginal / Archetypal Approach to the Loss of the Mother at an Early Age*. Ph.D. Dissertation. Pacifica Graduate Institute.
- ²⁶Godwin, G. Pg 350.
- ²⁷*Ibid*. Pg 320.
- ²⁸*Ibid*. Pg 374-375.
- ²⁹*Ibid*. Pg 373.
- ³⁰Kubler-Ross, E. and Kessler, D. Pg 26.
- ³¹*Ibid*. Pg 27.
- ³²Kubler-Ross, E. Pg 18.
- ³³Godwin, G. Pg 57.

Who Is Uriah Heap?

BY KATIE HANCOCK
COLORADO STATE UNIVERSITY

Last week, one of my professors, wringing his hands during a lecture, laughed nervously and said, “I’m turning into Uriah Heap up here.” It was a reference to an obsequious, constantly hand-wringing character in Charles Dickens’ *David Copperfield*, one of those “classic” books that makes you sound smart if you’ve read it. David Copperfield is one of those books that only a few people might understand a reference to outside of a college campus.

Statistics from the United States Census Bureau show that, on average, a high school diploma is the highest level of education reached in the United States, and according to the CIA, 99% percent of Americans are literate.^{1,2} If that is the case, why might so few people outside of academia understand a Dickens reference? The answer lies in a study conducted by Renaissance Learning, Inc. that breaks down the top 40 books read by students from ninth to twelfth grade in the United States. The list makes no distinction between assigned reading and reading for pleasure, but the two are easy to tell apart. For example, only two Shakespeare plays made the list, but all of the Hunger Games and Twilight book series did.³ I can personally attest to the different ways public high schools can decrease an overall appreciation of classic Western literature: In tenth grade one of the books we were required to read was *A Tale of Two Cities* (Dickens again—but at a third of the length of *David Copperfield*, it’s certainly more easily digested). One of the Honors English teachers, upon hearing several students complain that it was “too hard,” told her classes that they didn’t have to finish it, and promptly moved on to the next unit in the curriculum.

This unfortunate trend is not limited to English departments. For example, statistics from the National Endowment

for the Arts indicate that only about four percent of Americans who have only a high school diploma regularly attend live theater, and those in the highest-income group are more likely to see stage performances than anyone else.^{4,5} Additionally, total attendance at live theater events has been steadily declining over the past seven years, reports Americans for the Arts.⁶

Interest in the arts and humanities has been declining at the university level as well. The Institute of Education Sciences reports that more Bachelor’s degrees have been awarded in business than in any other major and that the total number of business degrees is almost double the next-highest-ranking set of degrees, those in the social sciences and in history.⁷ In third and fourth place are health and education, respectively. Natural science, health, and engineering have all seen dramatic increases in the number of bachelor’s degrees conferred in the last decade, but this trend fails to appear in the number of liberal arts degrees awarded.

The arts and humanities are indeed in a state of crisis, both in the public and in academia. We can see it reflected in the adolescent crowd’s favorite books (which have an average difficulty level of fifth grade) and in songs whose lyrics pander to the lowest common denominator. As a culture, we’ve come a long way from Mrs. Dalloway and Eleanor Rigby—a long way in the wrong direction.

To quote The New York Times op-ed writer David Brooks, “People think by comparison—Iraq is either like Vietnam or Bosnia; your boss is like Narcissus or Solon. People who have a wealth of analogies in their minds can think more precisely than those with few analogies.”⁸ He’s right: We think with similes and we make allusions in speech, media, and culture. For that we can thank the two thousand years’ worth of material that is

the focus of liberal arts studies. In the midst of all this history and literature we can live a multi-layered existence, one that engages our minds and connects us to the distant past. But as we devalue the arts and humanities, it seems more and more as though our society is taking a dive into the shallow end of the pool—we humans are naturally creative and insightful creatures, but if we keep on our present path our only collective knowledge base will consist solely of catchy pop tunes, teen romance novels, and Internet memes. We need to stand up for the past and encourage the appreciation of classical works and great artists, so the great artists of the future still have hope of being inspired.

References

- ¹N.A. (2012) “Selected Social Characteristics in the United States: 2012 American Community Survey 1-Year Estimates.” United States Census Bureau. U.S. Department of Commerce. <http://factfinder2.census.gov/>. (09/12/2014)
- ²N.A. (2014) “The World Factbook.” Central Intelligence Agency. Central Intelligence Agency. <https://www.cia.gov/>. (09/12/2014).
- ³Renaissance Learning. (2013) “What Kids Are Reading: The Book-Reading Habits of Students in American Schools.” Renaissance Learning. Renaissance Learning.
- ⁴Office of Research and Analysis. (2013) “How a Nation Engages with Art: Highlights from the 2012 Survey of Public Participation in the Arts.” Office of Research and Analysis. National Endowment for the Arts.
- ⁵AMS Planning and Research Corp. (1996) “American Participation in Theater.” AMS Planning and Research Corp. National Endowment for the Arts.
- ⁶Cohen, R. Kushner, R. (2013) “National Arts Index 2013: An Annual Measure of the Vitality of Arts and Culture in the United States: 2000-2011.” National Arts Index. Americans for the Arts.
- ⁷N.A. (2012) “Digest of Education Statistics—Chapter 3: Postsecondary Education.” National Center for Education Statistics. Institute of Education Sciences. <http://nces.ed.gov/>. (Accessed 09/12/2014).
- ⁸Brooks, D. (Jun. 2010) “History for Dollars.” The New York Times. A27.

An Appeal to Anyone Writing Anything

BY QUINTN PARKER

COLORADO STATE UNIVERSITY

As an English Major, staff member at the Journal of Undergraduate Research and Scholarly Excellence, and general book-lover, I have come to believe formal writing is a lie.

Growing up, I was taught that first person – the “I” and “me” of writing – was inappropriate for academia, and would be treated as such. If you spend any time with academic English papers, you’ll see this notion holds strong. Some scholars even employ the unfortunate technique of replacing first-person ideas with third-person sentences, endowing the piece with the voice of an awkward-yet-omnipresent king.

Formal writing creates a tone of opinion, which may be interpreted as bias. But unlike science, whose laws exist whether humans understand them or not, writing is purely a human invention. English writing, especially, has more exceptions to rules than rules themselves. To attempt formality is to pretend there exists a standard, unbreakable set of rules that there simply is not.

The rules guiding formality exist (and should only exist) when they serve to make writing as clear and precise as possible. As language evolves, so does writing. It used to be considered incorrect to end a sentence with a preposition (some still hold onto this 18th century relic), but no modern speaker would argue that “paid for the house had been” is clearer than “the house had been paid for.”

Writing is a form of communication. The goal of writing is to communicate. Rules of writing exist to make writing as accessible as possible. If following a rule makes your writing less accessible, that rule has failed to do perform its goal, and should be ignored. Rather than clarity, academic writing seems to value the intentionally obtuse. By layering simple statements with jargon and third-person distance, the academic creates writing which is safe – writing without accountability. Although scholars will always be there to push the field forward, their insights may be found beneath a mire of jargon, tepidness, and purposeful dilution. What can be said for

a field of study that favors the obtuse over the confrontational? That prefers pompous mediocrity to humble innovation?

My appeal is this: be comfortable with fallibility. The next time you have an idea, don’t water it down until it’s an inoffensive, pale reflection of itself. State it clearly and boldly. Admit all human thought, no matter how fundamental it seems, will by definition be imperfect and worthy of reexamination.

I’m tired of seeing academic intelligence defined by the pretentious unoriginal. Advancement in thought should be for everyone, not just the formally trained. Don’t be formal: be straightforward.



K. Broscheit, *The Geology of Who You Share Your Bed With*, 2013
Wood, plaster, packing materials,
newspaper, bed sheets; 4.5' x 6' x 2'



The Geology of Who You Share Your Bed With is a nearly 600 pound bed about the landscape of who you share your bed with, and the historical and geological relationships one creates in the human experience. It is a build up of layers of mixed materials that show the weight and complexity of our relationships, and the mess they can create. Inside these layers a human impression has been cast, representing the permanent impression our partners have on our lives, whether those relationships are romantic or not. Sharing a bed with someone is an intimate experience, which creates moments that are both stable and dynamic. I wanted to create a piece that documents the layering of those relationships, how they build on each other, and how their geologic representation can be messy and full of complex moments and conversation.



The piece is cut in half and placed on wheels to reveal the layers of these relationships. This also allows for the gap between the halves to be constantly shifting in size. With this possibility, the piece can also talk about the distance between those partners and their relationships. As people viewing the bed enter the gap, there is a strong sense of disruption and the feeling of entering an intimate space that was once shared by another relationship or experience.

These layers of relationships have the power to define who we are, and continue to shift how we discover the history of ourselves through partners we share a space with.



This was the first poster I designed in the series. For this cover I wanted to use thematic elements of the story without using blatant symbolism. *Frankenstein* has a lot of false imagery associated with the story. The monster is not green, does not have bolts in its neck and is not unintelligent as most movie versions of the story would lead you to believe.

The actual book is about the dangers of obsession. On the right of the poster I wanted to use something symbolizing a man chasing another man or perhaps a dream or other obsession. On the left I wanted to include something more from the actual story by creating a shape from a dogsled chasing another dogsled and editing it down for minimalism. It also invokes ice breaking apart, which is again an important detail from the book. With the minimalism I wanted to create a sensation of not quite knowing what you're looking at, as though the details have been interpreted too far, just as the movie is interpreted too far from the book to something almost unrecognizable.



K. Chasarik, *Frankenstein*, 2013
 Print; 16" x 24"



K. Chasarik, *Animal Farm*, 2013
Print; 16" x 24"

One of the most important symbolic elements of George Orwell's book *Animal Farm* is the windmill that the pigs force the animals to build and then blame its ultimate destruction on Snowball. Using the windmill as the main focal point of the cover, I wanted to invoke constructivist style of art in a post-modern way.

KRYSTIN GUTIERREZ

COLORADO STATE UNIVERSITY



As my way of thinking, creating art is how I understand and visually explore the world around me. I believe that everything has a story – an untold significance – and that if you just look a little closer, you will always learn something new. Calling attention to the details of natural forms and textures that inspire me, I aim to uncover these mysteries. Collections of the little moments I wish to capture, my work consists of accumulated marks, text, spills, and washes of tea and ink that come together to visually communicate my personal observations and discoveries.

Process has always played a large role in my work, and for this piece, I found myself needing to fully embrace an impulsive and intuitive way of making art. Layers of found objects, plexiglass, Mylar, paper, and various wet and dry mediums, these accumulations of details and ideas became a visual manifestation of the impressions the world has left on me.



In *Bones of the Earth*, I was drawn to the idea that in the end, bones are all that remain. They tell our stories, reveal our habits, and provide a truly honest glimpse of the person (or place) that left them behind. Initially this piece was meant to help me discover what the bones of the earth could be, and allow me to connect with places that possessed a certain level of antiquity. I was inspired by the duality between growth and decay and was fascinated by the idea that with enough time even the greatest monuments will fade away. As this piece progressed though, it became less about ‘finding’ the bones and more about the explorative process itself.

K. Gutierrez, *Bones of the Earth (past)*, 2013
Paint, tea, ink, graphite, charcoal, pastel,
marker, salt, tracing paper, Mylar, plexiglass;
40" x 48"



K. Gutierrez, *Bones of the Earth* (present), 2013
Paint, tea, ink, graphite, charcoal, pastel,
marker, salt, tracing paper, Mylar, plexiglass;
56" x 62"



B. Pack, *My Pietà*, 2013
Oil, collage, wood putty, and gold leaf
on wood panel; 30" x 48"



B. Pack, *His Affliction*, 2013
Oil on canvas; 36" x 48"

My current work investigates narrative identity and how I define myself in relation to others.

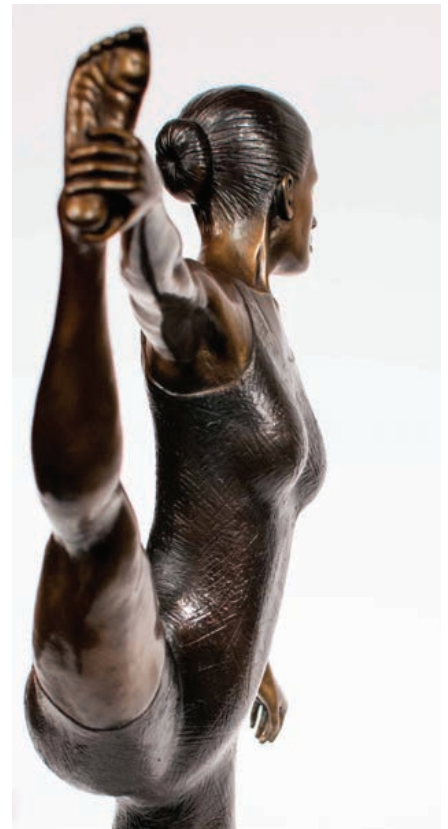
His Affliction is about the hardship that someone very close to me has been fighting through for four years. I painted this piece in a very loose and expressive style so that it would evoke the feelings of pain, anger, and frustration that he and I feel. This affliction that he endures consumes his identity and his perception of the world, so I created a very chaotic atmosphere around him.

My Pietà parallels and complements the themes at play in the first piece, because it is about how my identity in relation to him is defined by trying to be his savior. I lament over him the way Mary lamented over Jesus after he died, which is what Michelangelo's *Pietà* depicts. The line drawings surrounding the figures are police officers and judges, which relate to his afflictions. However, I have utilized sanding techniques which fade the drawings, therefore bringing emphasis to the intimate lamenting figures.

DONALD WATTS
COLORADO STATE UNIVERSITY



D. Watts, *Poise*, 2010
Bronze; 20" x 2.5" x 12"





D. Watts, *Id*, 2010
Bronze; 15" x 4" x 12"



My reasons for creating art are many and varied. Since early youth I have been hyper-visual. As far back as I can remember I have been deeply affected by what my eyes take in. Color, form, shape, texture, pattern, line; I have always been extremely tuned-in to these things at a level that is almost visceral. Ever since I was a child, art has been an escape. I remember, even at a young age, turning to drawing or sculpture to deal with emotional problems. Creative activity is an outlet that helps me maintain balance, so oftentimes I create simply because it enhances my mood. Mostly I make art because I like to be challenged, both creatively and intellectually. And as much as I like to be challenged, I also like to do the challenging, so sometimes I make art to provoke or agitate. The ultimate goal of my work is to have a psychological impact on the viewer.

More than anything, I find inspiration in nature and within nature I am inspired most by the human form. The art I like most is representational and so it is with my own art. This is not to say that I don't appreciate a little abstraction. Without a little abstraction I would just be a copy machine reproducing what I see. But for me, when things are too abstract they become removed from what is universally understood about the human condition. In my opinion, good art—whether it be film, sculpture, or songwriting—contributes something to our understanding of what it means to be an uncertain human being.

My preferred art form is sculpture: seeing things in the round reminds me to look at my life and the world around me with the same perspective. I have worked only with clay and metal. In addition to sculpture, I love to draw. I have recently discovered a love for pen and ink and watercolor. Also, I am currently exploring digital media and—when I have some time—I'd love to learn more about photography.

Effects of barley extract on the growth of *Spirogyra*, *Synedra*, and *Ankistrodesmus* algae

BY BROOKE BURMEISTER, EMILY DEAVER, PHD,
AND THOMAS DILLEY, PHD
SOUTHWEST MINNESOTA STATE UNIVERSITY

Abstract

Excessive amounts of algae in lakes can lead to oxygen depletion and fish kills. An experiment was conducted to determine the effectiveness of barley straw extract in controlling algal growth in three species of freshwater algae. *Spirogyra* (filamentous green algae), *Synedra* (diatom), and *Ankistrodesmus* (single-celled green algae) were exposed to barley straw extract in an environmental chamber for nine days. Chlorophyll concentrations were analyzed at the beginning and end of the study to determine effects on the growth of the algae. All three species of algae grew in the unexposed controls, but growth was significantly reduced for all three species when exposed to barley extract (ANOVA, analysis of variance, $p = 0.05$). This experiment confirms the inhibitory effect of barley straw extract on three types of algae not previously tested. These data indicate that barley straw extract may be effective for reducing algae growth and preventing noxious blooms.

Introduction

There is an increasing amount of fertilizer used in urban and rural areas to increase crop production and enhance plant growth. Fertilizer contains nutrients including phosphorus, potassium, and nitrogen.¹ These chemicals get carried into lakes through runoff as nutrient pollution, which causes an excessive growth of phytoplankton.² Cultural eutrophication, or excessive algae growth in response to an increase in nutrients, is one of the biggest problems in surface waters today.³ Large blooms of blue-green algae are toxic to fish.⁴ Some algae have noxious odors and a foul taste. As a result livestock will not drink the water, and humans will not use it for recreation.⁵ Extensive algae blooms can also lead to oxygen depletion and fish kills.⁶ In the past, the introduction of herbicides to lakes have reduced the amount of algae present, but there may be an alternative that reduces algae growth without herbicide treatment.⁷

Studies have shown that decomposing barley straw inhibits algae growth. Laboratory research using chopped barley straw reduced the growth of harmful cyanobacteria, *Microcystis aeruginosa*.⁸ These bacterial cells were not killed, but the cell densities began to decline after the first day.⁸ Similarly, a field study in England found that using netted barley straw can reduce the growth of algae and improve water clarity. Barley straw did not eliminate the existing algae; instead it inhibited the growth of new algae.⁹ These studies suggest that barley straw could be used as an algistatic agent, which would prevent algae growth, rather than as

an algaecide, which would kill existing algae.⁸

Research using barley straw extract (from decomposing barley straw) has had similar results. In laboratory experiments, barley straw extract was applied for a four-week period to *Prymnesium parvum*, an invasive species of golden algae. Both high and low doses of barley straw extract lowered the amount of algae growth.¹⁰ Growth of *Microcystis aeruginosa*, a cyanobacteria that produces toxic algal blooms, was also inhibited by using a barley straw extract.⁷

Previous research has focused primarily on noxious algae, but it is unclear whether it will have the same effects on other species of algae. Some researchers have found mixed results, with barley straw inhibiting growth for some species of algae, but not others.¹¹ In this experiment, three different types of algae were exposed to barley straw extract: the filamentous species of green algae *Spirogyra*, the diatom *Synedra*, and the green algae *Ankistrodesmus*.

The green algae *Spirogyra* is commonly found in lakes, streams, and ditches.¹² It can grow into very dense masses that can clog shallow open water treatment filters.¹³ The macroscopic filamentous algae causes problems in water bodies by disturbing both swimming activity and the fish-oxygen balance. *Spirogyra* is also a food source for many different species of carp.¹⁴

Synedra is a diatom that has long, needle-shaped cells. Diatoms are small phytoplankton commonly found in oceans, lakes, slow-flowing rivers, and streams.¹⁵ Their external shell is made of silica and sinks when the organism dies. The silica

plays a role in global cycling through the aquatic food web. The shells are used in pool filters, cat litter, and water treatment systems.¹⁶ When diatoms become too thick, they can create an odor inside and block water treatment filters.¹³

Ankistrodesmus is single-celled green algae. It is found in all types of freshwater, artificial ponds, eutrophic lakes, and slow-flowing rivers, often appearing in bundles and groups in more acidic waters.^{13,15} Little research has been done on the ecology of *Ankistrodesmus*.

These three algal species were tested in the lab to determine the effects of commercially available barley extract on the growth of algae. Chlorophyll content was used as the measure of algal growth in this study. Chlorophyll a is a pigment found in all algal groups in inland waters and can be directly related to algal biomass.¹⁷ We predicted that barley extract would reduce the amount of algae growth in all three species over the nine-day exposure, and it was expected that the chlorophyll concentrations would be lower in the treatment groups compared to the controls.

Materials and methods

Algae Exposures

Spirogyra, *Synedra*, and *Ankistrodesmus* algae cultures were purchased from Carolina Biological Company. A total of 35 sterile 50mL screw-cap test tubes were filled with 9mL of sterile Alga-Gro nutrient (Carolina Biological Company). 7mL *Spirogyra* was added to ten of the test tubes, five for a treatment group and five for a control. For the treatment group 9mL of barley extract

(Pondlife Co.) was added in addition to the *Spirogyra*. The positive control group received 9mL of pasteurized spring water. 7mL of *Synedra* were added to another set of ten test tubes for treatment and positive control groups. In addition to *Synedra* and the Alga-Gro the treatment group received 9mL of barley extract and the positive control group received 9mL of pasteurized spring water. 7mL *Ankistrodesmus* was added to ten of the remaining test tubes. 9mL of barley extract were added to the treatment group and 9mL of pasteurized spring water was added to the positive control. 9mL of barley extract and 7mL of pasteurized spring water were added to the five remaining test tubes for the negative control.

To allow for gas exchange, test tube caps were not screwed on all the way. Test tubes were placed in a Percival PGC-10 environmental chamber for nine days at a temperature of 21°C and a 12-hour photoperiod (light-dark cycle) with a light strength of 157 Lux. To promote gas exchange and to keep algae suspended, the test tubes were fully capped and inverted twice every 48 hours and placed back in the environmental chamber.

Assessment of growth and analysis

To determine the effects of the barley extract on the growth of the algae, chlorophyll concentrations were measured at the beginning of the study and after nine days of exposure. Contents of each test tube were glass-fiber filtered (Gelman AE; effective pore size 0.7µm) and dried using four drops of magnesium carbonate (MgCO₃) to stabilize the samples for chlorophyll analysis.¹⁸ The initial samples were frozen and analyzed along with the final samples following the experiment. A 30mL Potter-ELV glass tissue grinder was used to disrupt the cells until the glass-fiber filter was completely broken down. Samples were ground for approximately 20 minutes. Samples were placed into 50mL test tubes with screw caps and 15mL of

90% acetone was added to each test tube and shaken. Samples were placed into a dark refrigerator at 4°C.¹⁹ After two hours, test tubes were placed in the Beckman J-58 centrifuge for 15 minutes at 500rpm. The liquid was decanted into a 1cm spectrometer cuvette and absorbance read at wavelengths of 750nm and 650nm on a Spectronic 20D spectrometer. To make corrections for phaeo-pigments and particulates 0.1mL of hydrochloric acid (HCL) was added to each sample. Samples were then read again on the spectrometer (Spectronic, 20D) at 750nm and 664nm.¹⁹ Chlorophyll concentration was calculated using the following formula:¹⁹

$$Chl a(\mu g / L) = \frac{26.7(664B - 665A) \bullet V_1}{V_2 \bullet L}$$

V_1 =Volume of extract 664B =664-750nm before acid
 V_2 =Volume of filtered 665A =665-750nm after acid
 L =Path of length (1cm)

The Shapiro-Wilk test was used to confirm that the data were normally distributed. Student's T-tests were performed comparing mean chlorophyll concentration at the beginning of the experiment to chlorophyll concentrations after nine days of exposure to barley extract for each of the three species. ANOVA was used to compare differences in chlorophyll concentrations between the positive controls (no barley extract) and the three species, as well as to compare chlorophyll concentrations between the species.

Results

According to ANOVA, the difference in chlorophyll concentration between the positive controls and all three species of algae after the nine days of incubation was significantly reduced ($p < 0.05$). *Spirogyra* with no barley extract (untreated group) grew significantly during the nine-day period in the environmental chamber (Figure 1). Initial growth for *Ankistrodesmus* (Figure 2)

and *Synedra* (Figure 3) was also higher than the untreated group. All three algae species exposed to barley extract had lower levels of chlorophyll when compared to the untreated groups.

Spirogyra growth was significantly inhibited by barley extract. After the nine-day period, chlorophyll was hardly detectable at 20.50 µg/L ±SE16.13 in the barley straw treatment compared to the control, which had a chlorophyll content of about 2060.81 µg/L ±SE426.34 (Figure 1). Results indicated that the barley extract did significantly reduce the growth of *Spirogyra* compared to the positive control. *Ankistrodesmus* growth was also inhibited by barley extract. After the nine-day exposure period, the positive control (no barley extract) had an average of 167.89 µg/L ±SE16.64 of chlorophyll present (Figure 2). The treatment group (with barley extract) had chlorophyll at a significantly lower rate of 12.82 µg/L ±SE4.53. ANOVA tests indicated the probability of this result happening at random was very low ($p = 0.007$).

Synedra growth was also inhibited when exposed to barley extract. The probability of this occurring is 0.000. *Synedra* exposed to barley had a chlorophyll concentration of 15.38 µg/L ±SE4.35 compared to 55.11 µg/L ±SE14.84 (Figure 3), which was the chlorophyll concentration of the samples not exposed to barley.

An evaluation was also done of the chlorophyll concentration in the test tubes at the beginning of the experiment ("initial") and after nine days of growth in control tubes (no barley extract) to determine if the three algae samples were growing over the course of the experiment.

After nine days in the environmental chamber, the *Spirogyra* controls (without barley extract) grew significantly (Figure 4). The initial chlorophyll concentration was 359.95 µg/L ±SE56.24 and the final concentration was 2060.81 µg/L ±SE426.34 µg/L. *Ankistrodesmus* chlorophyll concentration at the beginning of the

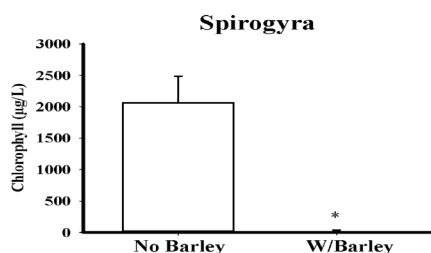


Figure 1. Average concentration of chlorophyll in *Spirogyra* after nine days of exposure to barley extract ±SE (n=5) *statistically significant difference ($p=0.000$).

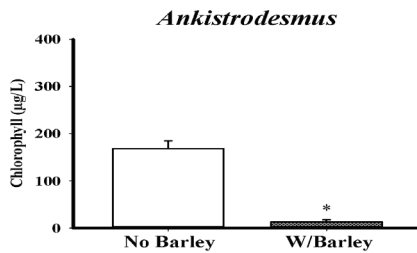


Figure 2. Average concentration of chlorophyll in *Ankistrodesmus* after nine days of exposure to barley ±SE (n=5) *statistically significant difference ($p=0.007$).

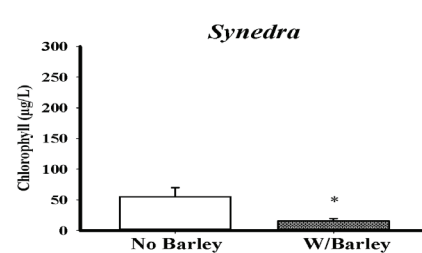


Figure 3. Average concentration of chlorophyll in *Synedra* after nine days of exposure to barley ±SE (n=5) *statistically significant difference ($p=0.000$).

experiment ($273.94 \mu\text{g/L} \pm \text{SE } 90.98$) was higher than the ending control chlorophyll concentrations ($167.89 \mu\text{g/L} \pm \text{SE } 16.64$), though this was not a statistically significant difference (Figure 5). After nine days in the environmental chamber, the *Synedra* controls (without barley extract) showed a reduction in growth. The initial chlorophyll concentration was $347.35 \mu\text{g/L} \pm \text{SE } 9.54$ and the final concentration was $55.11 \mu\text{g/L} \pm \text{SE } 14.84$ (Figure 6).

The appearance of the algae exposed to barley extract changed over the nine-day experiment compared to the positive control. By the second day, the *Spirogyra* sank to the bottom of the test tubes compared to the positive control which were at the top. Filaments were also shorter in length compared to controls. The *Ankistrodesmus* turned brown and *Synedra* turned white. By day six, the *Synedra* treatment group was almost clear with a faint cloudy appearance; *Spirogyra* changed from green to white at the bottom of the test tubes. *Ankistrodesmus* had a white film on the bottom. These color changes also indicate decreased growth of algae in barley extract. The positive controls for *Spirogyra* and *Ankistrodesmus* did not appear to change color throughout the experiment and remained green. The positive control for *Synedra* did change to a lighter color, likely due to a lack of silica.

Discussion

Barley straw extract was effective for inhibiting the growth of the *Spirogyra*, *Ankistrodesmus*, and *Synedra* species of algae. The methods followed were similar to previous research performed by Ferrier et al. except that this project used barley extract purchased from Pond Life Company. Ferrier et al. prepared barley extract from decomposing barley and then tested unfiltered and sterile filtered extract on 12 species of algae, including *Spirogyra* and *Synedra*.⁵

Ferrier et al. found that *Spirogyra* growth was significantly reduced compared to the

control when exposed to sterile filtered extract.⁵ These results are similar to the results of this project. *Spirogyra* growth was significantly reduced when exposed to barley extract. The effects of barley extract on the algae *Synedra*, however, are different in each study. This study did show a statistically significant ($p < 0.05$) reduction in growth of *Synedra* compared to the control. Ferrier's results⁵ showed no significant difference in growth between the control, unfiltered, and sterile filtered barley straw extract. The difference in response of *Synedra* between the two studies may be due to the aforementioned differences in the barley extract source.

A study conducted by Geiger et al. on *Ankistrodesmus* exposed to decomposing barley straw showed that *Ankistrodesmus* growth was suppressed, which supports the results found here.²⁰

Another study conducted in the United Kingdom used lab-prepared barley straw extract and collected algae samples from lake water.⁷ They had similar results using the lake water they collected and tested. The lake water contained the algae species *Scenedesmus*, *Microcystis*, *Chlorella*, and *Anabaena*. In the presence of barley straw extract, these four species showed no signs of growth during a 28-day experiment.⁷

Spirogyra controls showed significant growth over the course of the study. *Ankistrodesmus* had a slight, though not statistically significant drop in growth and chlorophyll concentration. However, a large drop in *Synedra* chlorophyll concentration was measured in the control. Decreasing *Synedra* growth in the positive control (no barley extract) could be due to the extra nutrient requirement for diatom growth. According to James, diatoms can grow on a variety of different media but they need a silicate source to have good growth.²¹ It is recommended that 10mg/L of sodium metasilicate be added to media to produce good growth. The growth media used in this study was consistent for all test containers

and did not include increased silica content.

Another difference in the response of the three algae species tested in this study was the order of magnitude in response. All three species of algae had initial chlorophyll concentrations of approximately $250\text{--}350 \mu\text{g/L}$. Over the course of the experiment, *Spirogyra* chlorophyll concentration in the controls increased to over $2000 \mu\text{g/L}$. *Ankistrodesmus* and *Synedra* ending chlorophyll concentrations in the controls were both under $200 \mu\text{g/L}$.

The inhibiting effects of barley extract might result from the chemical compounds hydrogen peroxide and oxidized phenolics.^{4,7,22} These compounds are produced during the decomposition process. Zhou analyzed chemical compounds in decomposing barley straw and found that butylated hydroxytoluene and 2-methoxy-4-vinylphenol occurred in many of the samples they observed.²² These chemical compounds qualify as candidates for further research on effects of algae growth.

Results of this research project in conjunction with those of previous studies indicate that barley extract could possibly be used as an alternative to harmful chemicals to rid lakes and rivers of algae.^{5,8,10,20} The occurrence of excessive algae growth in surface waters appears to be increasing and is likely to continue as global temperatures rise.⁶ The availability of nutrients and light, coupled with warm waters typically results in blooms of blue green algae. These algae blooms can result in food web disturbances, reductions in species diversity, taste and odor problems in water, and oxygen depletion resulting in fish kills.^{3,6} The study suggests that the use of commercial barley straw extract may prevent excessive blooms in a variety of species, thus reducing the occurrence of these problems, and providing a less costly, non-herbicidal option for lake management.

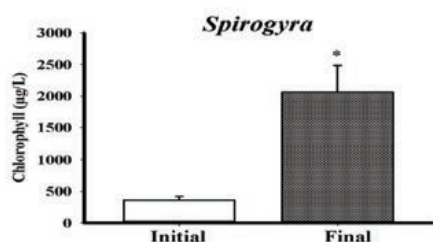


Figure 4. Average concentration of chlorophyll in *Spirogyra* at the beginning of the (initial) $\pm \text{SE}$ and after the nine-day experiment without barley $\pm \text{SE}$ ($n=5$) *statistically significant difference

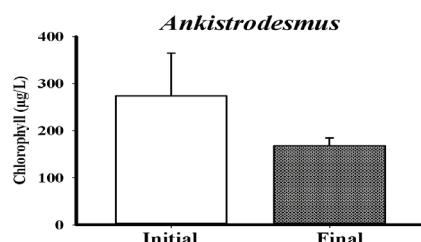


Figure 5. Average concentration of chlorophyll in *Ankistrodesmus* at the beginning of the (initial) $\pm \text{SE}$ and after the nine-day experiment without barley $\pm \text{SE}$ ($n=5$).

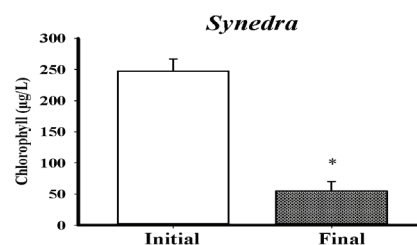


Figure 6. Average concentration of chlorophyll in *Synedra* at the beginning of the (initial) $\pm \text{SE}$ and after the nine-day experiment without barley $\pm \text{SE}$ ($n=5$) *statistically significant difference ($p < 0.05$).

Acknowledgements

We would like to acknowledge the Southwest Minnesota State University Environmental Science Program for providing laboratory equipment and supplies, Jim Carver for preparing some solutions, Cara Carson and Tony Ross for helping in the lab, and Dr. Jeff Bell for helping convert graphs into proper formats.

References

- ¹Zublena, J.P., Talo, R., Baird, J.V. and Lilly, J.P. (1999) "Soil Facts. Nutrient content of fertilizer and organic material." North Carolina Cooperative Extension Service Publication # AG-439-18. Pg 1-12.
- ²Valkama, E., Uusitalo, R., Ylivainio, K., Virkajarvi, P. and Turtola, E. (2009) "Phosphorus fertilization: a meta-analysis of 80 years of research in Finland." Agriculture, Ecosystems and Environment 130. Pg 75-85.
- ³Smith, V.H. and Schindler, D.W. (2009) "Eutrophication science: where do we go from here?" Trends in Ecology and Evolution 24. Pg 201-207.
- ⁴Everall, N. and Lees, D. (1996) "The use of Barley-Straw to control general and blue-green algal growth in a Derbyshire reservoir." Water Resource 30.2. Pg 269-276.
- ⁵Ferrier, M., Butler Sr., B., Terlizzi, D. and Lacouture, R. (2005) "The effects of barley straw (*Hordeum vulgare*) on the growth of freshwater algae." Bioresource Technology 96. Pg 1788-1795.
- ⁶Iredale, R.S., McDonald, A. T. and Adams, D.G. (2012) "A series of experiments aimed at clarifying the mode of action of barley straw in cyanobacterial growth control." Water Research 46. Pg 6095-6103.
- ⁷Ball, A.S., Williams, M., Vincent, D. and Robinson, J. (2000) "Algal growth control by a barley straw extract." Bioresource Technology 77. Pg 177-181.
- ⁸Xi, X., Ying-xu, C., Xin-qiang, L., Li-ping, L. and Xian-jin, T. (2010) "Effects of Tibetan hullless barley on bloom-forming cyanobacterium (*Microcystis aeruginosa*) measured by different physiological and morphologic parameters." Chemosphere 81. Pg 1118-1123.
- ⁹Lembi, C. (2002) "Barley straw for algae control." Aquatic Plant Management. <<http://www.ces.purdue.edu>> (Accessed 03/27/2012)
- ¹⁰Grover, J., Baker, J., Urena-Boeck, F., Brooks, B., Errera, R., Roelke, D. and Keisling, R. (2007) "Laboratory tests of ammonium and barley straw extract as agents to suppress abundance of the harmful algae *Prymnesium parvum* and its toxicity to fish." Water Research 41. Pg 2503-2512.
- ¹¹Peczula, W. (2013) "Influence of barley straw (*Hordeum vulgare* L.) extract on phytoplankton dominated by *Scenedesmus* species in laboratory conditions: importance of the extraction duration." Journal of Applied Phycology 25. Pg 661-665.
- ¹²Hainz, R., Wöber, C. and Schagerl, M. (2009) "The relationship between *Spirogyra* (Zygnematomyceae, Streptophyta) filament type groups and environmental conditions in Central Europe." Aquatic Botany 91. Pg 173-180.
- ¹³Bellinger, E. and Sigee, D. (2010) Freshwater Algae Identification and Use as Bioindicators. Wiley-Blackwell. Pg 33-34, 153, 224-225, & 238.
- ¹⁴Kumar, H., Gajaria, S. and Radha, K. (2004) "Growth and development of catla (*Catla catla*) fed up with different levels of diet containing *Spirogyra* sp." Bioresource Technology 95. Pg 74-76.
- ¹⁵Graham, L., Graham, J. and Wilcox, L. (2009) Algae. Pearson Education, Inc. Pg 236.
- ¹⁶Hosja, W. (1998) "Water Facts: Algal Bloom." Water and Rivers Commission 6. Pg 1-15.
- ¹⁷Wetzel, R. G. (2001) Limnology: Lake and river ecosystems. 3d ed. Academic Press. Pg 372.
- ¹⁸Parsons, T., Maita, Y. and Lalli, C. (1984) A manual of chemical and biological methods for seawater analysis. Pergamon Press, Inc. Pg 101-104.
- ¹⁹American Public Health Association. (1989) Standard Methods for the Examination of Water and Wastewater, 17th Edition, American Public Health Association Washington, DC. Pg 1031-1034.
- ²⁰Geiger, S., Henry, E., Hayes, P. and Haggard, K. (2005) "Barley straw-algae control literature analysis." South Dakota State University. <<http://www.sdstate.edu>> (Accessed 03/27/2012)
- ²¹James, D. (1978) Culturing Algae. Carolina Biological Supply Company. Pg 12.
- ²²Zhou, J. (2010) "Inhibitory effect of decomposing barley on algal growth in water and wastewater." ISTC Reports.

Foraging frequency of juvenile Mountain Plovers (*Charadrius montanus*) among three Colorado habitat types

BY ALAN H. HARRINGTON AND PAUL F. DOHERTY, PhD
COLORADO STATE UNIVERSITY

Abstract

Mountain Plover populations in North America have been subject to increasing population decline for more than 40 years. This decline has prompted scientists to further investigate habitat relationships in this species. During the summer of 2011 I examined the foraging frequency of juvenile Mountain Plovers among three habitat strata (prairie dog colonies, rangeland, and agricultural fields). Observations took place on private lands around Karval, Colorado, where a large breeding population of Mountain Plover exists. Due to an ongoing chick mortality study by Colorado Parks and Wildlife, I was able to collect data from chicks equipped with radio transmitters throughout the brood rearing season. My objective was to assess the habitat-specific and age-specific foraging rates of chicks. I found foraging rates did differ among habitat types, but not by age of chicks. Chicks in grassland habitat had the highest foraging rate, and chicks in agriculture habitat had the lowest foraging rate. I discuss my results without regards to prey availability and predation pressures. Understanding habitat use and foraging ecology of juvenile Mountain Plovers will provide important conservation implications for this species, and will contribute to the needs of further investigations.

Introduction

The Mountain Plover (*Charadrius montanus*) has been the focus of Endangered Species Act (ESA) listing activity for over two decades.^{1,2} With this attention, previous studies have been undertaken to consider Mountain Plover ecology and to determine potential conservation measures needed. Of particular concern is juvenile survival and habitat use. A large amount of research has been done to look at chick survival. Examining various stages of development and associated juvenile growth and survival rates is crucial for identifying causes of declines in a species. Collecting such data with precocial, cryptic young is difficult.³ Studies have also looked at habitat use of Mountain Plovers. Dreitz (2009) found that Mountain Plover chick survival and brood movements were influenced by habitat. This study more deeply examines the foraging frequencies of these juvenile birds among different habitat types, and as a function of chick age.

During the breeding season, Mountain Plovers have been shown to occupy three different habitat types: black-tailed prairie dog (*Cynomys ludovicianus*) colonies, grasslands without prairie dogs, and dryland agriculture.⁴ Dreitz (2009) predicted that plover chick movement and survival would be highest on prairie dog habitat where prey density and biomass are greatest. The availability of the prey in these habitat types during the brood-rearing period is hypothesized to provide an explanation for chick survival

and brood movement activity. Plover chicks' foraging opportunities may be affected by changes in food availability among habitats. Optimal foraging habitats are advantageous for the development of chick body mass.⁵ Body mass has a positive effect on juvenile survival of Mountain Plover.⁶ Based on previous studies, I predict chick survival will be highest where the foraging availability is greatest and juvenile plovers are able to gain maximum body mass.

Breeding habitat may provide the best foraging availability or broods may disperse to other habitat types. Dreitz (2009) found that plovers that nested in prairie dog habitat, containing the highest survival of chicks, moved to other habitat types and did not remain only in prairie dog habitat. Breeding habitats that minimize the energetic costs of foraging and reduce an organism's exposure to predators are the most suitable for survival.⁷ Individuals that are able to decipher between habitat types and the quality of those habitats will have greater survival and reproduction potential. Similar to the ability of individuals to select optimal habitat, the probability of chick survival also increases with age.⁸ A chick that is able to survive to 11-13 days will triple its probability of surviving the entire first year.¹ Thus, parents that select for optimal habitats and raise chicks past 11-13 days should be the most effective at raising chicks to fledging. Understanding the use of different habitat types by young birds may have important conservation implications

due to the fact that the survival of young is reflective on the population dynamics of that species.⁹ Conservation efforts that assess and reverse avian population declines demand reliable information on population status and habitat requirements.¹⁰ Examining foraging frequencies of juveniles and the use of different habitat types, may inform managers on the population status of this species. This study describes chick foraging frequency among grassland, agricultural, and prairie dog habitats in the pre-fledging period of juvenile plovers. I propose that foraging rates will be highest in black-tailed prairie dog habitat and that the frequency of foraging will increase with age of plover chicks.

Methods

Study area and study species

The study took place near Karval, Lincoln County, CO (U.S.) (Figure 1). Lincoln County contains a high breeding population of Mountain Plovers. The area consists of dryland agriculture fields and cattle ranchlands. Populations of Mountain Plover are supported by the fertile short grass prairie ecosystem. There is limited public land within the study area. The region has three defined habitats. Active black-tailed prairie dog colonies, grassland habitat without prairie dogs, and fallow and active dryland agricultural fields will all be considered.

Mountain Plovers (Figure 2) are a migratory species native to shortgrass

prairies ranging from the Canadian border to northern Mexico. Mountain Plovers possess similar ecological and physical demographics as Killdeer (*Charadrius vociferous*).¹¹ Breeding birds choose to nest on bare ground with sparse vegetation. Adult males will select multiple sites for the nest and scrape at the ground to indicate location to the female. The female may lay two separate clutches during the breeding period where both the male and female will incubate in separate nests. The incubation process lasts from 28-31 days and chicks hatch within 24 hours. Once hatched, chicks are immediately able to find food and move along the ground until they fledge at 34-36 days. The Mountain Plover is an insectivore and obtains 100% of its water supply through its diet. For this reason, this species can persist in dry and arid locations, away from water sources.¹²

Field methods

I focused on areas where broods had been detected on the previous day as part of an ongoing chick mortality study.⁶ I then located individual birds using telemetry, as the ongoing chick mortality study equipped adults and chicks with transmitters (Figure 3). All observations took place from All Terrain Vehicles (ATV) between 06:15 and 16:50. I kept a distance of at least 0.16 km from the brood so as not to disturb the birds. At the beginning of an observation period I recorded the habitat (grassland, prairie dog colony, agriculture) and the time of day. After a chick was detected, I confirmed the specific telemetry frequency of the chick by pointing the antennae at the bird and listening for the loudest response on the receiver among all of the possible frequencies. I observed the chick with binoculars and I counted, using a hand tally counter, every foraging attempt (i.e., peck at the ground or foliage). I assumed that each foraging attempt was successful. Counting took place for as long as I could observe the chick without obstruction. If a chick went out of my line of vision, I subtracted that amount of time from the total observation time to the nearest minute. Once a chick was either no longer in my sight or too far away to make accurate observations, I completed that observation by recording the time of day and total number of forage attempts for that chick. If another chick from the brood were visible, I would repeat my observation process. Once all observations were completed, I would immediately leave the area. The ongoing Mountain Plover chick mortality study provided me with the exact age of each of the chicks due to nest monitoring measures that took place.⁶

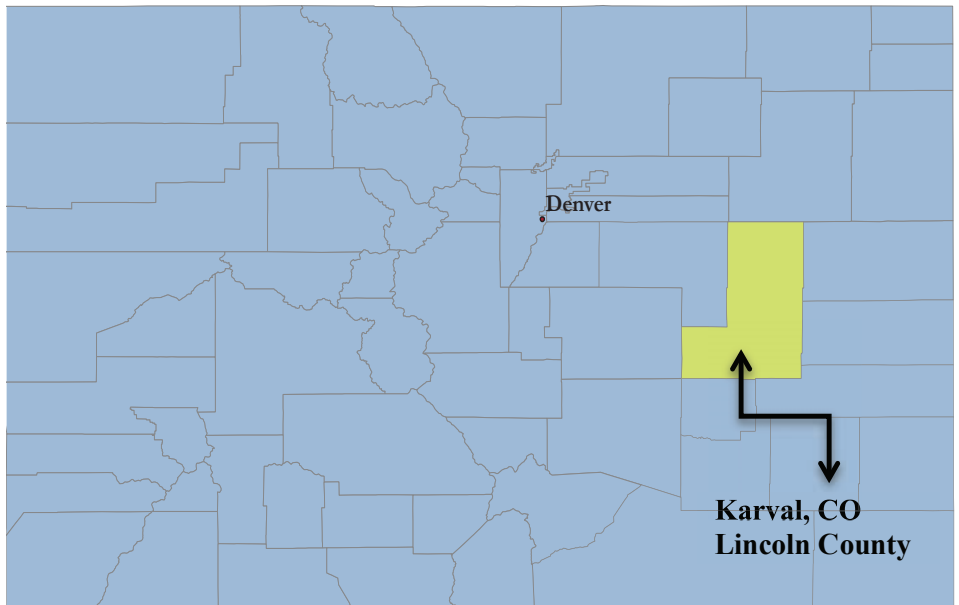


Figure 1. Study area



Figure 2. Adult Mountain Plover



Figure 3. Juvenile Mountain Plover with backpack transmitter

Analysis Methods

I defined foraging rate per individual as the number of foraging attempts per total minutes of observation. I compared foraging rate per habitat and per age of chick using an ANCOVA statistical test.¹³ Foraging rate was a dependent variable and habitat type and age of chick were independent variables. I performed all analyses using Excel and considered tests with results of $p < 0.05$ to be significant.

Results

Results for foraging rate per habitat, showed a significant difference among strata. ($P=0.002$, $F(2,32)= 7.47$) (Table 2). Grassland had the largest average foraging rate of 0.88 attempts/minute and the greatest number of observations among strata. ANCOVA analysis was used to examine foraging rate and average age of chick for all habitats combined and among habitats. No significant differences were found among strata ($P= 0.78$, $r^2= .003$) (Figure 4).

Discussion

Our results did not support the hypothesis that foraging frequencies would be highest in black-tailed prairie dog habitat. Grassland habitat foraging frequencies were significantly greater. However, Schekkerman and Beintema (2007) note that prey resources can aggregate during the breeding season and among years as resources fluctuate. The quality of grassland habitat during the summer of 2011 could have supported greater resources. Other studies on shorebirds have suggested that broods will move to and remain in habitats that support the highest chick survival.^{14,15} Dreitz (2009) showed that Mountain Plover broods have moved to areas with lower chick survival in the past. Potentially optimal foraging habitat has no direct correlation to chick survival in this species. Further studies should take this quandary into consideration.

Our results differ from other precocial juvenile chick foraging studies that show a significant increase in foraging rate as chicks increase in age.¹⁶ I was unable to determine if each foraging attempt by juvenile plovers was successful. With my assumption that all attempts were successful, further studies should consider accounting for the differences in successful and unsuccessful foraging attempts. I assumed that chicks did not move among strata per observation and that individuals were identified and recorded correctly. I may have overlooked correlations among chick age, habitat, and foraging rate that were not demonstrated in this study.

If studies were to be conducted in the future, allocating efforts equally among strata, increasing the sample size, and observing

Strata	Total Chicks/ Strata	Time Watched/ Strata (min)	Average Minutes of Observation/Day
Grassland	11	317	21.133
Prairie Dog	6	261	23.73
Agricultural	4	88	9.78

Table 1. Summary of juvenile Mountain Plover observations.

Strata	Average Foraging Rate (Attempts/min)	Standard Deviation
Grassland	0.877	0.247
Prairie Dog	0.455	0.498
Agricultural	0.19	0.461

Table 2. ANCOVA results for foraging rate per strata.

Foraging Frequency Per Age of Chick

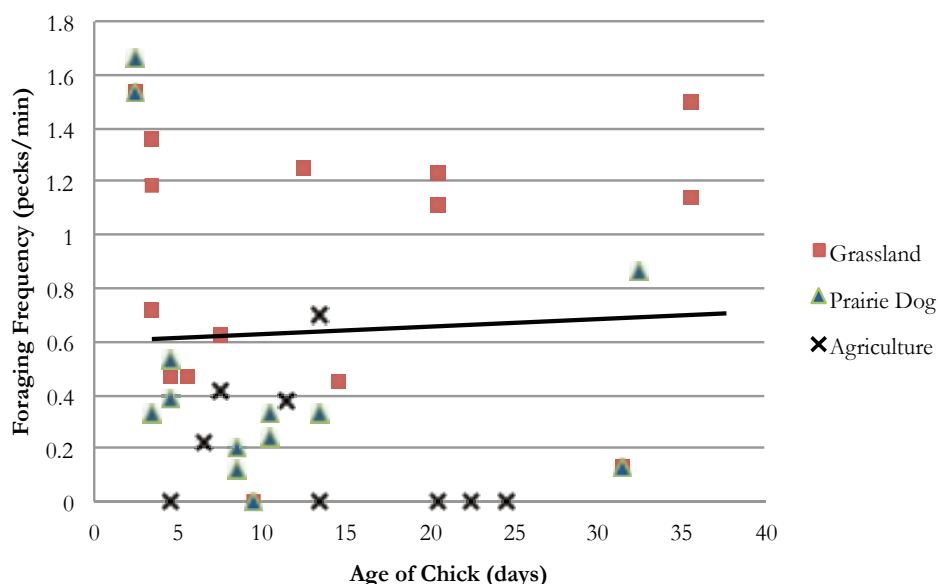


Figure 4. Foraging frequency among habitats and per age of chick.

chicks at different ages equally would greatly benefit the validity of foraging data. Differences in foraging activity may be due to prey resources as opposed to some other component of the three defined habitat types. Collecting information on food resources in each habitat type may enable researchers to determine if prey availability or ease of capture is contributing factor in foraging activity. A further understanding of the use of different habitat types by juvenile plovers may inform managers of the population status of Mountain Plover. Managing for optimal foraging habitat by juvenile Mountain Plovers may greatly contribute to the conservation of this species.¹⁷

Acknowledgements

I would like to thank the private landowners who allowed access to their lands. This research would not have been completed without assistance from Dr. Victoria Dreitz, Maggie Riordan, Lindsey Messinger, and Colorado Parks and Wildlife who hired me as a field technician for the Mountain Plover chick mortality study. My mentor, Dr. Paul Doherty, gave insurmountable advice to me with his recommendations and guidance.

References

¹³Dinsmore, S. (2000). *Endangered Animals: a reference guide to conflicting issues*. Greenwood Press. Pg 213-218.

- ²N.A. (2011). "Mountain Plover." U.S. Fish and Wildlife Service Endangered Species. U.S. Fish and Wildlife Service. <<http://www.fws.gov>>. (Accessed 08/30/2011).
- ³Miller, B. and Knopf, F. (1993) "Growth and Survival of Mountain Plovers." *Journal of Field Ornithology*. 64.4. Pg 500-506.
- ⁴Dreitz, V. (2009). "Parental Behaviour of a Precocial Species: Implications for Juvenile Survival." *Journal of Applied Ecology*. 46.4. Pg 870-878.
- ⁵Knopf, F. (1998). "Foods of Mountain Plovers Wintering in California." *The Condor*. 100.2. Pg 382-384.
- ⁶Dinsmore, S., White, G. and Knopf, F. (2003). "Annual Survival and Population Estimates of Mountain Plovers in Southern Phillips County, Montana." *Ecological Applications*. 13.4. Pg 1013-1026.
- ⁷Poysa, H., Elmberg, J., Sjöberg, K. and Nummi P. (2000). "Nesting Mallards (*Anas platyrhynchos*) Forecast Brood-stage Food Limitation When Selecting Habitat: Experimental Evidence." *Oecologia*. 122.4. Pg 582-586.
- ⁸Graul, W. (1975). "Breeding Biology of Mountain Plover." *Wilson Bulletin*. 87.1. Pg 6-31.
- ⁹Anders, A., Dearborn, D., Faaborg, J. and Thompson, F. (1997) "Juvenile Survival in a Population of Neotropical Migrant Birds." *Conservation Biology*. 11.3. Pg 698-707.
- ¹⁰Tipton, H., Doherty, P. and Dreitz, V. (2009). "Abundance and Density of Mountain Plover (*Charadrius montanus*) and Burrowing Owl (*Athene cunicularia*) in Eastern Colorado." *Auk*. 126.3. Pg 493-499.
- ¹¹Sibley, D. (2000). *The Sibley Guide to Birds*. Alfred A. Knopf, Inc. Pg 167.
- ¹²Knopf, F. (1996) "Mountain Plover (*Charadrius montanus*)." In: Poole, Alan and Gill, Frank, eds. *The Birds of North America*, Inc. Pg 1-16.
- ¹³McDonald, J. (2009). "Handbook of Biological Statistics." Sparky House Publishing. Pg 232-237.
- ¹⁴Lengyel, S. (2006) "Spatial Differences in Breeding Success in the Pied Avocet (*Recurvirostra avosetta*): Effects of Habitat on Hatching Success and Chick Survival." *Journal of Avian Biology*. 37. Pg 381-395.
- ¹⁵Schekkerman, H. and Bientema, A. (2007). "Abundance of Invertebrates and Foraging Success of Black-tailed Godwit (*Limosa limosa*) Chicks in Relation to Agricultural Grassland Management." *Ardea*. 95. Pg 39-54.
- ¹⁶Schekkerman H., and Boele, A. (2009). "Foraging in Precocial Chicks of the Black-tailed Godwit (*Limosa limosa*): vulnerability to weather and prey size." *Journal of Avian Biology*. 40.4. Pg 369-379.
- ¹⁷Dinsmore, S., Wunder, M., Dreitz, V., and Knopf, F. (2010). "An Assessment of Factors Affecting Population Growth of the Mountain Plover." *Avian Conservation and Ecology*. 5.5. <<http://www.ace-eco.org>>. (Accessed 8/30/2011)

Arsenic concentration and flood discharge in Southern California

By THOMAS W. LUCKIE

COLORADO STATE UNIVERSITY

Abstract

Arsenic in the environment is a hazard to human and ecosystem health. Understanding how arsenic behaves in nature aids in ecological remediation and prevention of contamination of groundwater sources. Using data published by the Natural Resources Conservation Service (NRCS) and the United States Geological Survey (USGS) StreamStats application, the relationship between arsenic (As) concentration in groundwater and maximum discharge during flood events was examined in Southern California. After normalizing data points to their respective drainage basin area, a negative correlation between arsenic concentration and discharge during flooding events arises. Power regression lines for high arsenic concentration data produce an R^2 value of 0.83, and low arsenic concentration data produce an R^2 value of 0.83—both of which are within acceptable ranges defined in the study.

Introduction

The purpose of this paper is to investigate any possible statistical correlations between arsenic concentrations in Southern California with peak flooding discharge for various recurrence intervals. Past research connecting groundwater chemistry and geomorphology has been established, and this article seeks to examine specific variables in order to gather evidence on this connection.^{1,2} The expected result was a negative correlation between flood discharge and arsenic concentration—as peak flood discharge increases, arsenic concentrations will decrease. The proposed hypothesis was that more arsenic will be removed from the area by larger flooding events, resulting in a decrease in the observed arsenic concentrations. Essentially, the flooding will ‘wash’ away the arsenic from the area, as one might expect. The null hypothesis was that there is no relation or correlation between arsenic concentration and flood discharge—that is, both are variables which are independent of, and uninfluenced by, each other.

Southern California was chosen as the study site due to the presence of many anthropological sources of arsenic—such as mining and agricultural practices—as well as the severe drought and water-rights issues present in this region of the state.³ When water resources become scarce and the prioritization of its users becomes a public concern, the introduction and transportation of contaminants such as arsenic can exacerbate an already large problem. In California, the governmental goal for minimum arsenic concentration in drinking water is 0.004 $\mu\text{g/L}$ —and this limit is strictly enforced by the California Safe Drinking Water Act in order to protect

the state’s residents.³ Thus, understanding how contaminants behave and how they are influenced by variables such as flooding becomes crucial in ensuring the delivery of clean, safe water to where it is needed.

Arsenic is a highly toxic and carcinogenic substance, and poses a serious hazard not only to human health, but also to ecosystems due to its ability to remain in organisms for extended periods of time.⁴ Although high concentrations of As in surface or groundwater is often attributed to anthropogenic practices such as mining operations and the use of agricultural pesticides, arsenic can also be the result of natural weathering processes.⁵ The primary concern for human populations is the presence of arsenic in drinking water: An estimated 100 million people consume water containing arsenic above the World Health Organization’s recommended limit of 10 micrograms per liter.⁵ Arsenic can be present in solid and aqueous phases as well as several oxidation states; since it is more mobile in its aqueous phase, the presence of arsenic in the aqueous phase is of more concern with respect to the contamination of water sources.⁵

In surface and near surface conditions, two oxidation states of arsenic are most abundant: arsenic (V) and arsenic (III).⁵ The ability of arsenic to adsorb onto the surface of soil solids is strongly controlled by its oxidation state. As(V) binds strongly to a wide range of mineral components of soils and sediments and is generally insoluble, whereas As(III) solid phase adsorption is more dependent on certain soil chemical conditions (see Table 1).⁵

Solid state arsenic in minerals can be broken down into two categories: arsenates, which contain the AsO_4^{3-} anion; and arsenites,

which are less common, and contain the AsO_3^{3-} anion.⁶ Arsenates are associated with arsenic acid (H_3AsO_4), which has three steps of dissociation.²

Additionally, arsenious acid—associated with arsenites—has only one dissolution step, where $\text{pK} = 9.2$.² The large pK value for arsenious acid, as well as steps one and two of the dissociation of arsenic acid, indicates a large reduction in the strength of the acid. Although acidity can be an issue in certain situations, these pK values likely mean that just the presence of arsenic in a given environment is more of a concern than the effects of the acids.

There are additional arsenic minerals outside of the arsenates and arsenites that can have an influential presence in a watershed. In areas rich with sulfide minerals (e.g., many mining districts), minerals such as realgar (As_2S_3), orpiment (As_2S_5), and arsenopyrite (FeAsS) can form. When these minerals are subjected to chemical weathering, arsenic can be produced.⁶ Additionally, arsenopyrite can be a byproduct of gold, silver, copper, and lead ore processing, called smelting. The mishandling of this arsenic bearing mineral post-smelting can also result in the release of arsenic into the environment.

Estimates predict as much as half of the arsenic in nature is bound to solid phases, such as soils. In Southeast Asia, sedimentary basins with high concentrations of arsenic in groundwater undergo extended periods of anaerobic conditions; these environmental factors promote the production of highly mobile As(III), compared to As(V)—which is more commonly found in aerobic conditions.⁴ A remediation technique in West Bengal involves the process of pumping aerated water to a target depth to create an oxidation zone.⁵ This zone promotes the

Adsorbent	As(V) (mmole/Kg)	pH	As(III) (mmole/Kg)	pH
<i>Al Oxides</i>				
Gibbsite	35	4.0		
Amorphous Al hydroxide	15	9.0		
	1500	4.0		
	600	9.0		
	1600	5.0		
	1200	7.0		
	500	9.0		
Activated Al	67	6-7	14	6.5-8.5
Bauxite	52	6-7	16	6.5-8.5
<i>Aluminosilicates</i>				
Montmorillonite	8	5.0	3	5.0
Kaolinite	7	5.0	1	5.0
<i>Fe (hydr)oxides</i>				
Hydrous ferric oxide	3514	4.0	2675	8.0
Goethite				
Magnetite	173	4.0	173	8.0
2-line ferrihydrite			332	8.0
	2000	4.6	>6000	4.6
2-line ferrihydrite on quartz sand	1500	9.2	>6000	9.2
	483	7.1	1206	7.1
<i>Others</i>				
Birnessite	100			
Pyrolusite	10	6.5		
Cryptomelane	25	6.5		
Activated Carbon	10	3-4		
Humic Acids	90-110	5.5		5.5

Table 1. Retention maxima for arsenic on common soil forming minerals⁵

growth of arsenic oxidizing bacteria, which produces the insoluble arsenic (V); the entire process can be carried out in-situ, and does not produce any waste stream.⁵

Concentrations of arsenic are controlled by both climate and geology.⁷ Iron oxide bearing minerals appear to release a significant amount of arsenic, and are the most common source of arsenic in areas with high arsenic concentrations.⁷ The release of arsenic from iron oxides can be the result of geochemical processes, such as the reaction of iron oxides with organic carbons and hydrocarbons, from either a natural or anthropogenic source.⁵ This poses an increased threat from arsenic in areas with large hydrocarbon deposits, and surficial concentrations of arsenic can be exacerbated by events such as oil spills.⁵

Another large source of arsenic in natural settings is from iron oxides in felsic volcanic rocks.⁷ When these iron oxides come into contact with alkaline ground water, arsenic undergoes a redox reaction, allowing it to become much more mobile in an aqueous phase.⁷ Interestingly enough, a process called iron oxide adsorption is used to remove arsenic from drinking water.⁵ The process uses iron hydroxide, which is a strong adsorbent of arsenic—particularly arsenic (V)—at low pH ranges, allowing the purification of the water. In addition to iron oxides, sulfide minerals can be a

source and sink for arsenic.⁵ Typically, there is a correlation between areas with high arsenic concentrations in ground water and areas with high evaporation rates, which is very common in the American West and Southwest.⁴

Methods

Using the USGS StreamStats online application for the state of California, peak flood discharge in liters per second was collected for recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years, with their associated standard errors in percent. This was completed using the drainage basin delineation from a point tool, which uses calculations, methods, and standards laid out by Thomas et al in the USGS Open-File Report 93-419.⁸ The 500 year recurrence interval was not used in the data analysis due to its lack of a standard error statistic, and its anomalously high and infrequent flow parameter. StreamStats was also used to calculate the drainage basin area for each point. Soil composition was found using the NRCS Web Soil Survey online application, which is a compilation of data from various soil survey manuscripts published by the NRCS for California. Care was taken to ensure both points from the Web Soil Survey and StreamStats coincided, and represented the same sample. This was done using various landmarks in each application, such as roads, channels, elevation benchmarks, and USGS gauging stations.

Arsenic concentrations were divided into two populations: high arsenic concentrations ($\geq 25 \mu\text{g/L}$) and low arsenic concentrations ($< 1.0 \mu\text{g/L}$), as defined by Anning et al and Beisner et al.^{1,4} Intermediate concentrations of arsenic were omitted—only the highest and lowest brackets of arsenic concentration were used, so that any relationship between flooding and concentrations would become inflated and more apparent. General areas of high and low arsenic concentrations

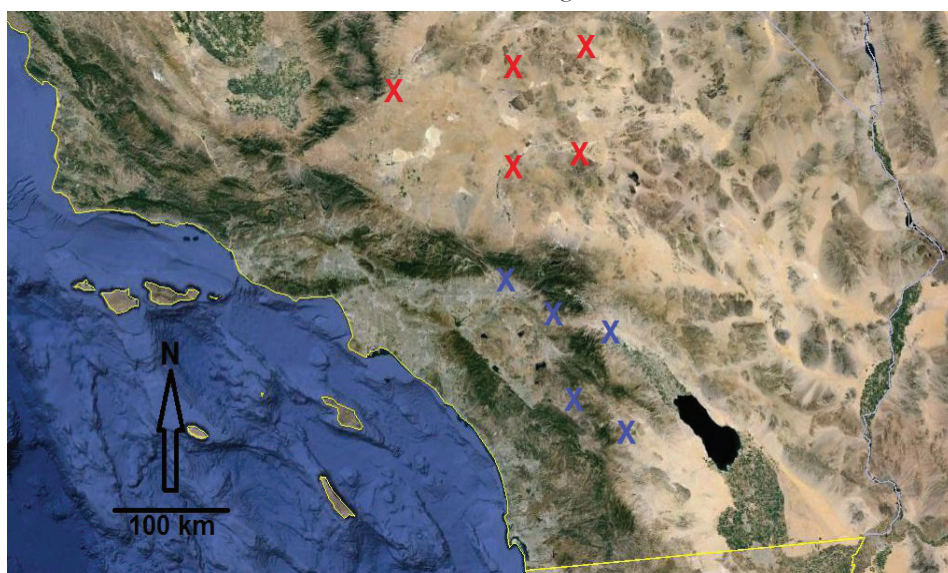


Figure 1. Map showing sampled locations. Red points indicate high arsenic concentration sites, while blue represents low concentration sites.

were determined using data from Besiner et al.⁴ These two populations represent the two end members of a range of measured arsenic concentrations collected by Anning et al.¹ For each population, five points were chosen across Southern California (Figure 1), taking care that none were within the same local drainage basin in order to ensure comprehensive and non-overlapping data. Large areas of approximately homogenous arsenic concentrations were common, so chosen points were taken from different areas to ensure a more diverse sampling. To make certain none of the data would become skewed due to arsenic's adsorption behaviors, soil textures of each site were considered. The drainage basin area of each point was used to normalize the peak flood discharges for each recurrence interval, in order to standardize the effects that drainage area could have on arsenic concentration and/or flood discharge.

Acceptable R^2 values for the support of the hypothesis were defined to be ≥ 0.80 . That is to say, 80% or more of the correlation can be described using the variables of arsenic concentration and flood discharge. Values for R^2 were calculated using a power regression line for high arsenic concentration data and low arsenic concentration data plotted against flood discharge. Acceptable standard errors were defined as $\leq 5\%$ of the measured value. Data were entered into and normalized to basin area using Microsoft Excel. Both data sets (normalized and un-normalized) were plotted, and R^2 values were also calculated using Excel. A power regression line was used to find the trend line for each data set (high and low arsenic concentrations), and the R^2 values were calculated using this regression. A logarithmic scale was used for the flood discharge (y) axis to better present the data.

Data and results

Prior to normalization (see Appendix), plots of flood discharge versus recurrence interval showed a higher discharge rate for the points with high arsenic concentrations ($R^2=0.685$) compared with the points with low arsenic concentrations ($R^2=0.728$). After normalizing each point to its respective drainage basin area (Figure 2), a higher discharge rate per basin unit area was found in the lower arsenic concentration points ($R^2=0.885$) than the higher concentration points ($R^2=0.834$). Both sets of data (high and low concentration points) were comprised of primarily loams (sandy loam, sandy clay loam, etc.) and sands (loamy sand, gravelly loamy sand, etc.), and showed no obvious correlation between soil texture and the other parameters of the points (drainage basin area, flood discharge, and arsenic

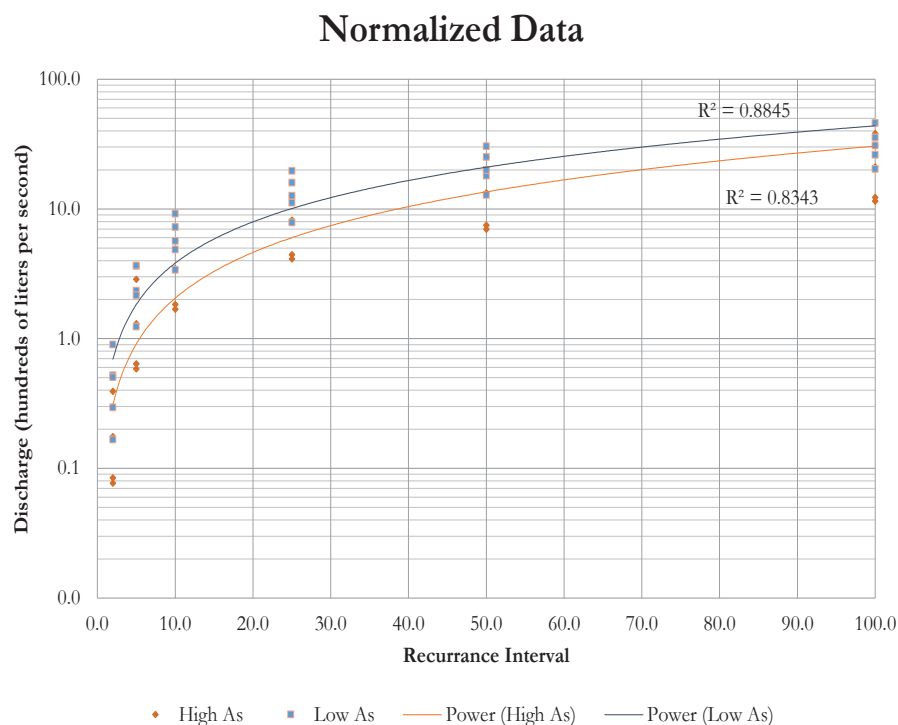


Figure 2. Flood discharge data normalized to basin area. Un-normalized data can be found in the appendix.

concentration). Standard errors were mostly within acceptable ranges (0.6% to 1.2%), except for points six and nine, both of which were low arsenic concentration points and had standard error ranges from 85% to 150%. However, when these points were removed, the R^2 value dropped from 0.885 to 0.877. This was within a reasonable range from the inclusive R^2 value (0.885), and was still distinct enough from the un-normalized R^2 value of 0.728 for these two points to be included in the analysis. When these standard errors were plotted for each point, the range of errors was approximately the same size as the points used to represent the data, so it was discarded. The R^2 values showed that most ($\geq 80\%$) of the controlling variables were included in the analysis.

Discussion

The statistical evidence strongly supports the hypothesis that there is a negative correlation between arsenic concentrations and peak flood discharge, and that the null hypothesis should be rejected. Of the samples taken, the points with lower arsenic concentrations display larger peak flood discharges; this can be said when the discharge per basin area is considered. The R^2 value is within an acceptable range, indicating that the two variables, peak discharge and arsenic concentration, are

correlated. Since it appears that the arsenic is removed by flooding, it can be assumed that the arsenic removed must have been in an aqueous phase and is readably mobile; both of these conditions point to the preferential removal of As (III) over As (V).

The increase in R^2 values for the normalized data indicate that the basin size is an important variable in the comparison of flood discharge and recurrence interval, presumably because basin area is a control on the cross-sectional area of the flow, which accounts for two of the three variables in the continuity equation. The points with low arsenic concentrations show much higher values for peak flood discharge per basin unit area, indicating a negative correlation between arsenic concentration and flood discharge per basin unit area. The high R^2 values for each set of data points show that many of the controlling variables have been accounted for in the analysis and are high enough to be deemed acceptable, yet not high enough to raise suspicion of both variables representing the same thing.

Based on qualitative descriptions of the soil textures sampled for this study, and with the use of a soil texture ternary diagram, a more quantitative description can be obtained. All soil samples fall into one of the following five soil types: sand, loamy sand, sandy loam, sandy clay loam, and loam (Figure 3). It can be inferred that the soil

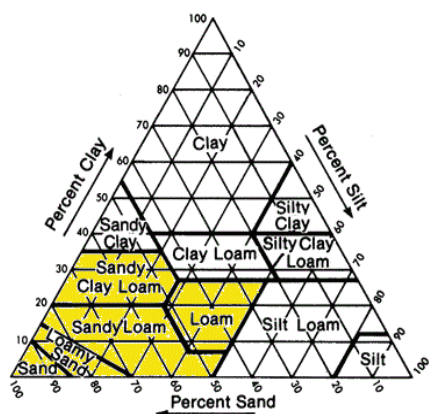


Figure 3. Soil texture ternary diagram, with observed soil textures highlighted²

samples all had the following ranges of sand, clay, and silt particle percentages:

Sand: 25% to 100%

Clay: 0% to 75%

Silt: 0% to 50%

With such a wide range of soil textures for both high and low arsenic points, it appears that there is no control on the arsenic concentration from the soil texture. To definitively determine this, however, sample sites containing more silt- and clay-rich soils should be considered in possible future research.

Potential issues arise when other controlling factors on the mobility of arsenic are included. The oxidation state of arsenic can be heavily influenced by environmental factors. If an area contains reducing fluids in contact with arsenic or potential arsenic sinks, arsenic (V) would become more prevalent. Since As (V) is much less resistant and is more likely to become adsorbed by solid phases, flooding would have little influence over the arsenic concentrations in a basin. The exception to this, however, lies in whether or not the sediment, which has As (V) adsorbed to its surfaces, is transported by the flooding event.

Other possible influencing factors must be considered: the capacity and competence of the flooding event, and the proportion of arsenic bearing solid phases in the dissolved, suspended, and bed loads of the flood. Furthermore, the properties of solid phase arsenic and its transportation by the flooding event also need to be included in a more holistic understanding of the correlation. The ability for As (III) to be adsorbed to the solid phase is dependent on the mineral and chemical composition of the solids. Although it is safe to assume that As (V) is the most abundant adsorbed state of arsenic, this cannot be verified until chemical properties of the soil are considered, not just

its textural component.

One other crucial key to determining the controlling variables on arsenic concentrations would be the source of the dissolved or aqueous arsenic. Assuming only As (III) is present in the system due to its relative mobility, groundwater discharge and surface runoff should be examined more closely. Assuming an initial, discrete input of arsenic onto the surface, arsenic concentrations will decrease with increasing number of runoff events; essentially, surficial arsenic is washed away by runoff. It is estimated that about 7% of total arsenic in a system can be transported by surficial runoff, and of that, 38% goes into solution with the rest adsorbing to the solid sediment phase.⁵ This transportation by runoff events would be controlled by not just the permeability of the soil, but also the amount of precipitation a particular basin receives. The presence of rain shadows where one side of a drainage divide receives more precipitation than another would heavily influence this transportation by runoff. As a result, all else being equal, two geographically close points separated by a high drainage divide could display two drastically different arsenic concentration measurements. Another factor related to this would be groundwater discharge. Pre-existing arsenic in groundwater, the arsenic's initial source, the source of the groundwater, and how groundwater is interacting with surficial runoff are all things that would need to be determined for each point under investigation, and considered in the analysis. Means of resolving all these potential influential factors in arsenic concentration would be to include quantitative data on these variables in the analysis and the inclusion of a larger sample size, in order to remove any and all factors which may skew the data.

Conclusions

Statistically speaking, arsenic concentration and flood discharge are negatively correlated—at least for sandy to loamy textured soils when basin area is included. With R^2 values above 0.80 for both high arsenic concentration and low arsenic concentration sites, there is strong evidence to support the relationship between arsenic concentration and flood discharge. To further promote this correlation, studies should be carried out with more control over possible influential variables on arsenic concentration in the ground water, and with a larger sample size of locations.

Whether or not this correlation deems action to remove the effects of flooding on arsenic is beyond the scope of this study. The possibility of the implementation of a remediation technique is an issue

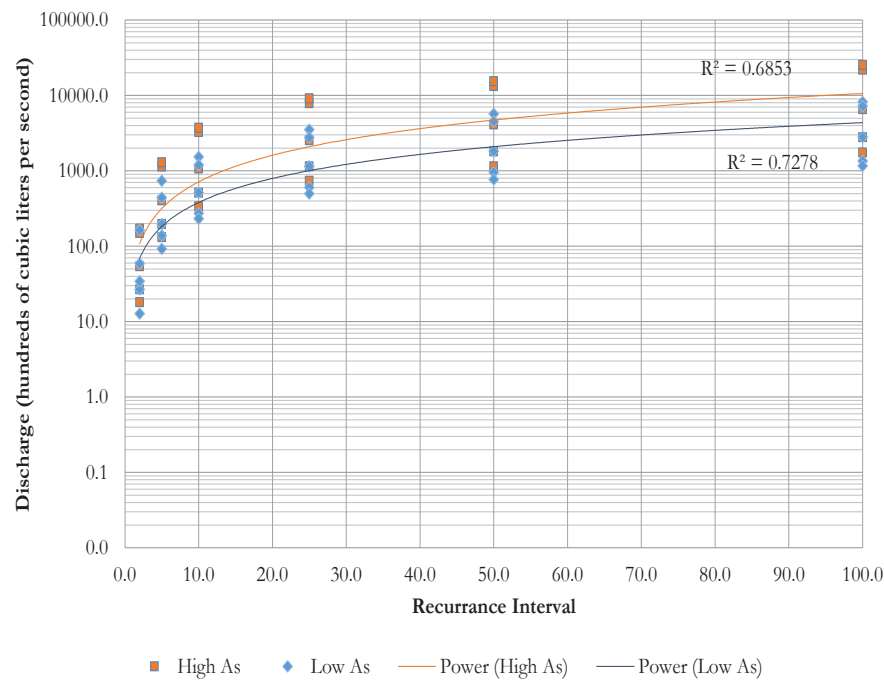
that should be addressed by authorities such as environmental consulting firms or local government agencies. However, understanding how arsenic interacts with its environment is critical in evaluating and implementing remediation procedures. If arsenic is found in excess of this limit, not only is it in violation of laws such as the California Safe Drinking Water Act, it also puts the health of residents at risk. If such a case occurs, remediation efforts must take place in order to protect citizens—and to determine which technique is most effective, scientists and engineers need to have access to as much information on arsenic as possible.

References

- ¹Anning, D. W., Paul, A. P., McKinney, T. S. and Huntington, J. M. (2012) "Predicted Nitrate and Arsenic Concentrations in Basin-Fill Aquifers of the Southwestern United States." U.S. Geological Survey. USGS Scientific Investigations Report 2012-5056.
- ²Faure, G. (1998) *Principles and Applications of Geochemistry*. Prentice Hall.
- ³Fan, A. M. and Alexeeff, G.V. (2004) *Public Health Goals for Chemicals in Drinking Water: Arsenic*. California Environmental Protection Agency.
- ⁴Beisner, K. R., Anning, D. W., Paul, A. P. and McKinney, T. S. (2012) "Maps of Estimated Nitrate and Arsenic Concentrations for Basin-Fill Aquifers of the Southwestern United States." U.S. Geological Survey. USGS Scientific Investigations Map 3234.
- ⁵Fendorf, S., Nico, P. S., Masue, Y. and Tufano, K. J. (2010) "Arsenic chemistry in soils and sediments." Lawrence Berkeley National Laboratory.
- ⁶Klein, C. and Dutrow, B. (2008) *Manual of Mineral Science*. Wiley, John & Sons, Inc.
- ⁷Welch, A. H., Westjohn, D., Helsel, D. R. and Wanty, R. B. (2000) "Arsenic in Ground Water of the United States: Occurrence and Geochemistry". *Ground Water* 38.4. Pg 185-206.
- ⁸Thomas, B. E., Hjalmarson, H. and Waltemeyer, S. (1994) "Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States." U.S. Geological Study. USGS Open-File Report 93-419.
- ⁹Rahn, P. H. (1996) *Engineering Geology*. Prentice Hall.

Appendix

Raw Data



The importance of accounting for overdispersion in site-occupancy estimations

By ADAM ERIC MILLER

COLORADO STATE UNIVERSITY

Abstract

Understanding species distributions across landscapes can help set management goals to protect vital areas for species persistence. Areas of high species occurrence may represent a crucial habitat that should be protected against anthropogenic and environmental impacts. Recently, a new model has been developed to estimate the probability that a site is occupied, given cryptic individuals that are imperfectly detected, allowing experts to infer how habitat use varies across the landscape. However, ecologists and conservationists often make the mistake of trying to choose the model that best fits the data, which may not necessarily accurately model the environment being studied. In this study, we review occupancy modeling, and techniques to account for overdispersion in data sets, and then examine a data set on Northern Colorado birds to test its importance. We found that the estimates of the overdispersion parameter varied from species to species. Not accounting for overdispersion in some species caused the bias of multi-model inference, and could lead to misleading recommendations by conservationists. As environmental agencies face limited resources, drawing inference from poorly fitting misleading models could be extremely costly. We demonstrate the importance of assessing overdispersion in site-occupancy models, as it can change the inference made and the knowledge drawn from monitoring.

Introduction

In the face of many potential negative impacts on wildlife populations, understanding species distributions across landscapes has become an important consideration in many ecological studies.^{1,2} Because some species and individuals are cryptic (hard to see or find), recent advancements in wildlife research have emphasized the importance of accounting for detection probability in estimating population and landscape level parameters.^{3,4} Tied with this advancement in ecological statistics, is the use of presence/absence data, which is often less time and cost intensive than count and mark/re-capture studies to estimate population abundance and occurrence.⁴

Recent population models have been developed that take into account imperfect detection probabilities ($p < 1.0$) while estimating the probability that a site is occupied by a species.^{3,5} Although similar models have been developed in the past, the model developed by MacKenzie et. al. has proven to be more robust, and has become widely used in monitoring programs, ecological studies, and conservation biology.^{3,6,7}

MacKenzie et. al. use a sampling design where a certain number of sites (N) are sampled a specific number of times (T). Researchers visit the sites multiple times (T), and detect species using various methods (e.g., point counts, traps). Then for each site (i) a detection history can be observed (X_i) and a combination of site and sample level covariates can be used to explain variation.^{3,5}

In basic occupancy models, the two main parameters of interest are the proportions of N sites occupied (Ψ) and the probability of detecting species Z (p). A detection history (X_i) can then be used to estimate a site specific Ψ at site i . For example, if site i was sampled six times, and species Z at site i had a detection history of “001100”. This denotes that the species was not detected at the site during the first two or last two sampling occasions, but was detected in the third and fourth sampling occasion. The probability of observing the above outcome can be described as:

$$\Pr(X_i = 001100) = \Psi_i(1-p_1)(1-p_2)(p_3)(p_4)(1-p_5)(1-p_6) \quad (1.0)$$

A history of all 1s denotes that a species was detected at each sampling occasion, while a detection history of all 0s denotes a history where the species was never detected. Given the number of sampling occasions, there are a variety of combinations of detections and non-detections at a site. This can be described as:

$$L(X_1, X_2, \dots, X_n | \psi, p) = \prod_{i=1}^N \Pr(X_i) \quad (2.0)$$

This likelihood can then be used to calculate the maximum likelihood estimates for model parameters of interests (i.e., site occupancy). However, MacKenzie et. al. express occupancy and detection probabilities based on various site and sample level covariates (x).³ Therefore, a logistic regression is used to estimate the parameter of interests (θ_i) by the following

equation:

The goal of using models to estimate

$$\theta = \frac{e^{(B_0 + B_1 x)}}{1 + e^{(B_0 + B_1 x)}} \quad (3.0)$$

individual, population, and community-level parameters is to fit a set of models that represents the researchers' hypothesis to a given data set to choose the most accurate model(s).⁸ A popular approach in ecological studies is to use model selection techniques such as Akaike's Information Criterion (AIC) to choose the model that best fits the data.⁸ However, an important assumption in using such model selection criteria, is that at least one model adequately fits the data.^{8,9} This raises concerns that without other methods to assess model fit, researchers could make the mistake of choosing the statistical model that best fits the data, rather than an ecological model that accurately describes the environment being studied.

A good ecological model of species distributions may hinge on accurate estimates of overdispersion.¹¹ Although the method for calculating the overdispersion parameter for occupancy models has been developed recently, few studies have investigated its accuracy with respect to the numerous effects it may have on different data sets.¹² Additionally, the application of this method is still not directly included in popular population modeling software such as MARK.¹³ However, the program does have the ability to call on other programs to assess model fit.

Despite this recent advancement in assessing model fit for site occupancy studies, few demonstrated studies have evaluated the potential effects of overdispersion on model results. We had two primary objectives. First, we review the method for assessing model fit used in our study.¹² Second, we validate its use in ecological studies. Specifically, we test the importance of assessing model fit on a data set of detection/non-detection data on winter bird habitat use in Northern Colorado to show the importance of accounting for model fit. With the recent development of powerful statistical software that has increased the access to modelling, studies that evaluate the importance of different methodologies within these programs are crucial to keep scientists aware of ways to evaluate the efficacy and reliability of their model sets.

Methods

Assessing model fit

MacKenzie and Bailey assess model fit by obtaining a test statistic for a model calculated as:

(4.0)

$$X^2 = \sum_{h=1}^{2^T} \frac{(O_h - E_h)^2}{(E_h)}.$$

By acquiring a test statistic the over dispersion parameter can be calculated as described by White et. al., and modified for occupancy studies in MacKenzie and Bailey:

(5.0)

$$\hat{c} = \frac{X^2_{obs}}{X^2_{\hat{c}}}.$$

In (5.0), the denominator represents the average test statistic obtained from the bootstrap procedure described above.^{12,14} This estimate can then be used to adjust variation and model selection criteria (i.e., switch from AIC to QAIC).

Field data collection

We collected data on winter bird habitat use from December 2012-March 2013. A total of 53 sites were sampled in Northern Colorado with four each site being sampled four times on average. Sites were sampled along a residential housing gradient built in ArcGIS 10 using a fixed kernel density estimator map that scaled the home range size of the coyote.¹⁵ This study was conducted simultaneously with a study investigating the effects of exurban development on mammalian habitat use. However, the home range size of the coyote is appropriate for this study as it is large enough to encompass the winter home range size of small passerines which were the focus of this study. This was then used as a resistance layer in a least-cost

distance map. For the purposes of this paper, this methodology will not be covered as it does not directly relate to assessing model fit. We mean to make no commentary based on the importance of these covariates, but rather use them to draw inference on how accounting for overdispersion can affect model inference.

Fixed-radius point counts were used at each of the 53 sites to assess winter bird habitat use. Each site was visited, then all birds were noted during the duration of a seven-minute count within a 100 meter radius. Additionally, we used ArcGIS to calculate the percent of privately owned land in a 40 meter radius around each point. To account for other anthropogenic covariates, we used a handheld palm pilot from the National Park Service Sounds and Night Sky Division to conduct 15-minute surveys at

each point. These surveys were then used to calculate the percent of audible non-natural noise. Finally, in a 25 meter radius around the center of each point, we recorded the ocular proportion of canopy cover, and percent understory cover (to the nearest 5%), and the average understory height of vegetation (to the nearest 0.1 meter). These data were used as site covariates in combination with the residential gradient, percent of land privately owned, and percent audible non-natural noise (Table 12). We chose to collect environmental covariates on a micro scale (25 meter radius around each point), and a macro scale (using ArcGIS) in order to attempt to accurately describe the possible variables that may affect species occurrence. Information on the time of day, temperature (average high for day in degrees C), wind (assessed qualitatively on a scale from 0-5),

Site Name	X Actual	Y Actual	Site Name	X Actual	Y Actual
B2-1	483867	4510303	G1-10	464200	4509073
B2-2	483615	4509717	G1-11	464294	4508333
B2-3	482956	4511847	G1-12	465458	4506880
B2-4	482416	4511103	G1-13	464549	4507127
C1-1	465868	4523248	G1-14	466535	4509776
C1-2	467140	4523731	G1-15	467205	4509168
C1-3	465948	4522843	G1-3	463982	4509791
C1-4	463235	4523412	G1-4	463348	4510539
C1-5	462516	4524985	G1-5	465144	4508427
C1-6	461007	4523529	G1-6	465288	4509670
C1-7	469975	4522413	G1-7	464643	4510563
C1-8	468295	4525369	G1-8	462950	4509562
C1-9	463482	4524075	G1-9	465185	4510246
C2-1	461618	4530621	G2-1	464477	4509977
C2-2	457867	4530278	G2-10	465407	4511262
C2-3	459928	4531678	G2-11	461741	4510321
C2-4	460574	4531915	G2-2	464815	4509810
C2-5	461067	4528801	G2-3	463724	4510151
C2-6	458701	4532193	G2-4	463936	4510501
C2-7	460237	4528897	G2-5	462689	4510645
DM-1	472006	4509257	G2-6	462535	4510406
DM-2	469541	4508237	G2-7	465378	4508030
DM-3	471298	4509557	G2-8	462803	4511118
G1-1	464493	4509513	G2-9	462505	4509727
U1-4	469009	4531360	U1-1	464366	4537487
U2-1	462181	4536457	U1-2	465027	4537177
U2-2	464785	4537422	U1-3	467735	4534961

Table 1. Coordinates for points located in Northern Colorado where data was collected

and percent cloud cover (to nearest 10%) was taken at each point. Furthermore, some point counts were only conducted a few minutes apart and therefore lacked temporal variation. To account for this in our model set, we used a “trap response covariate” as used by many mark-recapture studies.¹⁶ This will not be discussed extensively for the purposes of this study.

Data analysis

Program PRESENCE was used to fit occupancy models, calculate maximum likelihood estimations, and investigate the importance of accounting for overdispersion in occupancy models.⁵ For each species, a global model (i.e., most parameterized) was run with 10,000 parametric bootstraps.

We fit the occupancy parameter as constant with six site-level covariates, and fit detection probability as constant with six sample-level covariates (Table 1). For each species, we parameterized the occupancy to its most general state [$\Psi(\text{gradient} + \% \text{ canopy cover} + \text{own} + \% \text{ audible non-natural noise} + \% \text{ understory cover})$] and fit it with each of the possible covariates for detection probability (Table 2) to come up with the covariates that most impacted detection.³

Results

We fit single-season occupancy models on the American Robin (*Turdus migratorius*), the Black-billed Magpie (*Pica hudsonia*), the Steller’s Jay (*Cyanocitta stelleri*), the Townsend’s Solitaire (*Myadestes townsendi*), the Pygmy Nuthatch (*Sitta pygmaea*), the Dark-eyed Junco (*Junco hyemalis*), and the Mountain Chickadee (*Parus gambeli*).

Estimates of c-hat for the global model (i.e., most parameterized) varied by species. For example, the American Robin had an estimate of <one overdispersion, indicating the most global model is accurately modeling reality (Table 3). However, for the Steller’s Jay, the overdispersion factor was extremely high (Table 2; c=7.0).

The examination of two species yielded different overdispersion parameters, but both estimates were >1.0 reveals the effect of the c-hat parameter on model inference. The c-hat parameter for the Black-billed Magpie was 1.3. Accounting for overdispersion in the model set of the Black-billed Magpie caused model inference to change (Table 4). The most accurate model set (AIC weight>0.10), while not accounting for overdispersion revealed that occupancy was most impacted by land ownership and that detection probability was most impacted by wind (Table 3). However, after accounting for overdispersion within the data set (i.e., model set 2), the null model [$\Psi(\cdot), p(\text{wind})$], became

Occupancy (Ψ)	Detection Probability (p)
Constant	Constant
Percent Canopy Cover	Time of Day
Residential Gradient	Wind (1-5 scale)
Percent Understory Vegetation Cover	Temperature (C)
Average Understory Height	Percent Cloud Cover
Percent Audible Non-Natural Noise	Percent Canopy Cover
Percent of Land Private in 40m radius	Trap Response

Table 2. The covariates used to estimate site specific occupancy and detection probability.

Species	c-hat
Dark-eyed Junco	2.5
Black-billed Magpie	1.3
Townsend’s Solitaire	0.9
American Robin	0.5
Mountain Chickadee	1.0
Pygmy Nuthatch	1.3
Steller’s Jay	7.0

Table 3. Estimates of the overdispersion parameter as a result of 10,000 parametric bootstraps for each of the global models for the seven species.

Model Set 1	AIC	ΔAIC	AIC weight	K	-2LogLike
$\Psi(\text{ownership}), p(\text{wind})$	227.1	0	0.36	4	219.1
$\Psi(\cdot), p(\text{wind})$	227.47	0.37	0.21	3	221.5
$\Psi(\text{US height}), p(\text{wind})$	228.9	1.88	0.10	4	221.0
Model Set 2	QAIC	ΔQAIC	QAIC weight	K	-2LogLike
$\Psi(\cdot), p(\text{wind})$	170.25	0	0.24	3	221.5
$\Psi(\cdot), p(\text{wind})$	170.49	0.24	0.22	4	219.1
$\Psi(\cdot), p(\text{wind})$	171.88	1.63	0.11	4	221.0

Table 4. The most accurate models (AIC weight>0.10) for the black-billed magpie. The first set of models represent models that were not adjusted by the c-hat parameter, and second set represents models adjusted for over dispersion.

Model Set 1	AIC	ΔAIC	AIC weight	K	2LogLike
$\Psi(\text{US height}), p(\cdot)$	107.64	0	0.16	3	101.6
$\Psi(\text{US height}).p(\% \text{cloud})$	107.74	0.1	0.15	4	99.7
Model Set 2	QAIC	ΔQAIC	QAIC weight	K	2LogLike
$\Psi(\cdot), p(\cdot)$	107.74	0	0.15	2	105.9
$\Psi(\text{US height}), p(\cdot)$	46.21	0.33	0.13	3	101.6

Table 5. The most accurate models (AIC weight>0.10) for the dark-eyed junco. The first set of models represent models that were not adjusted by the c-hat parameter, and second set represents models adjusted for overdispersion.

the top model (i.e. model with highest QAIC weight). In both cases the third model in the top model set (AIC weight>0.10) showed that occupancy was impacted by understory vegetation height (US height).

The c-hat parameter for the Dark-eyed Junco was 2.5 (Table 2). In model set 1, which did not account for overdispersion, the first model (AIC weight=0.16) revealed that occupancy was impacted by understory vegetation height (US height), and that detection probability was constant. In model set 2, which did account for overdispersion, the most accurate model (AIC weight=0.15) was the null model [$\Psi(\cdot)$, $p(\cdot)$], revealing that occupancy and detection probabilities were constant across the landscape.

Discussion

For our selected species, and for this study area in Northern Colorado, we showed the importance of assessing overdispersion in population models. First, no two species had the same estimated overdispersion parameter. Although all species are common throughout their range and passerines (i.e., common songbirds), the range of values calculated for the overdispersion parameter differed greatly between species. This stresses the importance of calculating the overdispersion parameter for each species separately in conservation and management based research that include multiple species. Although the case could be made that species are generally similar in taxonomy and habitat use, even small differences can result in variation in the data set resulting a range of c-hat estimates. These results are similar to those reached by MacKenzie and Bailey, who found that accounting for overdispersion in occupancy studies was important to properly draw model inference, especially when assumptions of the models were violated.¹²

For the Black-billed Magpie and the Dark-eyed Junco, we examined the effect of accounting for overdispersion in the model set. In both species, adjusting for overdispersion greatly affected the inference drawn from the possible model set.^{5,12} Without this calculation, managers and conservationists could come to inaccurate misleading conclusions on species distributions, possibly leading to the improper use of resources. For example, if managers were concerned with Dark-eyed Junco conservation, and based their efforts on a model set that did not account for overdispersion, they might over emphasize restoring understory vegetation where in actuality species persistence was affected little by this covariate. This is a considerable concern when budgets and funding are limited in most agencies.

Adjusting for overdispersion has been

more properly documented and accounted for in count data and mark-recapture studies which share many similarities to site-occupancy estimations.¹⁷ Richards suggests there are four ways most studies deal with overdispersion in count data.¹⁷ First, is to estimate it, but to ignore it. Based on our results, failing to estimate the c-hat parameter for each should be greatly discouraged. Second, is to collect additional data (when data are available), to off-set for unexplained variation in the data set. Third, is to model the causes of variation (e.g., non-independence) directly in the model set by inclusion of covariates. Finally, overdispersion can be addressed by modifying model selection methods (e.g., switching from AIC to QAIC). Richards concluded that although in some species AIC and QAIC revealed similar results, and provided one of the first studies with quantitative support for QAIC.¹⁷

Despite the stressed importance of this, no method currently exists in some popular software used in mark/re-capture studies. For example, program MARK, one of the most popular programs used for population level research with an emphasis on presence/absence and mark/re-capture data, does not currently have the ability to estimate the c-hat parameter for occupancy studies.¹³ This suggests that a number of studies underutilize this method, and many may not be aware of its use in occupancy analysis, even though it is more commonly used in count data.

Acknowledgements

I would like to thank Erica Goad and Dr. Liba Pejchar, for their development of this project and help with its implementation. I would like to thank Dr. Larissa Bailey for first introducing me to occupancy modeling, and help in understanding its complexities. I also want to extend a thank you to all the private land owners who allowed us to collect data on their land, and the Center for Collaborative Conservation for funding this project.

References

- ¹Morrison, M. L., Marcot, B. G. and Mannan, R. W. (2006) *Wildlife-Habitat Relationships: Concepts and Applications*. Island Press.
- ²Gardner, T. A., Barlow, J. and Peres, C. A. (2007) "Paradox, presumption and pitfalls in conservation biology: the importance of habitat change for amphibians and reptiles." *Biological Conservation*. 138. Pg 166-179.
- ³MacKenzie, D. I., Nichols, J. D., Lachman, G. B., Droege, S., Royle, J. A. and Langtimm, C. A. (2002) "Estimating site occupancy rates when detection probabilities are less than one." *Ecology*. 83.8. Pg 2248-2245.
- ⁴Gu, W. and Swihart, R. K. (2004) "Absent or undetected? Effects of non-detection of species occurrence on wildlife-habitat models." *Biological Conservation*. 116. Pg 195-203.

- ⁵MacKenzie, D. I., Nicholls, J. D., Royle, J. A., Pollock, K. A., Bailey, L. L. and Hines, J. E. (2006) *Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence*. Academic Press.

- ⁶Geissler, P. H. and Fuller, M. R. (1987) "Estimating of the Proportion of Area Occupied by an Animal Species." In *Proceedings of the Section on Survey Research Methods of the American Statistical Association*. American Statistical Association. Pg 553-538.

- ⁷Azuma, D. L., Baldwin, J. A. and Noon, B. R. (1990) "Estimating the occupancy of spotted owl habitat areas by sampling and adjusting bias." USDA Forest Service General technical report. PSW-124.

- ⁸Burnham, K. P. and Anderson, D. R. (2002) *Model Selection and Multi-Model Inference: A Practical Information-Theoretic Approach*. Springer-Verlag.

- ⁹Anderson, D. R., Burnham, K. P. and White, G. C. (1998) "Comparison of Akaike information criterion and consistent Akaike information criterion for model selection and statistical inference from capture-recapture studies." *Journal of Applied Statistics*. 25.2. Pg 263-282.

- ¹⁰Guisan, A. and Thuiller, W. (2005) "Predicting species distribution: offering more than simple habitat models." *Ecology Letters*. 8. Pg 993-1009.

- ¹¹Potts, J. and Elith, J. (2006) "Comparing species abundance models." *Ecological Modeling*. 199. Pg 153-163.

- ¹²MacKenzie, D. I. and Bailey, L. L. (2004). "Assessing the fit of site-occupancy models." *Journal of Agricultural, Biological, and Environmental Studies*. 9.3. Pg 300-318.

- ¹³White, G. C. and Burnham, K. P. (1999) "Program MARK: survival estimation from population of marked animals." *Bird Study Supplement*. 46. Pg 120-138.

- ¹⁴White, G. C., Burnham, K. P. and Anderson, D. R. (2002) "Advanced Features of Program Mark." In *Integrating People and Wildlife for a Sustainable Future: Proceedings of the Second International Wildlife Management Congress*. Fields, R., ed. The Wildlife Society.

- ¹⁵ESRI (2011) *ArcGIS Desktop: Release 10*. Environmental Systems Research Institute.

- ¹⁶Riddle, J. D., Mordecai, R. S., Pollock, K. H. and Simons, T. R. (2010) "Effects of prior detections on estimates of detection probability, abundance, and occupancy." *The Auk*. 127.1. Pg 94-99.

- ¹⁷Richards, S. A. (2008) "Dealing with overdispersed count data in applied ecology." *Journal of Applied Ecology*. 45.1. Pg 218-227.

Discovery of the tallest redwoods in the Santa Cruz Mountains – their distribution and ecology

BY ZANE MOORE¹ AND STEVEN W. SINGER, MS²

¹COLORADO STATE UNIVERSITY, ²STEVEN SINGER ENVIRONMENTAL & ECOLOGICAL SERVICES

Abstract

*A search for tall trees in the coast redwood (*Sequoia sempervirens*) forests of the Santa Cruz Mountains was undertaken in the summer of 2012. Almost all publicly-accessible old-growth stands were searched, leading to the discovery of eleven additional trees greater than 90 m (295.2 ft) tall in several different stands. The tallest tree found was 100.01 m (328.1 ft) tall and was located in Big Basin Redwoods State Park. The previous record holder in the Santa Cruz Mountains was a redwood 93.08 m (305.38 ft) tall found in Portola Redwoods State Park.¹ In this article, we will discuss the ecological value of tall trees and speculate on the environmental conditions that favor the development of the tallest trees.*

Introduction

Naturalists and scientists have searched the northern reach of the redwood range in California and found some exceptionally tall trees, including Hyperion, at 115.72 m (379.65 ft) tall, the world's tallest known tree measured by Stephen Sillett in September 2011.² However, very little effort has been directed toward the southern part of the redwood range and prior to this study only three trees were known to exist that were more than 90 m tall.³

The coast redwood is a fast-growing, massive, and long-lived tree species that grows taller than any other tree in the world.⁴ Its natural occurrence is restricted to the coastal belt of summer fog or low stratus cloud cover that ranges from southwest Oregon to central coastal California and is only 8 – 58 km (5 – 35 mi) wide.⁴ Redwoods reach their best development in northern California where rainfall amounts and the frequency of summer fog are greater than in the Santa Cruz Mountains which are located in the southern portion of the redwood range.^{5,6,7}

Redwood forests, especially the few remaining old-growth stands, play a strong role in shaping their ecosystems. Individual trees can have an inordinately large impact on their forest stands. Below we discuss the impact of these trees in affecting water capture and providing living space for canopy flora and fauna, especially the endangered marbled murrelet (*Brachyramphus marmoratus*).

One way that redwoods capture water is through fog drip. Fog drip is moisture stripped from fog by vegetation, especially needle-leaf trees, which coalesces and drips onto the ground below. On the west coast of North America, it occurs primarily during the summer season when advection

fog forms offshore and is pushed inland and upward against the coastal range by prevailing westerly winds.⁸ Work done by Dawson of U.C. Berkeley in a northern California site that received heavy amounts of fog drip, found that up to 45% of the water used by redwood trees originated as fog drip precipitation.⁹ Fog drip onto the soil underneath a tree can not only increase plant available water but can also, over the long term improve biotic and abiotic soil properties.^{10,11} Recent studies have shown that redwood leaves can absorb some water directly from fog.¹⁰

Several studies have shown that fog drip is maximized under individual forest trees that are located in an exposed position such as on the windward edge of a stand or are taller in height than the rest of the stand.^{9,11,12,13} Oberlander measured fog drip with a single collector gauge under each of five trees for a five-week period between July and August on Cahill Ridge in the Santa Cruz Mountains.¹³ He collected 45 mm of fog drip precipitation under a mature redwood in the interior of a forest on the lee side of a ridge, while a Douglas-fir tree in a fully exposed position on the ridge top received 434 mm of fog drip.

Old-growth redwoods and Douglas-firs develop large branches that provide a substrate for other life forms. A diverse community of lichens, mosses, ferns, insects, arthropods and other species is sometimes found in the canopies of old-growth trees. These epiphyte communities are slow to form and only exist because long-lived trees are present in a stable environment that allows them to grow very old. In Northern California, where the climate is wetter and crown fires are less frequent, these epiphytic communities have

reached their greatest development – even supporting a new population of totally arboreal salamanders.^{14,15} In the Santa Cruz Mountains epiphytic communities have significantly less vegetation cover and a more limited biodiversity, but they still provide habitat for an endangered bird species – the marbled murrelet.¹⁶

The tallest trees in a stand may provide preferred nesting sites for the marbled murrelet. A study of 59 murrelet nests in British Columbia found that trees selected for nesting were both taller and larger in diameter than other trees in the stand.¹⁷ A study of all documented nests in the Santa Cruz Mountains did not find a preference for taller trees, but the sample size was only 17. However, that study did find a statistically significant preference for murrelets to nest in the largest diameter trees in a stand.¹⁸ A study of nine nests in Redwood National Park did not find that murrelets selected taller trees when choosing a nest site, but did find that the average tree height of successful nests (58.6 m) was taller than the average tree height of failed nests (52.8 m).¹⁹ In both cases the average nest height was similar. We postulate that murrelets may prefer taller trees and/or larger trees because they have higher quality potential nest sites.^{17,18}

Knowing the habitat variables that are most favorable for redwood growth in the Santa Cruz Mountains will be helpful when trying to understand how changes to these parameters brought about by global warming will impact tree growth. Extensive information is being collected at a different old-growth tree stand in Big Basin Redwoods State Park through the Redwoods and Climate Change Initiative Study instigated by the Save the Redwoods League, but no studies have yet looked at the habitat

variables held in common by all known tall tree areas. Through this simple study we hope to initiate that exploration.

Study Area

The study area consisted of almost all the publicly-accessible old-growth redwood stands in the Santa Cruz Mountains which included 12 properties ranging in size from 8 to 1,845 ha (20 to 4,560 acres) in size (see Table 1) and totaled 2,880 ha (7,116 acres). Stands searched for tall trees included Big Basin, Portola, Henry Cowell, and Butano state parks, and several county parks (see Table 1 and Figure 1). The areas that were surveyed represent about 70 percent of the remaining old-growth in the Santa Cruz Mountains.²⁰ These include most of the alluvial flat or valley bottom stands, which are known to support the largest trees.²¹ Consequently, we believe there will be few if any exceptionally tall trees in the old-growth stands that we did not examine.

Methods

We used maps of old-growth stands that we had produced previously to prescribe the areas that would be searched for exceptionally tall trees.^{20,22} These maps covered the entire Santa Cruz Mountains and were based on stereoscopic review of black and white aerial photos produced for the Big Creek Lumber Company in 1994 at a scale of 1:15,840. Old-growth stands were defined as stands having at least 10 old-growth trees per acre with old-growth trees being characterized by having old-growth structure (such as old-growth crown and branch structure) and having a diameter at breast height (DBH) of at least 1.0 m (3.28 feet). Old-growth trees were identified based on a combination of factors, including crown shape, size, gray-scale color, and the relative height of dominant trees compared to other trees in the stand. The advantage of stereo imagery is that it provides the dimension of height which allows one to recognize the tight clusters of second-growth redwood that originate from stump sprouts and appear to be a single large-crowned old-growth tree when viewed on regular two-dimensional aerial photos, orthophotos, or computer-generated aerial photos.

We searched for tall trees by walking through old-growth stands, bordering slopes, or ridgetops and looking into the stand. A majority of the trees in each surveyed stand were measured with a hand-held Impulse 200 LR Laser Rangefinder, which had an accuracy of plus or minus 0.30 m when hand-held and plus or minus 0.05 m when mounted on a tripod.

The height of all potential trees greater than 90 m was measured by trigonometric

leveling using a tripod-mounted Impulse 200 Laser Rangefinder and a tripod-mounted prism. The top of the tree was defined by sighting on the characteristic top tuft; the bottom of the tree was at the ground level. The ground level was taken to be the average of the top of the litter layer on the uphill side of the tree and the top of the litter layer on the downhill side of the tree.

The DBH of each tree was calculated from the circumference at 1.37 m above the lower ground level of the tree. If the tree was located on a slope and the upper ground level was more than 1.37 m above the lower ground level, then the circumference was measured at the upper ground level.

Although we discuss them below, we did not measure other ecological attributes of tall trees such as the number of potential murrelet nest sites or the quantity of fog drip. We estimated fog drip for our exceptionally tall trees by relying on a previous review of fog drip potential in the Santa Cruz Mountains.²³

Results and Discussion

Ten trees taller than 90 m (295.29 ft) were discovered and one more was found with a height of 89.93 m (295.05 ft). We consider these to be exceptional trees as previously there were only three trees known to be 90 m or taller^{1,24,25}. These exceptionally tall trees were in solitary settings, except for one small grove of four trees, and were found only in Big Basin Redwoods State Park and Portola Redwoods State Park (see Table 2). Some trees almost as tall were found in Heritage Grove County Park. The DBH values ranged from 2.59 m (8.5 ft) to 4.45

m (14.6 ft), although several trees had fused multiple trunks at breast height and were not measured.

For a tree to become one of the tallest trees in the stand, it needs a combination of good longevity and optimal growing conditions. Growing sites with reduced incidences of wildfire, high winds, and falling trees (especially comparatively short-lived Douglas-fir trees) might provide the longevity, but the environmental conditions that optimize growth rates in old-growth redwoods are not fully known – especially in the redwood’s southern range.

We looked at six of the most basic physical environmental parameters associated with these exceptionally tall trees and present the results in Table 3 below.

Our initial review of the site conditions associated with these 14 tall trees suggests that the following habitat variables warrant additional investigation (Table 3): (1) perennial water source present, (2) average annual precipitation of at least 1070 mm (42 in), (3) moderate to high frequency of stratus cloud cover, (4) alluvial or lower slope landscape position, (5) location between 10.8 and 12.1 km from the coast, (6) location within a deep canyon setting, and (7) location on a site free from historic crown fires.

Perennial water source

13 of 14 tall trees had a perennial source of either surface or near-surface water, whether it was a spring, creek, or both. For the coast redwood and other tree species as well, perennial water promotes maximum growth because it allows for maximum water intake—something vital for tree height.

Old-Growth Stand Number	Old-Growth Stand Name	Stand Size (ha)
1	Big Basin Redwoods State Park	1,845
2	Portola Redwoods State Park	391
3	Butano Redwoods State Park	243
4	Pescadero Creek County Park	130
5	Memorial County Park	97
6	Henry Cowell State Park	65
7	Roaring Camp Railroads	51
8	Nisene Marks State Park	15
9	Miller Property County Park	13
10	Heritage Grove County Park	12
11	Sam McDonald County Park	10
12	San Francisco YMCA Camp	8
Total		2,880 ha.

Table 1. Old-growth Stands Searched
Note: Old growth properties searched were given a number based on amount of area. These properties’ numbers are found on the corresponding map (Figure 1).

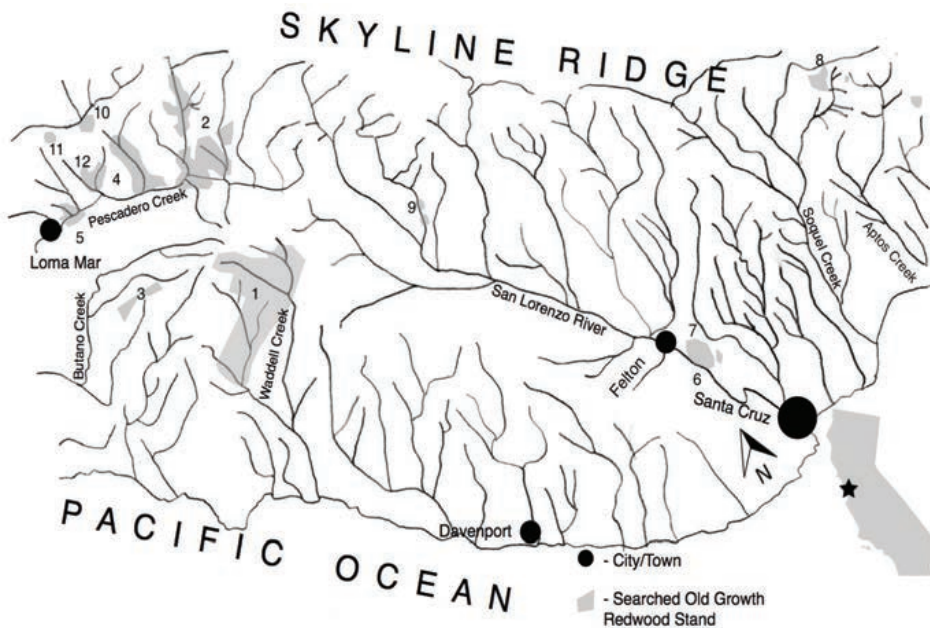


Figure 1. Location of Old-Growth Stands that were Searched for Exceptionally Tall Trees
Note: This map displays the areas searched by the authors (in grey). Stand numbers refer to the stand names found in Table 1.

Precipitation more than 1070 millimeters (42 inches)

All 14 of the tall tree sites had average annual precipitation of 1070 mm or more. Rainfall within the redwood region of the Santa Cruz Mountains varies from 741 to 1236 mm, with the higher amounts associated with higher elevations.

Moderate to high frequency of stratus cloud cover

A stratus cloud or fog layer is frequently associated with the redwood belt in summer months.⁸ Its presence benefits redwood water relations through higher humidity levels and cooler temperatures that act together to reduce the evapotranspiration rate. The top of the summer stratus cloud layer on the coastal side of the Santa Cruz Mountains is typically between 455 and 610 m high, although it varies from day to day.²⁷ Redwoods are not confined to locations below 610 m and our search for exceptionally tall trees was not limited to areas below 610 m in elevation. Since the stratus layer penetrates inland from the ocean, trees growing on locations less than 455 m elevation and not blocked from the ocean by an intervening north-south ridge would frequently be under the stratus layer. In contrast, trees growing at elevations above 610 m, or at other elevations on the leeward side of ridges that were 610 m or higher, would seldom be under the stratus layer. Using these considerations, we estimated the frequency of stratus cover for our tall trees in

Table 3 as “high” or “low”, respectively, with situations in-between rated as “moderate”. All but one of the tall tree sites rated moderate and the other rated high.

Alluvial or lower slope position

13 of 14 tall trees were located on either an alluvial plain or a lower slope topographic position and one tree was located on a stream terrace. Alluvial sites and lower slopes are usually associated with higher soil water availability.

Location between 10.8 and 12.1 km from the coast

Of the fourteen redwood tall trees known, nine are positioned from 10.8 – 12.1 kilometers (6.7 – 7.5 miles) away from the coast. Why this is the case remains unknown. A similar condition exists in northern California (Mendocino, Humboldt, and Del Norte counties) where the tallest coast redwoods are found from 8.0 – 11.2 km (5.0 – 7.0 miles) from the coast.¹ In our study, the closest redwood over 90 meters was located 8.4 km (5.2 miles) from the coast and the furthest redwood over 90 meters was located 18.5 km (11.5 miles) away from the coast (see Figure 2). In the northern redwood range, the closest redwood known over 106 meters (350 feet) is approximately 4.6 kilometers (2.85 miles) away from the coast and the farthest redwood known over 106 m is 45 kilometers (28 miles) away from the coast.¹

Deep canyon settings

Ten of our exceptionally tall trees were growing in deep canyon settings. These were locations where a ridge at least 75 m higher than the base of the tree was within 300 m or less of the tree and located to the south or west. Trees growing under such conditions would benefit from lower evapotranspiration rates due to such factors as shading in the late part of the day, cooler temperatures, protection from drying winds or wind damage, and increased local humidity. These conditions could favor more rapid tree growth if soil moisture was a primary limiting factor and irradiation levels were sufficient.

Trees regularly compete with neighboring trees for sunlight until one tree grows higher than its neighbors. However, trees growing in a deep canyon may still be shaded for part of the day or shaded in part for all the day. In canyons with a bordering ridge on the south or west, we observed that shading from the ridge blocks direct sunlight for an extra half-hour or hour before sunset each day. Yet if a tree is appropriately located, it can grow tall enough to extend into the direct sunlight above the ridge’s shadow. We speculate that some of our tall trees grew as tall as they did because they were competing with a bordering ridge for sunlight. This is analogous to the situation of seedlings grown in solid-walled translucent tree shelters that provide some degree of lateral shading. Such seedlings, including redwood seedlings, will grow taller faster than open-grown unshaded trees in order to extend above the top of the tube where direct sunlight is available.^{28,29,30} Thus deep canyon settings may encourage the development of exceptionally tall trees.

Sites free from severe crown fires

The mean fire recurrence interval in redwood forests of the Santa Cruz Mountains has changed over time. Prior to the 19th century, and under the influence of aboriginal burning, it was reported to be between 8 and 12 years (for northeastern Santa Cruz Mountains) and 17 and 82 years (for southern Santa Cruz Mountains).^{31,32} In the 1800’s and early 1900’s fires were more frequent due to logging activities and the recurrence intervals were reported to be either 4 to 12 years or 20 to 50 years.^{31,32} Since then fires have been much less frequent.

In all cases, the majority of the fires were ground fires that did not spread into the crown, or only did so in an occasional tree or group of trees. Widespread crown fires, where the fire spreads directly from crown to crown, were very uncommon.³³ Historical records indicate that the last severe crown fire to impact a large part of Big Basin Redwoods State Park was the 1904 fire which started near Waterman Gap and

Old-Growth Property	Height of Tallest Tree (m)	Number of Exceptionally Tall Trees
Big Basin Redwoods State Park – East Half	100.01 (328.12 ft)	9
Big Basin Redwoods State Park – West Half	92.20 (302.48 ft)	1
Portola Redwoods State Park – North	91.97 (301.75 ft)	2
Portola Redwoods State Park – South	93.08 (305.38 ft)	2
Heritage Grove County Park	88.81 (291.39 ft)	0

Table 2. Distribution of Exceptionally Tall Trees by Location. This table shows the distribution of tall trees (>90 m) in the tallest Santa Cruz Mountain groves.

Trees as identified by height (m) ¹	Extant Perennial Water Source?	Approx. Annual Ppt. ² (mm/yr)	Rel. Freq. of Summer Stratus Cloud Cover ³	Landscape Position and Aspect	Elev. (± 15 m)	Distance from Coast (km)
100.01 ⁴ (328.12 ft)	Yes, Spring	1190	Mod.	Lower Slope SW	435	11.3
99.17 ⁴ (325.36 ft.)	Yes, Spring	1190	Mod.	Lower Slope SW	435	11.3
93.08* (305.38 ft)	No	1120	Mod.	Lower Slope S	225	16.6
93.02 (305.18 ft)	Yes, Spring, Creek	1170	Mod.	Alluvial Site	225	18.0
92.95 (304.96 ft)	Yes, Spring	1190	Mod.	Lower Slope NE	435	11.3
92.23 (302.58 ft)	Yes, Spring	1220	Mod.	Lower Slope E	330	11.6
92.20 (302.48 ft)	Yes, Spring	1120	High	Alluvial Site	180	8.4
91.97 (301.75 ft)	Yes, Creek	1070	Mod.	Alluvial Site	210	18.5
90.33 (296.39 ft)	Yes, Creek	1220	Mod.	Lower Slope N	375	10.8
90.29 (296.22 ft.)	Yes, Creek	1120	Mod.	Lower Slope NE	195	18.3
90.22* ⁵ (296.0 ft.)	Yes, Creek	1220	Mod.	Alluvial Site	315	11.6
90.13* (295.70 ft.)	Yes, Spring	1220	Mod.	Terrace	330	10.8
90.11 (295.63 ft.)	Yes, Spring, Creek	1190	Mod.	Lower Slope NE	390	12.1
89.93 (295.05 ft.)	Yes, Spring	1190	Mod.	Lower Slope NE	435	11.3

Table 3. Environmental Conditions Associated with Exceptionally Tall Trees

¹Asterisks (*) indicate trees known previously and not discovered by us.

²Rantz, 1971.²⁶

³Estimated relative frequency of stratus cloud cover, rated as High, Moderate, or Low and based on elevation, topographic position, and distance inland.

⁴Height measured by Steve Sillett in September 2012 via direct tape drop.²

⁵Height measured by Steve Sillett in December 2009 via direct tape drop.²



Figure 3. Top of Old Tree in Portola Redwoods State Park



Figure 4. Typical Tall Tree Top



Figure 5. Spire-shaped Tree Top

spread rapidly under the influence of strong and dry northeast winds through the eastern portion of the park.³⁴ Park fire history maps and historic maps, indicate that the area containing the greatest collection of tall trees in Big Basin was not impacted by the 1904 fire and only two of our tall trees were found within the 1904 burn area.^{35,36} This may reflect the fact that crown fires, even though they seldom kill redwoods, will kill the tops of the trees where the bark is thinner and there is less protection for dormant buds. Height growth will be delayed because a new leader will have to form at a lower point on the tree bole. Moist canyons, like streamside groves, might have a lower probability of experiencing crown fires, which would reduce the risk of top damage and also increase the longevity of trees growing there, potentially allowing them to reach higher heights.³³

Surface fires may also influence tree growth rate through the formation of fire scars including large basal hollows in live

trees called goosepens. We observed that none of our tall trees had goosepens even though nearby trees occasionally did. We postulate that the effects of goosepen formation, such as the loss of the basal sapwood (including the xylem layer which conducts water upwards in the tree) and loss of the associated root network (due to loss of the phloem layer) are significant factors that can reduce tree height.

Other observations

All of the tall tree redwoods south of San Francisco have live tops. Thirteen of the trees have an erect, straight top leader. Old Tree in Portola Redwoods State Park happens to be the exception. Currently, Old Tree's leader is leaning rather distinctly but tree height is still 93.08 meters, indicating a significant growth in height since its last measurement in 2007 (see Figure 3).

All but one of the straight-topped trees resemble Figure 4, a 91.97 m tree found in

Portola Redwoods State Park. The crown has many lateral branches near the top of the tree with a vertical leader exactly in the middle of the tree. Another tree in Portola Redwoods State Park has a very small top without many lateral branches near the top (see Figure 5). Its first large branch is 20 feet below the top. Many young redwoods have crowns similar to this. Young trees emphasize growth in height initially and then once they've reached maturity, they branch out more and grow much more slowly in height.³⁷ This tree's small, pointed top and scarcity of lateral branches below suggests that it will keep growing and gain height more quickly than the other 90 m trees in Table 3.

Conclusions

Although redwoods in Santa Cruz Mountains do not grow as tall as do redwoods in Northern California, they can grow as high as 100.01 m (328.12 ft), which is higher than they are known to achieve in Marin County to the North and Monterey County to the South.

Exceptionally tall redwoods in the Santa Cruz Mountains are most closely prescribed by the presence of a perennial source of water, either spring or stream, and being situated inland from the coast at least 8.4 km and usually 10.8 km or more yet still lying within the marine overcast zone. A majority of the 90 m trees stand in the bottom of a deep canyon. Such settings can reduce evapotranspiration through shading in the late parts of the day, cooler temperatures, and increased humidity, thereby favoring more rapid tree growth. Although global warming models for Central California are unclear as to the changes that will occur in fog frequency and annual precipitation, other evidence has found a decrease in fog frequency.^{38,39,40} It is clear that average annual temperatures will increase, and therefore refuges provided by streams, spring-side areas, deep-canyon settings, and other as yet unidentified habitat variables (such as soil conditions) may be vital for the maintenance

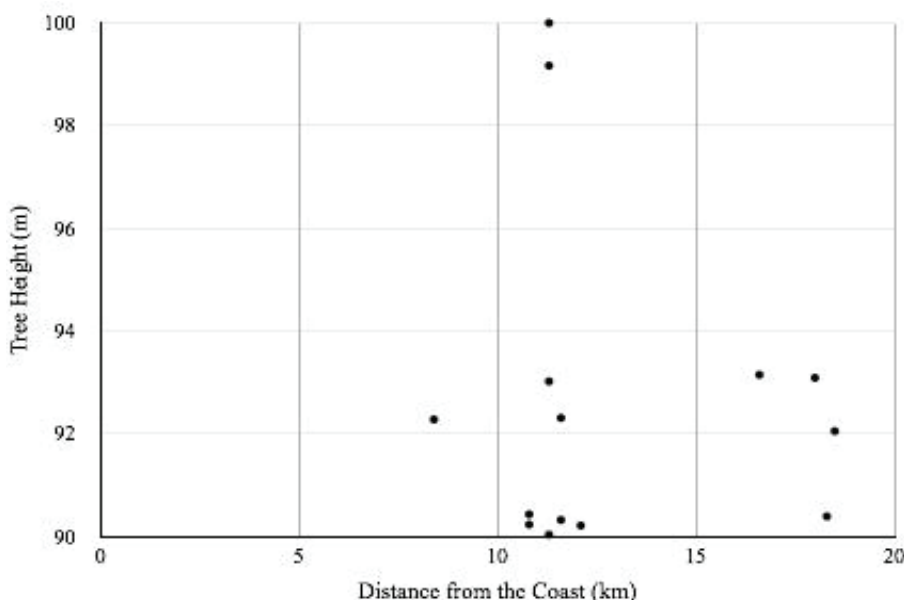


Figure 2. Exceptionally Tall Trees and Their Distance from the Coast

of healthy redwood communities.³⁹ Through further investigation of our tall tree areas we hope to identify what other factors may be important for producing exceptional redwood trees in the Santa Cruz Mountains.

Acknowledgements

We thank the staff at Big Basin Redwoods State Park, Butano Redwoods State Park, Portola Redwoods State Park, and the Santa Cruz District Office of the California State Parks Department, especially Susan Blake, Jason Rule, and Tim Hyland. We gratefully acknowledge the laser measurement assistance that was provided by Steve Moore, Angelo David, and Miguel Menendez-Pidal. We'd also like to thank Stephen Sillett, who provided tape drop measurements of our two tallest trees, and two anonymous reviewers, who provided helpful comments on an earlier draft of the manuscript. Finally, this study would not have been possible without the overwhelming help and support of Michael Taylor, who not only helped to confirm our measurements but also provided necessary equipment such as laser rangefinders, tripods, tapes and prisms.

References

- ¹Taylor, M. Personal communication. 19 Oct. 2011.
- ²Sillett, S. Personal communication. 6 Dec. 2009.
- ³Taylor, M. Personal communication. 16 Sept. 2011.
- ⁴Eyre, F. (1980) Forest Cover Types of the United States and Canada. Society of American Foresters.
- ⁵Evarts, J. and M. Popper. (2011) Coast Redwood: A Natural and Cultural History. Cachuma Press.
- ⁶Oneal, C., Stuart, J., Steinberg, S. and Fox, L. III. (2006) "Geographic Analysis of Natural Fire Rotation in the California Redwood Forest During the Suppression Era." *Fire Ecology* 2.1. Pg 73-99.
- ⁷Ornduff, R. (1998) "The Sequoia sempervirens (Coast Redwood) Forest of the Pacific Coast, USA". Pg 221-236 in Laderman, A., Coastally Restricted Forests. Oxford University Press.
- ⁸Patton, C.P. (1956) "Climatology of Summer Fogs in the San Francisco Bay Area." University of California Publications in Geography 10.3. Pg 113-200.
- ⁹Dawson, T. (1998) "Fog in the California Redwood Forest: Ecosystem Inputs and Use by Plants." *Oecologia* 117. Pg 476-485.
- ¹⁰Burgess, S. and T. Dawson. (2004) "The Contribution of Fog to the Water Relations of Sequoia sempervirens (D. Don): Foliar Uptake and Prevention of Dehydration." *Plant, Cell, and Environment* 27. Pg 1023-1034.
- ¹¹Singer, S., (2007) "A Forest and Watershed Evaluation of the Crestline Property in the Santa Cruz Mountains." Unpublished report prepared for the owner. Steven Singer Environmental and Ecological Services.
- ¹²Azevedo, J. and D. Morgan. (1974) "Fog Precipitation in Coastal California Forests." *Ecology* 55.3. Pg 1135-1141.
- ¹³Oberlander, G. (1956) "Summer Fog Precipitation on the San Francisco Peninsula." *Ecology* 37.4 Pg 851-852.
- ¹⁴Sillett, S. and M. Bailey. (2003) "Effects of Tree Crown Structure on Biomass of the Epiphytic Fern *Polypodium scolieri* (Polypodiaceae) in Redwood Forests." *American Journal of Botany* 90. Pg 255-261.
- ¹⁵Spickler, J., Sillett, S., Marks, S., and Welsh, H. Jr. (2006) "Evidence of a New Niche for a North American Salamander: *Aneides vagrans* Residing in the Canopy of Old-Growth Redwood Forest." *Herpetological Conservation and Biology* 1.1. Pg 16-27.
- ¹⁶Singer, S., Naslund, N., Singer, S. and Ralph, C. (1991) "Discovery and Observations of Two Tree Nests of the Marbled Murrelet." *Condor* 93.2. Pg 330-339.
- ¹⁷Silvergieter, M. and Lank, D. (2011) "Marbled Murrelets Select Distinctive Nest Trees Within Old-Growth Forest Patches." *Avian Conservation and Ecology* 6.2. Pg 3-16.
- ¹⁸Baker, L., Peery, M., Burkett, E., Singer, S., Suddjian, D. and Beissinger, S. (2006) "Nesting Habitat Characteristics of the Marbled Murrelet in Central California Redwood Forests." *Journal of Wildlife Management* 70.4. Pg 939-946.
- ¹⁹Golightly, R., Hamilton, C. and Hebert, P. (2009) "Characteristics of Marbled Murrelet (*Brachyramphus marmoratus*) Habitat in Northern California." Unpublished report prepared by the U.S. National Park Service and the California Department of Fish and Game.
- ²⁰Singer, S. (2003) "Old-Growth Forest Stands in the Santa Cruz Mountains." Unpublished report prepared for Save the Redwoods League.
- ²¹Fowells, H. (1965) *Silvics of Forest Trees*. Agricultural Handbook No. 271. U.S. Dept. of Agriculture, Forest Service.
- ²²Singer, S. (1998) "Extent of Old-Growth Forests in the Santa Cruz Mountains." Unpublished report prepared for Big Creek Lumber Company.
- ²³Singer, S. (2001) "'Fog Drip' in Watershed Resources Management Plan for the Santa Cruz Watershed Lands." Unpublished report prepared for the Santa Cruz City Water Department.
- ²⁴Blozan, W. Personal communication. 4 June 2012.
- ²⁵Blake, S. Personal communication. 12 May 2012.
- ²⁶Rantz, S. (1971) "Precipitation Depth-Duration-Frequency Relations for the San Francisco Bay Region. Basic Data Contribution No. 25, San Francisco Bay Region Environmental and Resources Planning Study." U.S. Geological Survey.
- ²⁷Hoffman, N. Personal communication. 25 July 2012.
- ²⁸Devine, W. and Harrington, C. (2008) "Influence of Four Tree Shelter Types on Microclimate and Seedling Performance of Oregon White Oak and Western Red Cedar." Research Paper PNW-RP-576. Pacific Northwest Research Station.
- ²⁹Svihra, P., Burger, D., and Harris, R. (1996) "Treeshelter Effect on Root Development of Redwood Trees." *Journal of Arboriculture* 22.4. Pg 174-178.
- ³⁰Holbrook, N. and Putz, F. (1989) "Influence of Neighbors on Tree Form: Effects of Lateral Shade and Prevention of Sway on the Allometry of Liquidambar styraciflua (Sweet Gum)." *American Journal of Botany* 76.12. Pg 1740-1749.
- ³¹Stephens, S. and Fry, D.D. (2005) "Fire History in Coast Redwood Stands in the Northeastern Santa Cruz Mountains, California." *Fire Ecology* 1.1. Pg 1-19.
- ³²Greenlee, J. and Langenheim, J. (1990) "Historic Fire Regimes and Their Relation to Vegetation Patterns in the Monterey Bay Area of California." *American Midland Naturalist* 124.2. Pg 239-253.
- ³³Sugihara, N., Van Wagtenonk, J., Shaffer, K., Fites-Kaufman, J. and Thode, A. (2006) "Fire in California's Ecosystems." University of California Press.
- ³⁴Meadows, D. (1950) "A Manual of the History and Biology of the Big Basins Redwoods State Park, California." Unpublished report prepared for Big Basin Redwoods State Park.
- ³⁵Langenheim, J., Greenlee, J. and Benson, A. (1983) "Fire History Map of Big Basin Redwoods State Park." Unpublished map prepared for the California State Parks Department.
- ³⁶Pope, J. (1912) "Map of California Redwood Park, Santa Cruz County, California."
- ³⁷Sillett, S., Van Pelt, R., Koch, G., Ambrose, A., Carroll, A., Antoine, M. and Mifsud, B. (2010) "Increasing Wood Production through Old Age in Tall Trees." *Forest Ecology and Management* 259. Pg 976-994.

³⁸Lebassi, B., Gonzalez, J., Fabris, D., Maurer, E., Miller, N., Milesi, C., Switzer, P. and Bornstein, R. (2009) "Observed 1970-2005 Cooling of Summer Daytime Temperatures in Coastal California." *Journal of Climate* 22. Pg 3558-3573.

³⁹Chaplin-Kramer, R. (2012) "Climate Change and the Agricultural Sector in the San Francisco Bay Area: Changes in Viticulture and Rangeland Forage Production Due to Altered Temperature and Precipitation Patterns." California Energy Commission.

⁴⁰Johnstone, J. and Dawson, T. (2010) "Climatic Context and Ecological Implications of Summer Fog Decline in the Coast Redwood Region." *Proceedings of the National Academy of Sciences* 107. Pg 4533-4538.

Creation of a single-vector I-SceI-based allelic exchange system

BY FAITH M. ROBISON, BRIAN H. KVITKO, PhD, HERBERT P. SCHWEIZER, PhD, AND ROXANN KARKHOFF-SCHWEIZER, PhD
COLORADO STATE UNIVERSITY

Abstract

Counter-selection markers are used extensively as genetic tools and have become an essential part of genomic engineering. One broadly applicable counter-selectable system in use is the I-SceI endonuclease, along with its rare 18 bp recognition site. Current systems for I-SceI counter-selection introduce I-SceI and sce sites in two steps because of the high activity of the I-SceI protein. Drawbacks of the two-step system are that they typically require additional selection markers which may not be available for some organisms, and that they require additional time for mutant construction. The purpose of this project was to create a broadly applicable one-step counter-selection system based on a single plasmid containing both an I-SceI gene encoding a temperature-dependent enzyme and sce sites. A pool of mutant I-SceI alleles was generated using mutagenic PCR and screened for temperature-sensitive alleles. The resulting pEXSceM0 and pEXSceMQ vectors carry both a mutated I-SceI structural gene expressing a temperature-sensitive I-SceI enzyme and two sce sites flanking a multiple cloning site. The utility of the pEXSceM0 vector was confirmed by creating a deletion of the amrRAB-oprA region in a Select Agent excluded Burkholderia pseudomallei strain. The newly developed plasmids will expand the utility of the I-SceI/sce counter-selection system.

Introduction

Counter-selection against unwanted DNA sequences is an integral step in many bacterial allele replacement systems. The various methods that have been described over the years employ different counter-selection strategies that are usually based on markers or properties that bestow a deleterious phenotype on the bacteria when they are cultivated under certain conditions. For instance, the widely used *sacB*¹ and *pheS*² counter-selection markers are toxic to the bacteria in the presence of the respective substrates sucrose and chlorophenylalanine.

The I-SceI system has been engineered as an alternative positive counter-selectable marker for genetic manipulations.³ The advantage of this system is that it does not rely on addition of substrates and is thus widely applicable in organisms where other counter-selection methods based on substrates such as sucrose and chlorophenylalanine are not applicable. The I-SceI gene codes for a homing-endonuclease found in the yeast *Saccharomyces cerevisiae*. I-SceI belongs to the LAGLIDADG homing endonuclease family and is a heterodimer that cleaves DNA by creating a double stranded break at an asymmetrical, non-palindromic, rare 18 bp nucleotide recognition site, leaving 4 bp overhangs exposing a 3'OH group open for recombination.^{4,5} Double stranded breaks are resolved by either repairing the break resulting in gene conversion or extensive single-

strand degradation leading to nonreciprocal crossovers creating a deletion.⁶ In its natural host, I-SceI is responsible for the mobility of introns in the mitochondria of yeast, initiating gene conversion or crossovers creating deletions. I-SceI creates crossover deletions at a higher frequency compared to the frequency of gene conversions.⁶

I-SceI restriction enzyme recognition sites are not found in bacterial chromosomes and cleavage of the chromosome will thus only occur at artificially introduced sce sites. Currently, researchers use the I-SceI gene and sce sites counter-selection by introducing the two components in a two-step procedure (Figure 1). In standard bacterial allelic exchange strategies, the first step is to generate a merodiploid strain via homologous recombination into the host chromosome. This is done by using a plasmid vector carrying the substitution allele as well as sce site(s) encoded in the vector backbone.⁷ The second step introduces the I-SceI gene expression plasmid, which results in I-SceI cleaving the marked DNA at the sce sites creating a double-stranded break. This step increases rates of recombination and provides selection for a second homologous recombination event to replace the chromosomal allele with the vector carried allele.^{3,7} However, by isolating an I-SceI allele encoding an enzyme with temperature-dependent activity, the I-SceI gene and sce site could be combined into a single

plasmid, which would be stable at permissive temperatures, greatly simplifying the use of I-SceI in genomic engineering.

A library of mutant I-SceI alleles has been created by mutagenic PCR and screened proteins encoded by these alleles for their ability to cure plasmids carrying sce sites in a temperature-dependent fashion. An I-SceI allele with enhanced activity at 42°C but reduced activity at 33°C was used for the creation of the allelic exchange vector, pEXSceM0, containing both an I-SceI gene and sce sites. The utility of our temperature-dependent I-SceI allelic exchange vector was demonstrated by deleting the *amrRAB-oprA* multidrug efflux pump structural and regulatory genes from the Select Agent-excluded *Burkholderia pseudomallei* strain, Bp82. This generated a strain with enhanced susceptibility to aminoglycosides and macrolides.^{8,9}

Results and Discussion

Isolation of mutant I-SceI alleles

A pool of I-SceI mutants was initially created for testing with a two-plasmid counter-selection system by mutagenic PCR, followed by cloning the I-SceI gene into pARAGW, replacing the Gateway cassette. This provides positive selection for clones with a replaced cassette. Only clones with a replacement could survive due to toxicity of the CcdB toxin carried by the GW cassette. Isolated colonies were picked by a Qpix

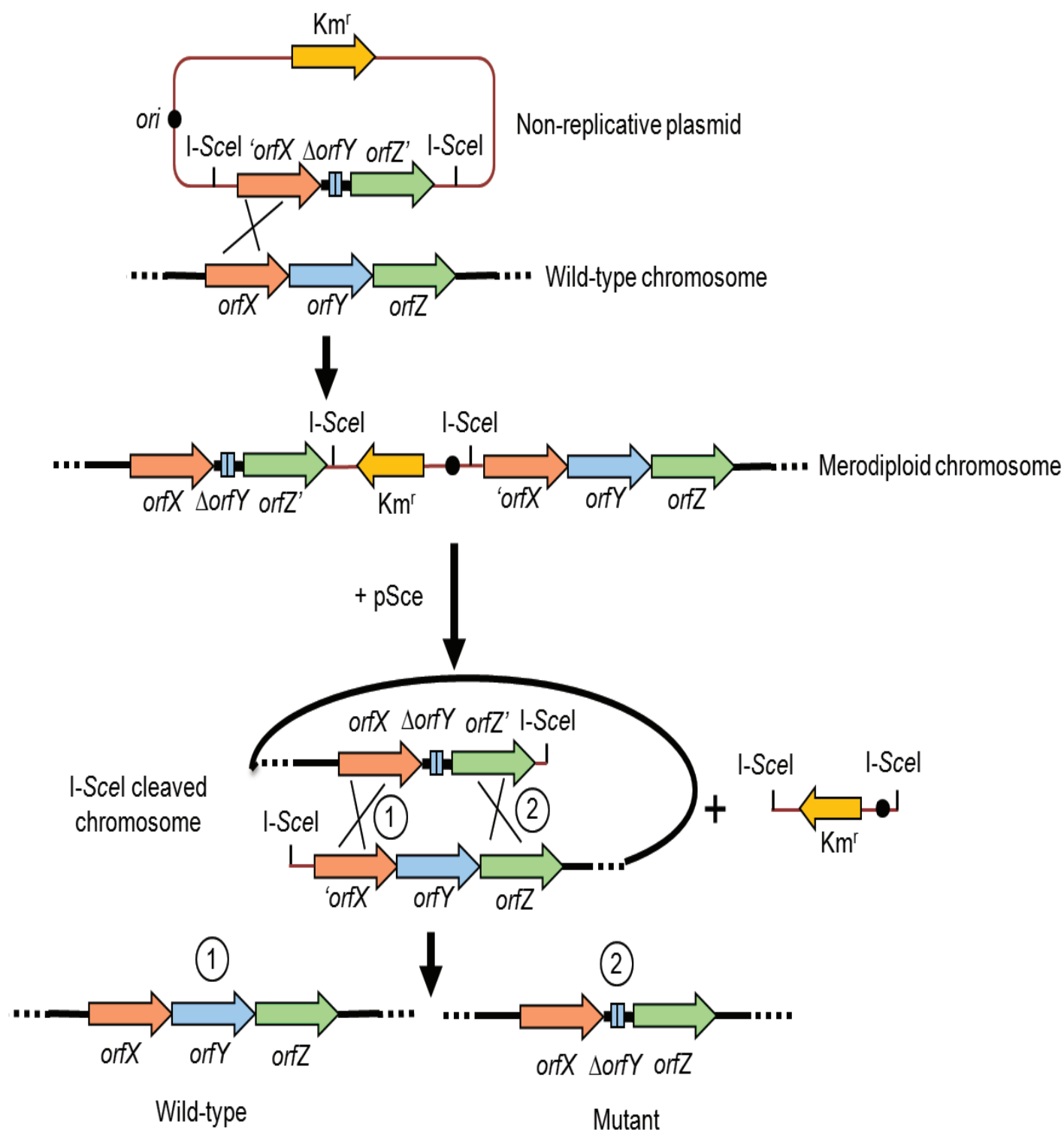


Figure 1. Schematic of two-step I-SceI allelic-exchange procedures. A chromosomal segment containing a deletion of *orfY* with flanking *orfX* and *orfZ* sequences is cloned into an appropriate vector that does not replicate in the target bacterium because it contains a narrow host range origin of replication (*ori*). This plasmid is transformed into the target bacterium, followed – in this case – by kanamycin resistance (*Km^r*) selection. This step results in integration of the allelic replacement construct into the chromosome by homologous recombination between cloned and chromosomal sequences. For I-SceI catalyzed resolution, the merodiploid is transformed with the I-SceI expression construct which results in double-stranded cleavage of the chromosome and release of most of the plasmid backbone. This event can be monitored by loss of *Km^r*. Repair of the double-stranded break by homologous flanking repeat sequences leads to formation of a wild-type strain (event denoted by circled “1”) or a mutant strain (event denoted by circled “2”). The two events are distinguished by phenotypic analyses and/or PCR.

colony-picking robot and pooled. One allele, Rob3A, was identified from initial tests that allowed partial curing of *sce* reporter plasmid pR6KSCE (Figure 2B) at 25°C and decreased curing at 33°C. Compared to the wild type I-SceI protein, the Rob3A allele encodes a protein with six amino acid substitutions: K65N, M70V, N154Y, V74I, Y201N, and S204P.

Counter-selection curing with a two-plasmid system

A two-plasmid system is currently the common counter-selection method for I-SceI. A two-plasmid counter selection reporter system was employed in this study to determine the curing rates of I-SceI mutant alleles. It consists of a plasmid containing

an I-SceI mutant allele, pARAI-SceImut, and a reporter plasmid, pR6KSCE, containing a single *sce* site (Figure 2A and 2B). The two-plasmid system was utilized to determine the curing rates of the *sce* site containing reporter plasmid by the I-SceI Rob3A mutant allele, compared to spontaneous curing of the reporter plasmid. The I-SceI Rob3A allele showed maximal curing rates at 42°C with decreased cure rates at 25°C and almost no curing at 33°C. In contrast, the reporter plasmid was maintained at all three temperatures tested in the absence of I-SceI Rob3A (Figure 3). These results provide evidence for the temperature-dependent and endonuclease-based curing of the reporter plasmid containing a *sce* site.

Screening for alleles with improved I-SceI activity

After initial tests the Rob3A allele showed promising results and the I-SceI gene was added to an allelic exchange vector carrying two *sce* sites. A one-plasmid system was created by placing the I-SceI gene and two *sce* sites onto a single plasmid also containing a *gusA* indicator gene and a gene encoding Km resistance. A secondary mutant pool was created by PCR mutagenesis in an attempt to identify a one-plasmid system clone expressing an I-SceI restriction endonuclease allele with more pronounced temperature-dependent activity. The screening assay consisted of assessing curing of the I-SceI plasmid by a decreased blue colony count on X-Gluc plates due to the loss of the *gusA*

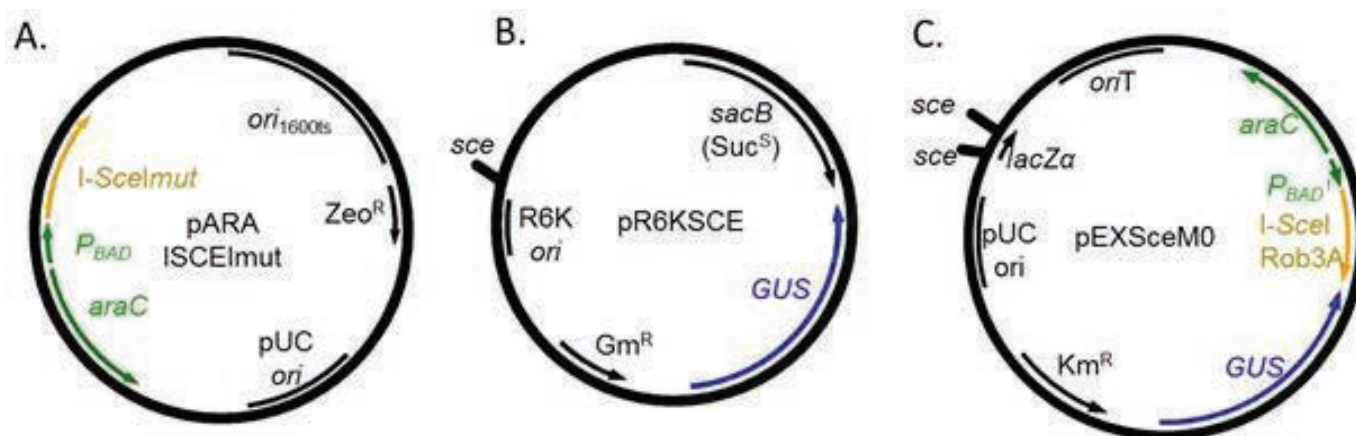


Figure 2. Maps of vectors used for two-plasmid and one-plasmid I-SceI-based curing

A. Plasmid pARAI-SceImut contains an I-SceI allele from the pool of mutant alleles, the P_{BAD} promoter which is under control of the *araC* encoded regulator, a pUC origin of replication, a temperature sensitive origin of replication (*ori*_{1600ts}) and a zeocin resistance (*Zeo*^R) marker.
B. Plasmid pR6KSCE contains the *sacB* counter selection marker, a *gusA* indicator gene, an R6K origin of replication and a gentamicin (*Gm*^R) resistance marker.
C. Plasmid pEXSceM0 contains an origin of transfer (*oriT*), a *gusA* indicator gene, a pUC origin of replication, a gene expressing the I-SceI Rob3A allele from the P_{BAD} promoter and a *LacZa* peptide-encoding gene with two I-SceI cleavage sites (*sce*).

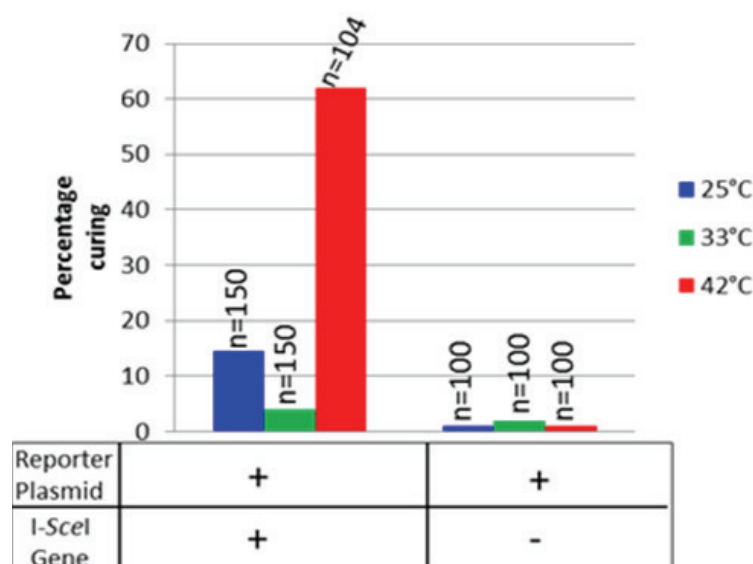


Figure 3. The Rob3A protein causes temperature-dependent plasmid curing at 42°C. DH5α(λpir+) carrying the *Gm*^R pR6KSCE *sce* containing reporter plasmid was transformed with the pARAI-SceImut vector expressing the Rob3A allele and transformant clones were recovered at 25°C, 33°C and 42°C. pARAI-SceImut Rob3A transformants were screened for *Gm*^R, which determined percentage curing rates of the pR6KSCE reporter at each temperature. DH5α(λpir+)/pR6KSCE was incubated under identical conditions to determine the percentage rate of pR6KSCE curing in the absence of I-SceI. The sample number of clones (n) screened from each test condition is listed.

gene and susceptibility to Km.

Initial screening on LB plates containing X-Gluc and LB plates containing 35 µg/ml Km produced many candidates that were later proven by PCR and DNA sequencing not to contain an *I-SceI* gene. The reason(s) for these puzzling results remain unclear. After intensive screening of 575 plasmids, one plasmid, pEXSceMQ, carrying *I-SceI* allele Q18 demonstrated increased cure rates and was shown to contain the *I-SceI* gene. The map of pEXSceMQ is the same as that of pEXSceM0 (Figure 2C), but the *I-SceI*

protein encoded by it has 18 additional amino acid substitutions compared to Rob3A, none of which represent reversion back to wild type *I-SceI* sequence. Mutations compared to the wild-type *I-SceI* protein are as follows (initial Rob3A mutations are indicated by bold letters): N5P, N9Y, **K65N**, Y69H, **M70V**, C74T, Y77F, V98E, Q104L, F106S, N116D, L140Q, D152V, **N154Y**, K160E, S161P, F169L, E173G, **V174I**, **Y201N**, **S204P**, M223T, E233V, and K237E.

Induction or repression of PBAD driven I-SceI

expression does not affect plasmid curing

Expression of the *I-SceI* gene in pEXSceM0 (Figure 2C) and pEXSceMQ is under control of the PBAD promoter and its cognate regulator encoded by *araC*. Transcription from PBAD is induced in the presence of arabinose and repressed in the presence of glucose.¹⁰ Both DH5α/pEXSceMQ and DH5α/pEXSceM0 were used to determine possible effects of absence or presence of induction on plasmid curing. DH5α/pEXKm5 was used as a negative control in this experiment because it does not contain an *I-SceI* gene. The results shown in Figure 4 demonstrate an increased cure rate of all three plasmids when cells are grown at 42°C, but cure rates were higher with plasmids encoding *I-SceI*. Absence or presence of inducing or repressing sugars had no effect on plasmid cure rates. These results indicate that plasmid curing is increased in the presence of *I-SceI* but not dependent on its induction. Increased cure rates in cells grown at 42°C are probably due to plasmid instability at higher temperatures.

The new pEXSceM0 vector is functional in allele replacement experiments

After initial experiments demonstrated use of pEXSceM0 in plasmid curing experiments, the use of *I-SceI* single vector counter-selection system in allelic exchange was tested by attempting to introduce a pEXSceM0-borne *amrRAB-oprA* deletion construct into the *B. pseudomallei* genome. The construct was integrated into the Bp82 genome after conjugation from *E. coli* (*Escherichia coli*) via a single crossover, creating a merodiploid exconjugant (Figure 5A and B). Undesired plasmid and chromosomal DNA sequences were then deleted via a second recombination event that was stimulated via *I-SceI* mediated chromosomal DNA cleavage (Figure 5C). Successful merodiploid resolution was assessed by obtaining white colonies on X-gluc that were Km^s and Gm^s due to the loss of the plasmid backbone that encodes Km^r and the wild-type *amrRAB-oprA* region, which when present confers Gm^r. PCR was performed to confirm the presence of the *amrRAB-oprA* deletion.

The results shown in Figure 5D confirm that the pEXSceM0-borne $\Delta(amrRAB-oprA)$ mutation was successfully transferred to the Bp82 chromosome. PCR primers used yield an amplicon size of 1,251 bp with DNA from strains containing the $\Delta(amrRAB-oprA)$ allele and an amplicon size of 215 bp with DNA from merodiploid strains with an *oriT* in the integrated plasmid backbone. The $\Delta(amrRAB-oprA)$ deletion allele was present in the merodiploid BP82SceM0-M2 and one of the resolved strains, BP82SceM0-R3. The deletion could not be detected in the

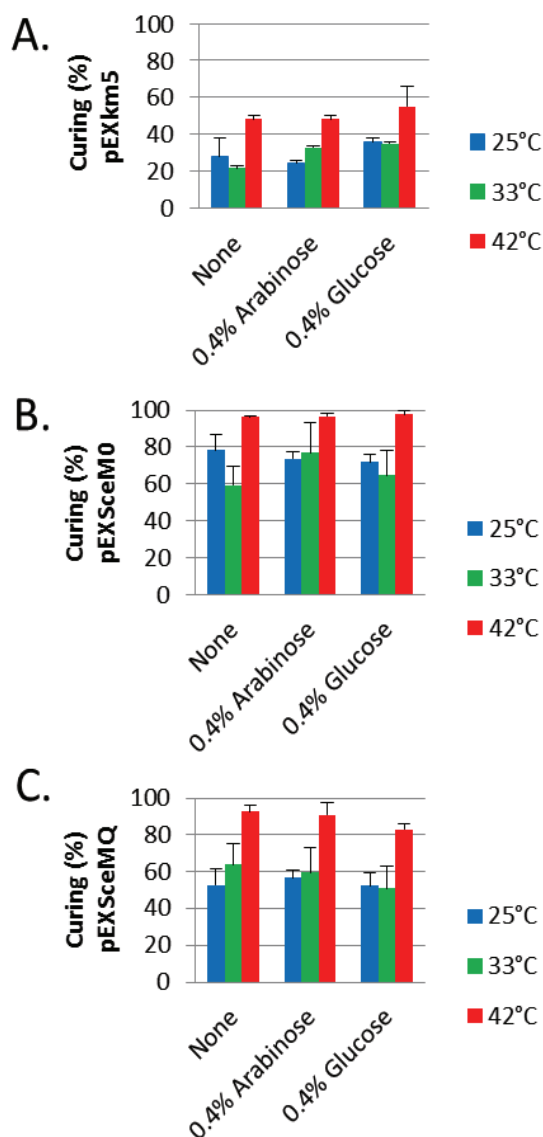


Figure 4. Neither induction nor repression of PBAD driven *I-SceI* expression effect curing percentages in a one-plasmid system. DH5α with the indicated plasmids, pEXKm5 (A), pEXSceM0 (B) and pEXSceMQ (C), was grown at 25°C, 33°C and 42°C in LB medium with no addition (none) or with 0.4% arabinose (inducing conditions) or with 0.4% glucose (repressing conditions). Ratios of blue to white colonies that grew on LB medium with X-Gluc were calculated to determine plasmid curing percentages. All experiments were performed in triplicate.

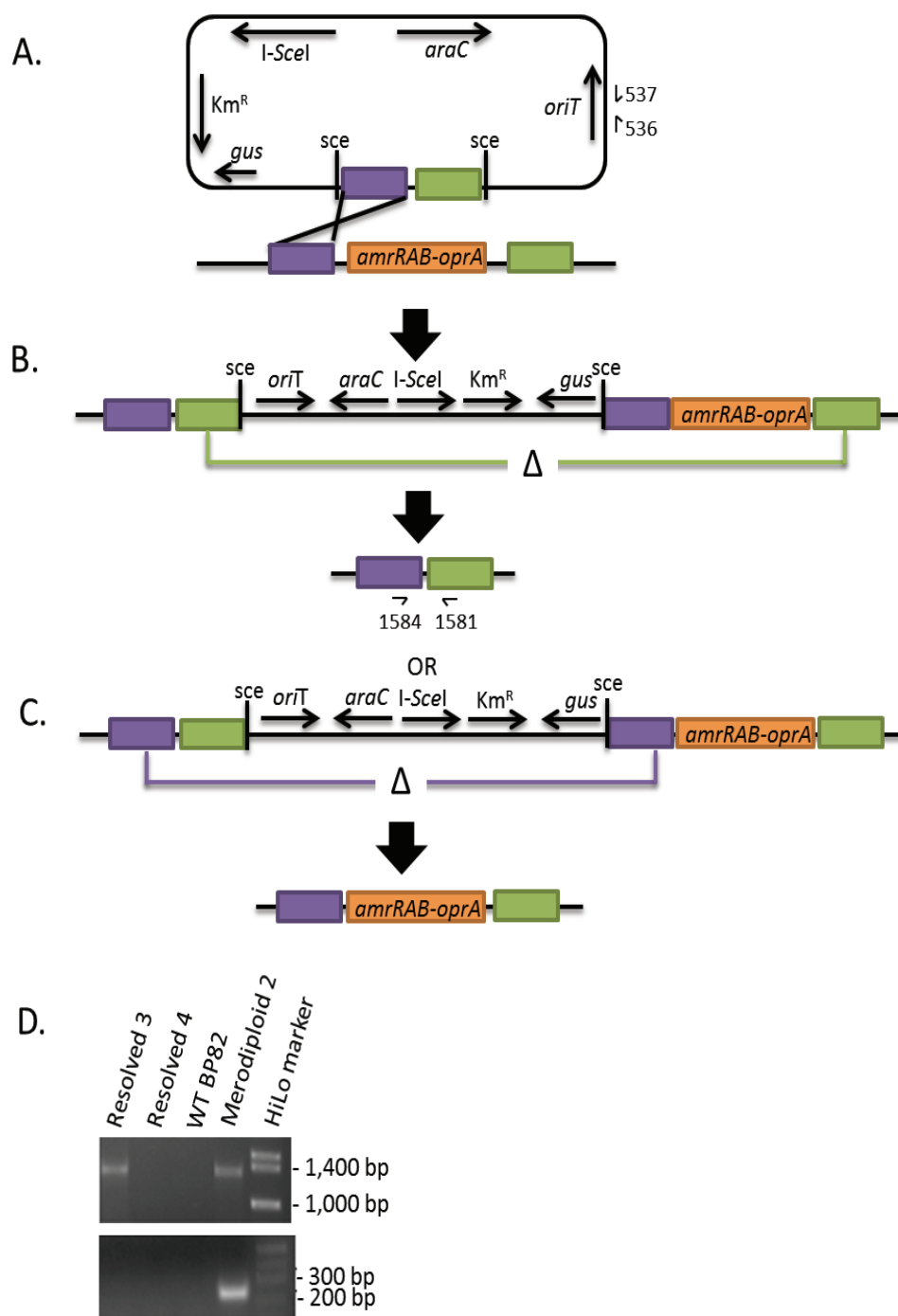


Figure 5. Schematic representation for the steps of allelic exchange at the *B. pseudomallei* *amrRAB-oprA* locus using pEXSceM0. The pEXSceM0 vector is transferred from *E. coli* to *B. pseudomallei* by conjugation and *Km^R* exconjugants are selected. Because pEXSceM0 cannot replicate in *B. pseudomallei*, *Km^R* colonies represent merodiploids which have the plasmid sequences incorporated in the chromosome via homologous recombination between sequences that flank the *amrRAB-oprA* deletion region. In the illustrated example recombination occurs between the cloned left flanking region and the respective chromosomal sequences (A). *I-SceI* expression leads to cleavage of chromosomal DNA and stimulates homologous recombination which either leads to incorporation of the plasmid-borne $\Delta(amrRAB-oprA)$ deletion into the chromosome (B) or restoration of the wild-type configuration of the *amrRAB-oprA* region (C). Inverted half arrows indicate primers used to check for presence of *oriT* sequences (536 & 537) or the presence of the $\Delta(amrRAB-oprA)$ mutation (1581 & 1584). Although, the 1581 and 1584 priming sites are present in the respective strains, the segment located between them in the intact *amrRAB-oprA* region in the wild-type strain and merodiploid is too large to be amplified using normal PCR conditions. (D). PCR confirmation of allelic exchange with primers 1581 & 1584 (presence of $\Delta(amrRAB-oprA)$ mutation, top panel) and 536 & 537 (presence of *oriT*, bottom panel). The 1,251 bp amplicon signifying presence of the $\Delta(amrRAB-oprA)$ mutation was present in the merodiploid strain BP82SceM0-M2 and resolved strain BP82SceM0-R3. It could not be detected in the parent strain BP82 and strain BP82SceM0-R4, indicating that this strain had reverted to the wild-type configuration of the *amrRAB-oprA* region. As expected, the *oriT* sequences were only detected in the merodiploid strain BP82SceM0-M2. Abbreviations: *araC*, AraC protein encoding gene; *gusA*, glucuronidase encoding gene; *I-SceI*, endonuclease encoding gene; *Km^R*, kanamycin resistance gene; *amrAB-oprA*, AmrAB-OprA efflux operon; *amrR*, *amrAB-oprA* efflux operon repressor; *oriT*, origin of transfer; *P_{BAD}*, *E. coli* arabinose operon promoter; *sce*, *I-SceI* cleavage sites.

resolved strain BP82SceM0-R4 indicating that it had reverted to back to wild-type. The *oriT* sequence could only be detected in the merodiploid strain BP82SceM0-M2.

Materials and Methods

Bacterial strains and culturing conditions

Bacterial strains used in this study are listed in Table 1. Strains were grown in Lennox Broth (LB) media (MO BIO Laboratories, Carlsbad, CA) or agar solidified LB plates at 42°C, 37°C, 33°C, or 25°C, as noted below. Media for *E. coli* were augmented with antibiotics or colorimetric agents at the following final concentrations: 35 µg/ml kanamycin (Km) (Gold Biotechnology, St. Louis, MO); 15 µg/ml gentamicin (Gm) (EMD Biosciences, San Diego, CA); 25 µg/ml zeocin (Zeo) (Life Technologies, Grand Island, NY); 25 µg/ml chloramphenicol (Cm) (Sigma, St. Louis, MO); and 40 µg/ml 5-bromo-4-chloro-3-indolyl-β-D-glucuronic acid (X-Gluc) (Gold Biotechnology, St. Louis, MO). For growth of *E. coli* RHO3, media was supplemented with 200 µg/ml diaminopimelic acid (DAP) in liquid cultures or 400 µg/ml DAP for agar solidified plates. *B. pseudomallei* Bp82 strains were grown in LB with 80 µg/ml adenine at 37°C with constant agitation overnight. For recovery of Km resistant Bp82 exconjugant merodiploids, cells were plated on LB plates containing 1000 µg/ml Km.

Strain	Genotype/Relevant Features	Reference or Source
<i>E. coli</i>		
DH5α	F ⁺ Φ80 <i>lacZ</i> ΔM15 Δ(<i>lacZYA-argF</i>)U169 <i>deoR recA1 endA1 hsdR17</i> (rK ⁺ mK ⁺) <i>phoA glnV44</i>	(11)
DH5α(<i>λpir</i> ⁺)	DH5α(<i>λpir</i> ⁺)	(12)
MaH1	DH5α::mini-Tn7- <i>pir116</i> ⁺	(13)
JM110(<i>λpir</i> ⁺)	<i>λpir</i> ⁺ , <i>rpsL</i> (Sm ^R) <i>thr leu thi-1 lacY galK galT ara tonA tsx dam dcm glnV44</i> Δ(<i>lac-proAB</i>) [F ⁺ <i>traD36 proAB lacIqZ</i> ΔM15]; Dam and Dcm methylase-deficient	(14)
DB3.1	F ⁺ <i>gyrA462 endA1 glnV44</i> Δ(<i>sr1-recA</i>) <i>mcrB mrr hsdS20</i> (r _B , m _B) <i>ara14 galK2 lacY1 proA2 rpsL20</i> (Sm ^R) <i>xyb5 Δleu mlh1</i> ; strain for maintenance of plasmids containing the CcdB ^R Gateway cassette	Invitrogen
KVT6	F ⁺ Δ(<i>gpt-lac</i>)5, <i>glnV44</i> (AS), <i>glnV89</i> (AS), <i>λ cI</i> ⁺ , <i>ara</i> (FG), <i>gyrA-0</i> (NaR), <i>metB</i> , <i>argE</i> (Am), <i>rpoB0</i> (Rif ^R), <i>thiE1</i> , <i>gyrA462</i> ; CcdBR Gateway maintenance strain	Schweizer laboratory stock
RHO3	F ⁺ , <i>λpir</i> , <i>thi-1</i> , <i>thr-1</i> , <i>lenB6</i> , <i>lacY1</i> , <i>tonA21</i> , <i>glnV44</i> , <i>recA</i> , <i>yjcU</i> ::Mu, Δ <i>asd</i> ::FRT, <i>ghbB</i> ::RP4-2-Tc ^R ::Mu, Δ <i>aphA</i> ::FRT (Km ^S); DAP-dependent conjugation strain	(7)
<i>Burkholderia pseudomallei</i>		
Bp82	1026b Δ <i>purM</i> ; Select Agent excluded strain, adenine auxotroph	(15)
Bp82SceM0-M2	Bp82::pEXSceM0Δ(<i>amrRAB-oprA</i>); merodiploid strain with plasmid integrated at the <i>amrRAB-oprA</i> locus; GUS ⁺ , Km ^R	This work
Bp82SceM0-R3	Bp82 Δ(<i>amrRAB-oprA</i>); aminoglycoside and macrolide susceptible strain	This work

Table 1. Strains used in this study

Descriptive Name	Laboratory Name	Relevant Features	Source [GenBank Accession Number]
pUC18-mini-Tn7T-Gm-GW	pPS1612	Source of Gateway cassette for pARAGW; Amp ^R , Gm ^R , Cm ^R	(16)[AY737004]
pBADSCe	pPS2212	I- <i>SceI</i> expression vector; Zeo ^R	(17)[FJ797515]
pARAGW	pPS2875	Source of Gateway cassette for pEXK-mGW; Zeo ^R , Cm ^R	This study [JX516791]
pEXK-mGW	pPS3028	Gateway destination vector; GUS ⁺ , Km ^R	This study
pR6KSCE	pPS2842	<i>see</i> counter selectable marker; sucrose curable, GUS ⁺ , Gm ^R	This study
pARAISeImut	pPS2929	Plasmid containing I- <i>SceI</i> Rob3A mutant gene; Zeo ^R	This study
pEXK-m5	pPS2539	Allelic exchange vector, GUS ⁺ , sucrose curable; Km ^R	(7) [GQ200735]
pEXSceM0	pPS2931	Allelic exchange vector; GUS ⁺ , I- <i>SceI</i> Rob3A, Km ^R	This study
pEXSceMQ	pPS3067	Allelic exchange vector; GUS ⁺ , I- <i>SceI</i> Q18, Km ^R	This study
pEXK-m5-Δ(<i>amrRAB-oprA</i>)	pPS2557	Δ(<i>amrRAB-oprA</i>) construct; sucrose curable, GUS ⁺ , Km ^R	Schweizer laboratory stock
pEXSceM0-2	pPS3068	Δ(<i>amrRAB-oprA</i>) construct; I- <i>SceI</i> curable, GUS ⁺ , Km ^R	This study

Table 2. Plasmids used in this study

Plasmid DNA purification

Plasmids used in this study are listed in Table 2. *E. coli* strains were cultured in LB medium with appropriate antibiotics at 33°C with constant agitation overnight. Plasmid DNA was isolated using the Fermentas Life Sciences GeneJet plasmid mini prep kit, (Thermo Scientific, Glen Burnie, MD) according to the manufacturer's instructions.

DNA manipulation

Restriction enzymes and *Taq* DNA polymerase were purchased from New England Biolabs (Ipswich, MA) and used according to manufacturer's recommendations. T4 ligase was purchased from Invitrogen (Grand Island, NY). All oligonucleotides were obtained from Integrated DNA Technologies (Coralville, Iowa) and are listed in Table 3. PCR reactions were performed as previously described in¹⁸ (Table 4.)

Plasmid transformation

Competent cells were prepared using a standard rubidium chloride protocol.¹⁹ Cells were transformed with plasmid DNA using previously described methods.¹⁸ For purposes of two-plasmid curing efficiency

testing, transformation mixtures were evenly split into three tubes of 200 µl each, which were incubated for 1 h without agitation at 25°C, 33°C, or 42°C, respectively.

Plasmid construction

To create pARA-GW, pBADSC⁷ was digested with Acc65I and HindIII, and the 5,980 bp backbone was ligated to the 1,746 bp Acc65I+HindIII digested Gateway (GW) cassette fragment from pUC18-mini-Tn7I-Gm-GW.¹⁷ After transformation into *E. coli* DB3.1, transformants were recovered on LB+Zeo+Cm plates. This step replaced the *I-SceI* gene with a GW cassette. The ribosome-binding site of the *I-SceI* gene was left intact. Correct clones were confirmed by Acc65I+HindIII and Acc65I+SalI digests.

To create pARA *I-SceI*mut (Figure 2A), the *I-SceI* gene was PCR-amplified from pBADSC⁷ using error-prone PCR and oligonucleotide primers 2352 and 2353 (Table 4) that introduce flanking KpnI and XhoI restriction sites. The 100 µl PCR reaction was split into four 25 µl reactions to avoid overrepresentation of early-cycle mutations in the pool. The PCR amplicons representing a library of mutant *I-SceI* alleles were digested with KpnI+XhoI and cloned into the KpnI+XhoI digested pARA-GW arabinose inducible expression vector to create the pARA *I-SceI*mut library. The cloned mutant *I-SceI* alleles replaced the GW cassette which encodes the CcdB toxin encoding gene. By recovering the plasmids in a CcdB^S strain of *E. coli*, this provided selection against any clones that lack an *I-SceI* allele.

The pARA *I-SceI*mut library was then transformed into the *I-SceI* activity reporter strain DH5α(*λpir*⁺)/pR6KSCE and transformants were plated onto LB+Zeo+0.2% arabinose and incubated at 25°C for 3 days. 1,900 isolated colonies were then picked by a Qpix colony picking robot into LB and LB containing Gm and incubated at 37°C to identify Gm^S clones. A total of 19 Gm^S clones were identified, pooled, and used for plasmid DNA isolation, creating a 19-clone pool. The 19-clone pool was re-transformed into the DH5α(*λpir*⁺)/pR6KSCE reporter strain and transformants were plated on LB+Zeo+0.2% arabinose and incubated at 33°C. Colonies from these plates were then patched onto Gm-containing plates in allele was PCR amplified from pEXSceM0, using error-prone PCR and oligonucleotide primers 2352 and 2353 as described above. The mutagenic PCR products were then purified, combined with pEXKmGW, and digested with NheI and ZraI. The digested DNA was purified directly from the digest reaction using the GenElute Gel Extraction Kit and ligated overnight at

Primer	Laboratory Name	Sequence 5'→3'
ISCE-I mut F	P2352	GGGCTAGCAGGAGGGTACC
Aat-iSCEmut-rev.2	P2522	TCTGACGTCGCTGAAAATCTTCTCTCATCCGCC
ISCE Forward	P2520	GATCGATGTTGATGATCGGTTTGTITTTT
ISCE Reverse	P2521	GCACAAAAAGAACGTGTTAACACCT
ISCE-I mut F	P2352	GGGCTAGCAGGAG GGTACC
ISCE-I mutR	P2353	TAACCTCGAG ACGTCGGGGCCCTTATT
OriT Up	P536	TCCGCTGCATAACCCTGCTTC
OriT DN	P537	CAGCCTCGCAGAGCAGGATTC
amrRAB-oprA-UP-For	P1581	AGGGTGTCCACATCCTTGAA
amrRAB-oprA-DN-Rev	P1584	GAAATACGCCCTTGACGCACT

Table 3. Primers and oligonucleotides used in this study

14°C. The ligation was transformed into *E. coli* DH5α and glycerol was added to a final concentration of 15%. The mixture was then divided into 200 µl aliquots and the resulting cell suspensions were frozen at -80°C, creating a mutagenic pool for screening.

Determining temperature-dependent *I-SceI*/sce curing rates with a two-plasmid reporter system

pARA *I-SceI*mut was transformed into DH5α(*λpir*⁺)/pR6KTSCE and cultures were outgrown, standing for one hour at either 25°C, 33°C, or 42°C in liquid LB. Transformation mixtures were plated onto LB+25 µg/ml Zeo+0.2% arabinose and incubated at either 25°C, 33°C, or 42°C. Recovered colonies were patched onto LB plates containing Gm to check for the presence or absence of the *sce* site containing Gm^R reporter plasmid pR6KTSCE.

Medium throughput screening of *I-SceI*/sce curing rates

Mutagenic pool aliquots from the secondary pool of mutant *I-SceI* alleles were removed from the -80°C freezer, plated onto LB agar plates containing 35 µg/ml Km and the plates were incubated standing overnight at 33°C. Recovered colonies were inoculated into 200 µl of LB medium and incubated standing overnight at 33°C. The incubated overnight cultures were diluted 1:100 in 200 µl aliquots with LB + 0.4% arabinose in wells of three 96 well plates, and the plates were incubated standing overnight at 25°C, 33°C, or 42°C. A 1:100 dilution was made of each overnight culture and 10 µl of each sample was spot-plated onto both LB+Km and LB+X-Gluc plates. The plates were incubated overnight at 33°C. Spots on LB+Km plates were then checked for decreased colony counts and LB+X-Gluc plates were checked for a decrease in the number of blue colonies. 575 individual plasmids were screened using this procedure.

To verify the presence of an *I-SceI* gene,

candidates were retransformed into DH5α and subjected to a second round of spot testing, and all potential candidates were confirmed via sequencing and standard PCR by amplifying a 280 bp *I-SceI* probe with primers 2520 and 2521. pEXSceMQ (pEXSceM0 derivative from test plate well Q18) was isolated using this procedure.

Quantitative self-curing tests

One ml of LB medium was inoculated with either DH5α/pEXSceM0, DH5α/pEXSceMQ, or DH5α/pEXKm5 (*I-SceI* lacking, negative control vector), and cultures were incubated standing overnight at 33°C. A 1:100 dilution was made into three 1.5 ml microfuge tubes containing LB+0.4% arabinose to 1 ml final volume. These cultures were then incubated standing overnight at either 25°C, 33°C, or 42°C. Tests were also conducted with LB+0.4% glucose (to repress expression from the P_{BAD} promoter) and plain LB. Serial dilutions were made into sterile saline to obtain a 10⁻⁵ dilution and a 10⁻⁶ dilution from each temperature variant culture. These dilutions were then plated onto LB+X-Gluc plates. After overnight incubation at 33°C percentages of blue versus white colonies were recorded.

Allelic exchange testing

To create a pEXSceM0-2 plasmid vector Bp82 merodiploid strain, 1 ml of RHO3/pEXSceM0-2 and 1 ml of Bp82 overnight culture were harvested by centrifugation, washed twice in equal volumes of fresh LB+adenine and concentrated 5X into 200 µl. 20 µl samples of both cell suspension were combined on a sterile cellulose acetate filter on an LB+DAP+adenine plate alongside individual parental controls and incubated overnight at 33°C. Cells were recovered from the filters by centrifugation and washed 1x in 1 ml LB. Merodiploids were recovered by plating contents of conjugation filters on LB+1,000 µg/ml Km+adenine.

Merodiploids were resolved using the I-SceI counter-selection curing protocol by first inoculating merodiploids into 1 ml of LB and incubating at 33° standing. Second, three 1:100 dilutions in LB were made of the initial overnight and incubated at 25°, 33°, or 42°. Another 1:100 dilution was made for each tube and plated onto LB agar containing X-Gluc. White colonies growing on these plates were patched onto LB+adenine, LB+Gm+adenine, and LB+Km1000+adenine. Patches that were Gm^S, Km^S and grew on the LB were then cultured for DNA boiling preparations.

DNA boiling preparations were performed by combining 10 µl of culture with 30 µl of distilled H₂O followed by boiling on a hot plate for 10 min. PCR was used to check for the presence of the $\Delta(amrRAB-oprA)$ mutation. Bp82, BP82SceM0-M2, and resolved BP82SceM0-R3 and R4 were confirmed with PCR using primers, allowing detection of the *amrRAB-oprA* deletion construct and the *oriT* from pEXSceM0. Primers 1581 and 1584 flanking the deletion construct of the *amrRAB-oprA* region were used for confirmation of the presence of the $\Delta(amrRAB-oprA)$ mutation. Electrophoresis using 1% agarose gels was performed to identify the expected $\Delta(amrRAB-oprA)$ 1,251 bp amplicon. Bp82 and wild type revertants should yield an amplicon size of 6,709 bp. Primers 536 and 537 were used to amplify an *oriT* probe amplicon of 215 bp.

Conclusions

Substantial progress has been made towards the development of a temperature dependent I-SceI allele to make the process of counter-selection with I-SceI more broadly applicable and simpler to use. Currently, the most effective counter-selective system that does not require supplementary genetic manipulation is the use of the *Bacillus subtilis sacB* gene along with sucrose, since this combination causes levan-poisoning in many bacterial strains. However, *sacB* is not compatible to work with bacterial species containing endogenous *sacB* genes. The temperature-dependent I-SceI/*sce* system does not require additional genetic manipulation or host-/replicon-dependent mutations and works as counter-selection with a simple shift in temperature. This makes this new genetic tool desirable for researchers working with diverse bacteria. I-SceI generated DNA stranded breaks are highly lethal regardless of the target organism, making this genetic tool highly versatile.

Acknowledgements

HPS is supported by several NIH grants and this research was made possible by

Indirect Cost Recovery funds from these grants. I would like to thank everyone in the Schweizer laboratory for the guidance for this project.

References

- ¹Schweizer, H. (1992) "Allelic exchange in *Pseudomonas aeruginosa* using novel ColE1-type vectors and a family of cassettes containing a portable *oriT* and the counter-selectable *Bacillus subtilis sacB* marker." *Molecular Microbiology* 6. Pg 1195-1204.
- ²Barrett, A., Kang, Y., Inamasu, K., Son, M., Vukovich, J., Hoang, T. (2008) "Genetic tools for allelic replacement in *Burkholderia* species." *Applied and Environmental Microbiology* 74. Pg 4498-4508.
- ³Tischer, B., von Einem, J., Kaufer, B., Osterrieder, N. (2006) "Two-step Red-mediated recombination for versatile high-efficiency markerless DNA manipulation in *Escherichia coli*." *Biotechniques* 40. Pg 191-197.
- ⁴Perrin, A., Buckle, M., Dujon, B. (1993) "Asymmetrical recognition and activity of the I-SceI endonuclease on its site and on intron-exon junctions." *The EMBO Journal* 12. Pg 2939-2947.
- ⁵Moure, C., Gimble, F., Quijcho, F. (2008) "Crystal structures of I-SceI complexed to nicked DNA substrates: snapshots of intermediates along the DNA cleavage reaction pathway." *Nucleic Acids Research* 36. Pg 3287-3296.
- ⁶Plessis, A., Perrin, A., Haber, J., Dujon, B. (1992) "Site-specific recombination determined by I-SceI, a mitochondrial group I intron-encoded endonuclease expressed in the yeast nucleus." *Genetics* 130. Pg 451-460.
- ⁷Lopez, C., Rholl, D., Trunck, L., Schweizer, H. (2009) "Versatile dual-technology system for markerless allele replacement in *Burkholderia pseudomallei*." *Applied and Environmental Microbiology* 75. Pg 6496-6503.
- ⁸Moore, R., DeShazer, D., Reckseidler, S., Weissman, A., Woods D. (1999) "Efflux-mediated aminoglycoside and macrolide resistance in *Burkholderia pseudomallei*." *Antimicrobial Agents Chemotherapy* 43. Pg 465-470.
- ⁹Trunck, L., Propst, K., Wuthiekanun, V., Tuanyok, A., Beckstrom-Sternberg, S., Beckstrom-Sternberg, J., Peacock, S., Keim, P., Dow, S., Schweizer, H. (2009). "Molecular basis of rare aminoglycoside susceptibility and pathogenesis of *Burkholderia pseudomallei* clinical isolates from Thailand." *PLoS Neglected Tropical Diseases* 3. e0000519.
- ¹⁰Zhang, Y., Shang, X., Lai, S., Zhang, G., Liang, Y., Wen, T. (2012) "Development and application of an arabinose-inducible expression system by facilitating inducer uptake in *Corynebacterium glutamicum*." *Applied and Environmental Microbiology* 78. Pg 5831-5838.
- ¹¹Liss, L. (1987) "New M13 host: DH5 α F' competent cells." *Focus* 9. Pg 13.
- ¹²Metcalfe, W., Jiang, W., Wanner B. (1994) "Use of the rep technique for allele replacement to construct new *Escherichia coli* hosts for maintenance of R6K γ origin plasmids at different copy numbers." *Gene* 138. Pg 1-7.
- ¹³Kvitko, B., Bruckbauer, S., Prucha, J., McMillan, I., Breland, E., Lehman, S., Mladinich, K., Choi, K., Karkhoff-Schweizer, R., Schweizer, H. (2012) "A simple method for construction of pir⁺ Enterobacterial hosts for maintenance of R6K replicon plasmids." *BMC Research Notes* 5. Pg 157.
- ¹⁴Yanisch-Perron, C., Vieira, J., Messing, J. (1985) "Improved M13 cloning vectors and host strains: nucleotide sequences of the M13mp18 and pUC19 vectors." *Gene* 33. Pg 103-119.
- ¹⁵Propst, K., Mima, T., Choi, K., Dow, S., Schweizer, H. (2010) "A *Burkholderia pseudomallei* Δ purM mutant is avirulent in immune competent and immune deficient animals: candidate strain for exclusion from Select Agent lists." *Infection and Immunity* 78. Pg 3136-3143.
- ¹⁶Choi, K., Schweizer, H. (2006) "Mini-Tn7

insertion in bacteria with single attTn7 sites: example *Pseudomonas aeruginosa*." *Nature Protocols* 1. Pg 153-161.

¹⁷Choi, K., Mima, T., Casart, Y., Rholl, D., Kumar, A., Beacham, I., Schweizer, H. (2008) "Genetic tools for select agent compliant manipulation of *Burkholderia pseudomallei*." *Applied and Environmental Microbiology* 74. Pg 1064-1075.

¹⁸Kvitko, B., McMillan, I., Schweizer, H. (2013) "An improved method for *oriT*-directed cloning and functionalization of large bacterial genomic regions." *Applied and Environmental Microbiology* 79. Pg 4869-4878.

¹⁹Sambrook, J., Russell, D. (2001) *Molecular Cloning*, Third ed. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY.

Climate change and energy efficiency: An analysis of the President's Climate Action Plan and public opinion

By KRISTEN BAILEY

UNIVERSITY OF RICHMOND

Abstract

This paper explores the intersection between public opinion and public policy in the areas of energy efficiency and climate change, and makes federal policy implementation recommendations based on analysis of public opinion survey data.

Climate change is an important challenge, and energy efficiency across all sectors is a highly effective, actionable mitigation tool. This paper analyzes for the first time an Associated Press-NORC public opinion survey question: "What does the phrase 'energy efficiency' mean to you?" Analysis of this public opinion survey data and other published reports recognizes energy efficiency as a salient issue and also demonstrates that the American public is increasingly recognizing the importance and urgency of climate change. This paper finds that the public identifies energy efficiency as largely a behavioral issue, meaning that they believe their individual actions are directly linked to energy efficiency. However, the public demonstrates little clarity and consensus on the definition of energy efficiency, and does not link energy efficiency to climate change.

Experts agree that there is a direct link between public opinion and public policy: Opinion influences policy, and policy influences opinion. On June 25, 2013, President Obama unveiled the President's Climate Action Plan, the contents of which have been heavily influenced by public opinion. Following the Action Plan's release, there is an opportunity for federal environmental policy to influence public opinion, addressing the shortcomings illustrated in the AP-NORC survey results. Specifically, federal environmental policy on climate change should channel public opinion towards a more specific definition of energy efficiency, link energy efficiency in tangible ways to climate change, and provide specific behavior recommendations on which the American public can take personal, individual action.

Background

Climate Change

Global climate change and its consequences are some of the most important problems facing modern society. The Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) states that there is "very high confidence that the global average net effect of human activities since the industrial revolution has been one of warming," and that the warming is "unequivocal."¹ The IPCC report asserts that global temperature increases since the 1950s are very likely due to the human-caused atmospheric release of greenhouse gasses, particularly carbon dioxide from burning fossil fuels.¹ According to the National Research Council and the U.S. Global Climate Research Program, global temperatures have risen approximately 0.8°C over the last one hundred years, and 0.6°C occurred during the last thirty years alone.² As further evidence, the 12 hottest years in recorded history have been in the last 15 years.³

Scientists predict that global temperatures will continue to rise in the next century. Global temperatures are projected to rise between 1°C and 6°C as compared with

1990 to 2000 temperatures, which could have significant consequences.¹ A warming of just a few degrees would have far-reaching economic, social, agricultural, and ecological repercussions. For example, millions of people living on the coasts would be forced from their homes due to sea level rise, agricultural production would decrease in many areas due to decreased rainfall, and many species would suffer from changing weather patterns and habitats.¹ Governmental responses to these problems would then cost the United States both time and money in mitigation and adaptation measures. Ultimately, all of these events are "almost certain to get much worse in the coming decades" with even a small further increase in global temperature.¹

When looking to mitigate the effects of climate change, it is beneficial to look first at the causes. Scientists widely accept that climate change is caused by the greenhouse effect, which occurs when gasses such as carbon dioxide, methane, and nitrous oxide are added to the atmosphere and cause global temperatures to rise. Many of these gasses are added in unnaturally large quantities by humans, resulting in what is called anthropogenic climate change. These gasses

then affect the balance of light entering and leaving Earth's atmosphere. Incoming short wavelengths of visible light are able to pass through Earth's atmosphere. After striking Earth's surface, these light waves bounce off and are re-radiated back into the atmosphere as infrared waves. Yet, they are unable to exit the atmosphere due to their wavelength and the atmospheric composition. These waves are confined within Earth's atmosphere, trapping additional energy and leading to higher temperatures.

Energy Efficiency and Climate Change

Most energy sources contribute to climate change. The combustion of fossil fuels, especially in transportation and the production of electricity, releases greenhouse gas emissions such as carbon dioxide. Therefore, efforts to improve energy efficiency can have a material impact on climate change.

Climate change science experts predict that carbon dioxide emissions must reach their peak by the year 2015 in order to significantly slow global climate change, and that energy efficiency will be an essential tool in reducing these harmful greenhouse gas emissions.¹ Goldman and colleagues noted

that energy efficiency is “our most important lever to climate stabilization efforts in the short and medium term.”¹ Improving energy efficiency is a critical piece of slowing climate change, especially in the coming decades. Improvements in energy efficiency account for more than thirty-three percent of the potential low-cost greenhouse gas reductions around the world and have been shown to be among the cheapest possible courses of action.⁵ Due to the relatively low cost of implementing energy efficiency improvements, energy efficiency “is one of very few tools in the climate adaptation toolbox that can claim to reduce climate change and save money.”²

Energy efficiency not only mitigates climate change by reducing greenhouse gas emissions, but also results in financial benefits such as lowering energy bills.¹ Experts assert that promoting energy efficiency would also result in many “co-benefits,” such as the alleviation of poverty in developing countries and employment benefits from new business activities in efficiency improvement.¹ Energy efficiency can also ease energy import dependence, improve energy security, reduce local and global air pollution, reduce vulnerability to weather extremes, improve health and quality of life, reduce pollutants and waste production, reduce maintenance and operating costs, and improve public image for efficient companies.¹ Therefore, energy efficiency is potentially a very powerful and beneficial tool to mitigate climate change.

Public Opinion and Policy

Recently, the American public has begun to realize the importance of the climate change problem. Chris von Borgstede, of the University of Gothenburg, and colleagues found that, since 2003, American public opinion has increasingly regarded climate change as a “real problem.”³ As a result, some Americans have started supporting more policies to mitigate the impacts of climate change, such as fuel economy and energy efficiency standards.⁵ In order to form effective environmental policies, policy makers must understand what is necessary for people to accept and follow the policies, a factor of which is public opinion.⁴ Also, the complex nature of climate change necessitates assessments of how the problem is viewed by the general public in order to determine what should be done to solve the problem.⁴

Public opinion and policy have been shown to have a cyclical relationship, with each impacting the other. The cycle generally starts when public opinion drives the creation of a public policy position. Then, public opinion reacts and allows for the policy to be

modified, if necessary.⁶

In 1983, Benjamin Page and Robert Shapiro were among the first to describe in detail the relationship between public opinion and public policy. They analyzed hundreds of national survey questions and determined when significant changes in public opinion occurred over time.⁷ Then, they identified when policy changes on the same issues took place.⁸ In their study, Page and Shapiro found remarkable consistency with changes in public opinion and changes in policy, and as a result they concluded that changes in public opinion cause corresponding policy to change.⁷

James Stimson, Michael MacKuen, and Robert Erikson reached the same conclusions in 1995 using a different methodology. Rather than reviewing survey questions, they measured public opinion by using Domestic Policy Mood, which they described as a sentiment underlying public policy preferences and being either in favor of an active or passive federal government.⁸ To measure public policy changes, they examined congressional votes and categorized them as moving either to the left or to the right politically.⁹ From their analysis, Stimson et al. definitively concluded that “policy is a simple and direct function of public opinion.”⁸ They found a one-to-one correlation of public opinion changes to public policy changes, from which they determined that policy is an indicator of the timing and range of opinion change in society. In explaining these results, they defined the term Dynamic Representation, in which public opinions change and politicians sense the change, causing them to adjust their policies. Ultimately, elections were the key to this phenomenon because opinions determine election outcomes, which in turn generate changes in policies.⁶ It is important to keep in mind that the relationship between policy and opinion is neither simple nor perfect. Adopting a historical perspective, however, they concluded that for over forty years (the scope of their analysis), political figures have translated public opinion into policy changes, showing that public opinion causes significant changes in American public policy.⁸

Paul Burstein further specified the impact that public opinion has on policies in 2003, and notes, “Policy is affected by opinion most of the time...the impact really matters substantively.”¹⁰ Burstein found that public opinion affects policies three-quarters of the time, and that opinion is significantly influential at least one-third of the time.⁹ Alan Monroe reasons that policy is not representative of public opinion more often because of the tendency in American politics to favor the status quo, making policy change

a challenge.¹⁰

The reverse effect of public policy affecting public opinion has also been studied. Politicians’ rhetoric has been found to cause widespread opinion changes by increasing the prominence of the issue in the public eye and bringing it to their attention.¹¹ Campaigning for a cause is an important way to raise the public’s awareness on issues, and policy makers have the ability to purposefully put issues on the public’s agenda.⁶ Importantly, Page and Shapiro found that policy affects opinion by “citizens learning about a policy’s impact, rationalizing its existence [by thinking that whatever the government does must be acceptable], or heeding the persuasive efforts of politicians, interest groups, or others...thus our data suggest that policy may affect opinion in close to half the cases of congruence between opinion and policy.”⁷ Policy makers can also teach the public about the merits of the policies, in a sense leading the public opinion.⁷ Lastly, once a policy is made, the public is prone to accept it, especially if the policy brings good results.⁶ The research on the opinion-policy link may be applied to both energy efficiency and climate change.

Public opinion polls can be valuable tools for policy makers. Previously, politicians had to guess about public opinion, but public opinion polls give policy makers valuable information about the public’s views.¹² Greer asserted that, “armed with polls, parties should avoid such errors [in guessing about the public’s preference]... rational parties should converge near the center of the distribution of public opinion.”¹² He went further to say that improved sampling techniques and better question wordings in public opinion polls have been the most important innovations in providing instrumental information to policy makers since women were allowed to vote in the nineteenth century.⁴ Accurate polls increase policy makers’ knowledge of public preferences, which should affect their behavior to write policies that are well aligned with public opinions.⁹

Public Opinion on Energy Efficiency and Climate Change

In 2012, the Associated Press-NORC Center for Public Affairs conducted a nationally representative household survey of 1198 adults age eighteen or older between March 29 and April 25, 2012. The survey was given by telephone and contained 56 questions. The response rate was 19 percent, with an overall margin of error of +/- 3.1 percent. The data from all questions (except the fourth question) on the survey were analyzed in the final report entitled *Energy Issues: How the Public Understands and*

Acts. This paper analyzes for the first time the fourth question from the survey: "What does the phrase energy efficiency mean to you?"

Data for this question were collected from 1198 survey participants and analyzed using a standard spreadsheet tool. Ten base categories, which were mutually exclusive but not exhaustive, were identified for the data:

- **Choice or behavior.** Responses were placed in this category when they focused on using less energy and saw energy efficiency as a personal choice. For instance, one respondent defined energy efficiency as "making smart choices in your use of energy."
- **Economic.** When a response focused on the economic benefits or costs of energy efficiency, it was placed into this category. One example is that energy efficiency means "lower electricity bills."
- **Environment.** Responses were categorized as environmental when they discussed how energy efficiency would affect the environment. For instance, one survey participant said that energy efficiency means "having minimal impact on our environment through energy usage."
- **Politics or government.** This category was used when a respondent spoke about the role that politics or the government plays in energy efficiency. For example, "As far as I'm concerned, the US government isn't doing enough because we all know there are cars out there that get 100 miles per gallon. I think that US government buildings should be energy star efficiency and they are not."
- **Resource.** Responses were categorized as resource when they defined energy as a resource, an example being when energy efficiency was defined as "we are conserving our natural resources and that's really important."
- **Savings, waste, or conservation.** Responses that spoke about minimizing waste or conserving and saving energy were placed into this category. One example is that energy efficiency means "using less fuel, less fuel waste." Another example of a response in this category is "to save energy for the next generation."
- **Tautology.** Some respondents did not provide a personal definition of energy efficiency and merely repeated the idea back to the surveyor. One survey participant defined energy efficiency as "being efficient."
- **Technology or consumer products.** This category was used when a respondent emphasized products or technologies that result in increased energy efficiency. For instance, one

respondent said, "it means using technology to limit the use of natural resources."

- **Cynical or skeptical.** Some respondents answered that they did not believe in energy efficiency and that it was a scam. For example, one person said that energy efficiency "doesn't mean much. I think it's another way for people to get your money. It's a big scam."
- **Don't know or no opinion.** This category was used when a respondent did not know what energy efficiency was or declined to answer the question, such as this response: "I'm not sure."

Each response was categorized and assigned to one of these ten base categories. The base categories were grouped together to create broader Tier Two groupings. Technology or consumer products, resource, and environment were grouped together to create the physical category; tautology, cynical or skeptical, savings, waste, or conserve, choice or behavior, and politics or government made the behavioral group; and economic was kept separate as its own group, as was don't know or no opinion. An inter-rater reliability test was performed with three additional coders, and inter-rater reliability was 87.5 percent.

The most frequent response from individuals in the Tier One classification scheme was a response focusing on the economic consequences of being energy efficient, with 276 responses in this category. The next largest response focused on savings, waste, and conservation, with 225 responses.

In Tier Two, the largest response was of the behavior category, with 545 responses. The next largest category was physical, followed by economic.

Salience of an issue is essential in determining the effect that public opinion has on public policy. Through his study, Burstein concluded that the impact that public opinion has on public policy increases as the salience of the issue increases. This is due to the fact that there may be electoral consequences for legislators' inactivity.⁹ Burstein noted that salient issues create a stronger relationship between public opinion and public policy, and salience is "a key element of democratic responsiveness."¹⁰ Monroe, Page, and Shapiro reached similar results in their studies. The more important an issue is to the policy makers' constituency, the more congruence there is between opinion and policy on that issue.⁷ On the other hand, if legislators do not think that an issue is important to the public or if the public does not seem to care, then policy makers will not feel obligated to take public opinion into account and their policies are much less likely to reflect public

opinion on that issue.⁶

The public recognizes energy efficiency as a salient issue, with 94.6% of respondents providing a definition. The AP-NORC survey also found that 78% of the public rates energy issues as extremely or very important to them personally. This means that the public is paying attention to energy efficiency. The public also believes that energy efficiency is a behavioral issue, evidenced by the largest Tier Two category. People have an understanding that they need to take action to impact climate change, and they seem willing to take that action. However, they seem to be at a loss as to what kinds of actions they should take. The diversity of responses to this question shows the multi-faceted nature of energy-efficiency, and that the public struggles to coherently define energy efficiency. This data also reveals that the public does not connect energy efficiency to climate change. In all 509 responses, there was only one mention of global warming, and only 75 responses (6.3 percent) mentioned the link between energy efficiency and the environment. This could be due to the open-ended nature of the question, but the link between energy efficiency and climate change was not represented in this data. Instead, the data shows a disconnection between climate change and energy efficiency.

Though the public does not connect energy efficiency directly to climate change, increasing numbers of people believe that climate change is occurring. Additionally, surveys conducted at Stanford University by Krosnick and MacInnis found that in 2010, 75% of people believed that climate change is occurring; in 2011, that number rose to 83%.¹⁴ There was also an increase in the number of people who think that the United States should take political action on climate change regardless if other countries do, from 67% in 2008 to 71% in 2010.¹³ From 2005 to 2010, there was also an increase in the awareness of the need for individuals to change their lifestyles to mitigate climate change.⁴ The AP-NORC study data support this finding and show that the American public is aware of the behavioral aspects of energy efficiency. In fact, the largest Tier Two category for the definition of energy efficiency was behavioral.

The climate change opinion surveys show that most Americans believe that anthropogenic climate change is taking place, and that climate change will threaten Americans if action is not taken.⁵ This increasing awareness of energy efficiency and climate change "may constitute a foundation for acceptance of the implementation of more strict policy measures instead of relying on voluntary and 'softer' policies, such as

Base Category: Tier One Groupings	Number of Respondents	Percentage of Total Responses
Tautology	95	7.9
Technology or Consumer Products	188	15.7
Economic	276	23.0
Cynical or Skeptical	31	2.6
Savings, Waste, or Conservation	225	18.8
Resource	49	4.1
Environment	75	6.3
Choice or Behavior	183	15.3
Politics or Government	11	0.9
Don't Know or No Opinion	65	5.4
Total	1198	100

Table 1. Tier One Response Table

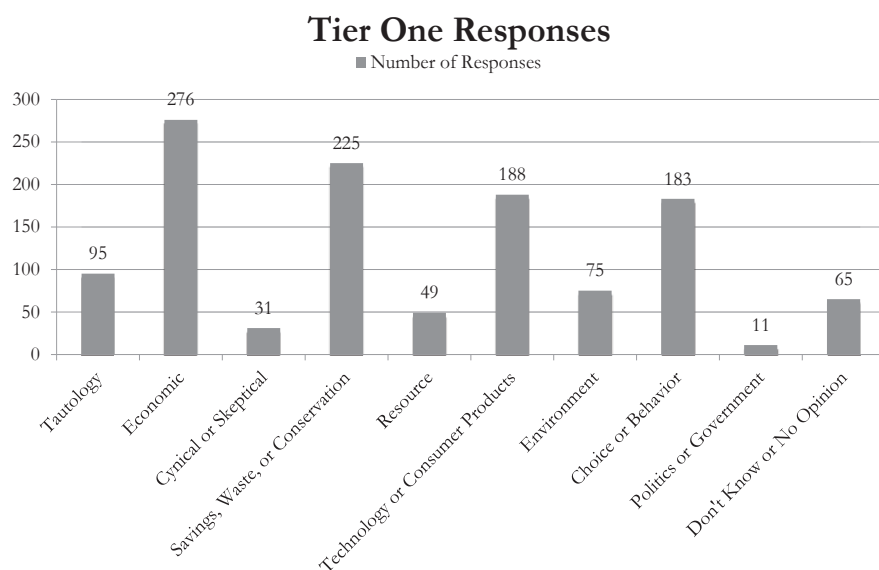


Figure 1. Tier One Responses Graph

information. An increase in awareness for the necessity of life style changes may make the public prepared for introducing stricter policy measures which will have life-style implications.²⁴

Energy Efficiency, Climate Change, and the President's Climate Action Plan

Due to the complex nature of causes and effects, climate change has been a continual challenge for policy makers. Elaine Sharp describes global climate change as a classic case where improved information affects policy and public opinion.¹⁵ In regard to climate change, "initially, scientists and environmentalists lobbied, but the public

was unresponsive, uninterested and, perhaps, skeptical. However, as new information emerged, the public has become more aware and less skeptical, which encourages policy responses."²⁶ The partisan congress has made congressional action difficult and has prevented President Obama from taking action to mitigate climate change, so executive action was necessary to address this pressing issue.

In response, President Obama unveiled the Climate Action Plan on June 25th, 2013 at Georgetown University. According to the AP-NORC and Krosnick and MacInnis surveys, energy efficiency is a salient issue, and the salience of climate change has been

increasing in the public opinion. Therefore, there is public support in the public opinion for action to be taken. Krosnick and MacInnis say, "Not surprisingly, these beliefs appear to have been important drivers of public support for policies" designed to mitigate climate change and improve energy efficiency.⁵

Energy efficiency is a key element of the Climate Action Plan, and the Action Plan established a clear connection between energy efficiency and climate change: "Roughly 84 percent of current carbon dioxide emissions are energy-related and about 65 percent of all greenhouse gas emissions can be attributed to energy supply and energy use. The Obama Administration has promoted the expansion of renewable, clean, and efficient energy sources and technologies worldwide."²³

It is not surprising that the recent policy on the salient issues of climate change and energy efficiency is in line with public opinion. Stimson, MacKuen, and Erikson found that "each point movement in public opinion produces about .74 points movement in presidential policy position."²⁸ They also state that presidential policy "reacts mostly to the public opinion of the previous year and (almost) entirely to the public opinion of the past four years."²⁸ In this case, it appears as if the public opinion shifts on the topic of climate change from 2008–2012 and the energy efficiency opinion of 2012 have influenced and encouraged the public policy on the issues through the described opinion-policy link.

The opinion results from the AP-NORC and Krosnick and MacInnis surveys show that both climate change and energy efficiency are salient issues, but that energy efficiency is a multifaceted problem that is not well defined in the public opinion. The resulting policy would be expected to follow this public opinion trend, as does President's Climate Action Plan. For example, the Action Plan discusses energy efficiency and focuses on the prevailing opinions of what energy efficiency is, according to the AP-NORC data. The Climate Action Plan, like the public opinion, also does not clearly define energy efficiency, but rather treats it as a problem that can be thought of in several different ways.

Economic

The AP-NORC survey data reveal that the economic costs and benefits of being energy efficient are important to many Americans (the number one response with 23.0%), and the President's Climate Action Plan addresses this concern directly. The Action Plan focuses on the economics of energy efficiency in a sub-section entitled,

Report Level: Tier Two Groupings	Base Categories	Number of Respondents	Percentage of Total Responses
Physical	Technology or Consumer Products, Resource, Environment	312	26.0
Behavioral	Tautology, Cynical or Skeptical, Savings, Waste, or Conservation, Choice or Behavior, Politics or Government	545	45.5
Economic	Economic	276	23.0
Don't Know/No Opinion	Don't Know or No Opinion	65	5.4
Total		1198	100

Table 2. Tier Two Responses Table

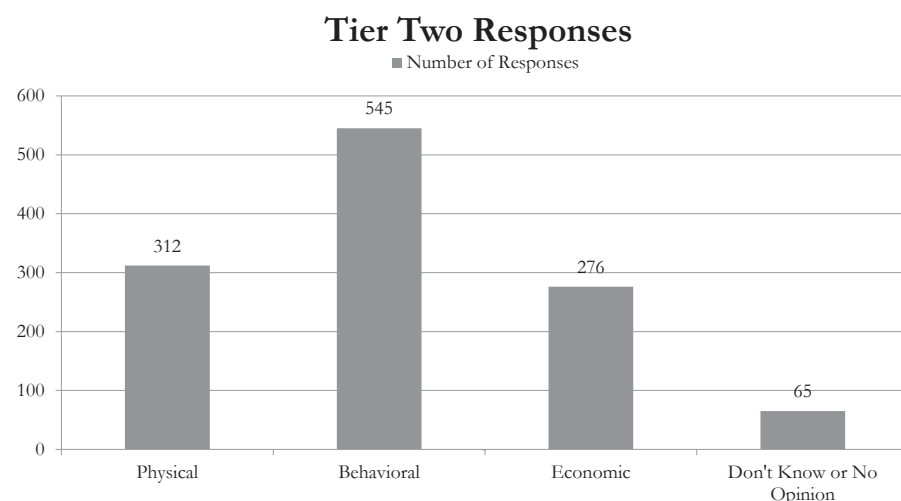


Figure 2. Tier Two Responses Graph

“Reducing Energy Bills for American Families and Businesses.”³ This section discusses the following:

- The Department of Energy’s new minimum efficiency standards will reduce electricity bills by hundreds of billions of dollars;
- The Department of Agriculture’s Rural Utilities Service’s Energy Efficiency and Conservation Loan Program will provide up to \$250 million in loans to rural America to invest in energy efficiency;
- The Department of Housing and Urban Development’s Multifamily Energy Innovation Fund will supply \$23 million for innovations in providing cost-effective residential energy;
- The Clean Energy Ministerial and key bilateral programs cost-effective opportunities are “enormous” by reducing energy waste; and
- The Better Buildings Challenge will

produce \$58 million in energy savings per year.

Savings, Waste, or Conservation

The savings, waste, and conservation category represented the second largest Tier One response in the AP-NORC data, representing 18.8% of the total responses. The Climate Action Plan addresses this area as well. For example, one of the main goals of the plan is to conserve natural resources in the face of a changing climate.³ The Action Plan also specifies how fuel economy standards for heavy-duty trucks, buses, and vans will save the equivalent of 530 million barrels of oils and 270 million metric tons of greenhouse gas emissions.³ Reducing waste is also something that the Action Plan addresses directly:

- Section 3.1 contains a section called Expanding Clean Energy Use and Cut Energy Waste, which describes how the Administration will reduce

energy waste. This includes financing and regulatory support for renewable and clean energy projects, actions to promote fuel switching from oil and coal to natural gas or renewables, support for the safe and secure use of nuclear power, cooperation on clean coal technologies, and programs to improve and disseminate energy efficient technologies.³

- Section 1.3, entitled Cutting Energy Waste in Homes, Businesses, and Factories, explains how the Administration will expand the Better Buildings Challenge to cut energy waste.³ Also, the Better Buildings Accelerators will support and encourage adoption of State and local policies to cut energy waste.³
- Section 1.3 also explains out how the Ministerial’s Super-Efficient Equipment and Appliance Deployment Initiative and its Global Superior Energy Performance Partnership are helping to accelerate the global adoption of standards and practices that would cut energy waste equivalent to more than 650 mid-size power plants by 2030. Also, the section entitled Phasing Out Subsidies that Encourage Wasteful Consumption of Fossil Fuels describes how the Administration estimates that phasing out fossil fuel subsidies would result in a ten percent reduction in greenhouse gas emissions by 2050. These subsidies promote wasteful use of fossil fuels, so by phasing them out, the Administration will reduce waste.³

Technology

A significant number of Americans (the third most popular response, at 15.7%) define energy efficiency as related to technological advancements, and the Action Plan also focuses on technological improvement in energy efficiency to mitigate climate change. Experts agree with the public opinion: “At least over the coming decades, new technologies, including energy efficiency measures, will be the main means to solve the problems related to global warming.”⁴ The Department of Energy has created new minimum efficiency standards for appliances, such as dishwashers, refrigerators, and other products, and plans to create similar standards for federal buildings through 2030. These standards focus on the energy efficiency of technology, and will reduce carbon pollution by at least three billion metric tons by 2030, cumulatively.³ President Obama plans to lead international efforts to address climate change by expanding clean energy use and cutting energy waste through programs to improve and distribute energy efficient technologies.³ The plan also describes how

the government will develop and deploy advanced transportation technologies, such as biofuels, advanced batteries, and fuel cell technologies, in order to improve energy efficiency.³

Environment

Overall, 6.3% of respondents defined energy efficiency as an environmental concern. The President's Climate Action Plan addresses the major environmental effects of global climate change, such as sea level rise, ecosystem deterioration, and biodiversity loss:

- Section 2.2's section entitled Conserving Land and Water Resources notes that America's ecosystems are critical to both the economy and the lives and health of American citizens. The Action plan shows how the Administration has invested significantly in conserving ecosystems by working with Gulf State partners and implementing climate adaptation strategies to promote ecosystem resilience.³
- In the Climate Action Plan, the President directs federal agencies to identify and evaluate creative approaches to protect biodiversity in the face of a changing climate.³ He has also implemented adaptation strategies to promote resilience in fish and wildlife populations, forests and other plant communities, freshwater resources, and the ocean.³ The Department of the Interior will launch a \$100 million competitive grant program to foster partnerships and promote resilient natural systems while enhancing green spaces and wildlife habitat near urban populations.³
- In order to prepare for sea level rise, the Action Plan identifies how federal agencies will update their flood-risk reduction standards to account for sea-level rise. This effort will incorporate the most recent science on expected rates of sea-level rise (which vary by region) and build on work done by the Hurricane Sandy Rebuilding Task Force. The Environmental Protection Agency is working with low-lying communities in North Carolina to assess the vulnerability to sea level rise and to identify solutions and reduce risks.³

Additionally, the Climate Action Plan shows how energy efficiency can be used to improve the state of the environment. It says, "We can protect our children's health and begin to slow the effects of climate change so that we leave behind a cleaner, more stable environment."³ Instituting a Federal Quadrennial Energy Review that will be led by the White House Domestic Policy Council

and Office of Science and Technology Policy will ensure that federal energy policy meets environmental goals.³ Improving energy efficiency in transportation and curbing emissions of hydrofluorocarbons and methane will protect the environment nationwide.³ Lastly, preserving forests will help to mitigate climate change and improve environmental health by removing 12% of total US carbon greenhouse gas emissions each year.³ Climate change increases the risk of wildfire, drought, and pests, which diminish the capacity of forests to sequester carbon. Pressures to develop forests for urban or agricultural uses are also increasing. Conservation and sustainable management can help to ensure that America's forests continue to remove carbon from the atmosphere while also improving soil and water quality, reducing wildfire risk, and otherwise managing forests to be more resilient in the face of climate change. The Administration is working to identify new approaches to protect and restore America's forests, as well as other critical landscapes including grasslands and wetlands.³

Resource

Although only 4.1% of respondents defined energy efficiency as related to resources, the Climate Action Plan discusses resources extensively. In the introduction, the Action Plan asserts that if Americans embrace the challenge of mitigating climate change, it will enable us to preserve our treasured natural resources for future generations.³ Already, states, cities, and communities are changing the way they manage natural resources, and the Action Plan directs Agencies to ensure that climate risk-management considerations are fully integrated into federal infrastructure and natural resource management planning.³ Section 2.2 of the Action Plan is dedicated to protecting our economy and natural resources. This section declares that current activities are depleting our nation's resources, and climate change threatens the health and safety of these resources. Natural resources such as barrier islands, marshes, forests, and plant communities can help to mitigate the impacts of Climate Change, so The Climate Action Plan declares that actions to protect these resources must be taken.³

Cynical or skeptical

According to the AP-NORC data, 2.6% of Americans are cynical or skeptical about energy efficiency. The Climate Action Plan takes steps to convince the skeptics of the importance of energy efficiency in climate change mitigation and adaptation. For example, the Action Plan states, "Energy efficiency is one of the clearest and

most cost-effective opportunities to save families money, make our businesses more competitive, and reduce greenhouse gas emissions [that produce climate change]."³ The plan focuses on the benefits of energy efficiency, such as significant cost savings, mitigating climate change through reduced carbon pollution, health benefits, encouraged business innovation and jobs, and decreased dependence on foreign energy supplies in order to convince the skeptics.³

Politics or government

Although only 0.9% of respondents connected energy efficiency to the government, The Climate Action Plan states that the Obama Administration will prepare the United States for the impacts of global climate change by working with and helping state and local governments.³ The Action plan recognizes that the government must play a central role in energy efficiency and climate change, and dedicates Section 1.5 to Leading at the Federal Level. This section identifies the role that the Federal Government will play:

- President Obama believes that the Federal government must be a leader in clean energy and energy efficiency. Federal agencies have reduced greenhouse gas emissions by more than 15%, which is the equivalent of permanently removing 1.5 million cars from roads. To continue these efforts, the Climate Action Plan establishes a new goal for the Federal government: to have 20% of its electricity consumption come from renewable energy sources by 2020.³
- In 2011, President Obama signed a memorandum entitled "Implementation of Energy Savings Projects and Performance-Based Contracting for Energy Savings," challenging federal agencies to enter into \$2 billion worth of performance-based contracts within two years to promote energy efficiency at the federal level. Federal agencies have committed to nearly \$2.3 billion from over 300 reported projects. In the near future, the Administration will take a number of actions to strengthen efforts to promote energy efficiency, including through performance contracting.
- The federal government must also lead in actions to prepare for the impacts of climate change that are too late to avoid. The Action Plan states, "The federal government has an important role to play in supporting community-based preparedness and resilience efforts, establishing policies that promote preparedness, protecting critical infrastructure and public resources,

supporting science and research germane to preparedness and resilience, and ensuring that federal operations and facilities continue to protect and serve citizens in a changing climate.”³

In various other sections, the Climate Action plan acknowledges that the government will need to play a critical role in the success of energy efficiency as a strategy to mitigate and adapt to climate change. The Administration will expand climate change and energy efficiency efforts in three major initiatives to better prepare America for the impacts of climate change: building stronger and safer communities and infrastructure, protecting our economy and natural resources, and using sound science to manage climate impacts.³ With a variety of clean energy options available and building on the leadership of states and local governments, the federal government can make continued progress in reducing power plant pollution to improve public health and the environment while supplying the reliable, affordable power needed for economic growth. By doing so, the government will continue to drive American leadership in clean energy technologies, such as efficient natural gas, nuclear, renewables, and clean coal technology.³

Conclusions and Recommendations

Global climate change is a severe and pressing issue, and energy efficiency is an important tool for climate change mitigation. The salience of the issue of anthropogenic climate change in the public opinion has been increasing since 2005. The 2012 Associated Press-NORC Center for Public Affairs data clearly show that energy efficiency is also salient issue, with 94.6% of respondents able to provide a definition for it when asked the question, “What does energy efficiency mean to you?” However, the wide diversity of responses to the question demonstrates a lack of consensus, and therefore the lack of focus in rallying public support for a specific energy efficiency policy objective. These data also reveal that the public is not making a connection between energy efficiency and climate change. While the AP-NORC survey results indicate that the public understands energy efficiency to be a behavioral or personal choice issue, with 45.5% of responses categorized as behavioral, they lack clarity on what actions they can take and how those actions can help address climate change.

There is a strong opinion-policy link, with each influencing the other. Public opinion has substantially influenced President Obama’s Climate Action Plan, as to be expected from the opinion-policy link, and

the policy is in line with public opinion. Given that public policy lags public opinion several years, and given that support for efficiency programs has increased, the President now finds himself in the right place for enacting change. The Climate Action Plan highlights energy efficiency, using it as a tool to reduce greenhouse gas emissions. It also addresses the salient issues and focuses on the prevailing opinions about what energy efficiency is, widespread and unfocused as they are. The Climate Action Plan treats energy efficiency as a multi-faceted concept, reflecting the dispersed perspectives of the American public.

Van Borgstede, Andersson, and Johnson concluded that policy action is necessary in order to improve energy efficiency, and the Climate Action Plan is an important first step. They asserted that, “without policies which give immediate feedback on environmental behavior, individuals are generally reluctant to a voluntary change in their behavior.”⁴ They went on further to add, “The challenge for policy makers will be to implement and communicate a program for improving energy efficiency and reducing energy use.”⁴ President Obama confronted this challenge by issuing his Climate Action Plan. Research has shown that public response to a policy is greater when the President makes it, rather than Congress, and this plan was a perfect opportunity.⁵

While it is an important step in the right direction, the Climate Action Plan is incomplete. The plan did not fully capitalize on the public’s awareness that energy efficiency is strongly impacted by personal behavior and choice. Further, it was a missed opportunity to use policy as a tool to lead public opinion in key areas, particularly as it relates to clarity about energy efficiency and its role in climate change. This paper offers the following recommendations for future climate and energy efficiency policy.

Clarify and define energy efficiency

Federal policy can help the public establish clarity on a more focused definition of energy efficiency. If the public’s definition is very broad, as it is today, policy-makers will have a difficult time rallying them around a key message. Policy should focus on defining energy efficiency for the public in easily accessible, relatable ways. For example, it will be easier to rally the general public behind the idea of more efficient personal behaviors, cars, and appliances, rather than behind more efficient industrial power plants.

Emphasize the link between energy efficiency and climate change

Though experts agree that there is a

strong link between energy efficiency and climate change, the public does not make this connection. Future policies should emphasize how energy efficiency can be a powerful and cost-effective tool to mitigate climate change.

Address personal choice and behavior

The terms “behavior” or “choice” do not appear in the Climate Action Plan, despite the fact that the public recognizes their personal behavior and lifestyle choices are key aspects to energy efficiency. Moving forward, policy-makers should capitalize on this public awareness, reinforce how important personal choices are, and offer specific actionable steps that the Americans can take.

Factoring these recommendations into environmental and energy policy efforts can promote policies that leverage the value of existing public opinion, while also influencing public opinion in positive ways.

This study is limited by the relative size of the data and the means used to acquire it. While it was a nationally representative survey of 1198 adults, individual responses were almost certainly shaped by issues of race, class, gender, and political affiliation. Further studies could benefit from collecting more varied raw data on this subject. Additionally, all data was collected by telephone, which may have impacted the results. Future studies may consider conducting in-person interviews to enhance the depth and thoughtfulness of the responses. Climate change and energy efficiency are vital topics that will impact many generations to come. Therefore, more research on this topic is necessary to fully understand the interaction between climate change, energy efficiency, and public opinion.

References

- ¹Urges-Vorsatz, Diana, and Bert Metz. (2009) “Energy Efficiency: How Far Does It Get Us in Controlling Climate Change?” *Energy Efficiency* 2.2. Pg 87-94.
- ²Goldman, Steven, Lowell Ungar, Steve Capanna, and Tom Simchak. (2012) “Energy Efficiency: A Tool for Climate Change Adaptation.” *Alliance to Save Energy*. Pg 1-18.
- ³The United States of America. Executive Office of the President. The President’s Climate Action Plan. Washington D.C., June 25 2013.
- ⁴Von Borgstede, Chris, Maria Andersson, and Filip Johnsson. (2013) “Public Attitudes to Climate Change and Carbon Mitigation- Implications for Energy-Associated Behaviors.” *Energy Policy* 57. Pg 182-93.
- ⁵Krosnick, Jon A., and Bo MacInnis. (2013) “Does the American Public Support Legislation to Reduce Greenhouse Gas Emissions?” *The American Academy of Arts & Sciences* 142.1. Pg 26-39.
- ⁶Kay, Ward. (2008) “The Role of Salience on the Relationship between Public Policy and Public Opinion.” Diss. George Mason University.
- ⁷Page, Benjamin L., and Robert Y. Shapiro. (1983) “Effects of Public Opinion on Policy.” *The American Political Science Review* 77.1. Pg 175-90.

⁸Stimson, James A., Michael B. MacKuen, and Robert S. Erikson. (1996) "Dynamic Representation." *American Political Science Review* 89.3. Pg 543-65.

⁹Burstein, Paul. (2003) "The Impact of Public Opinion on Public Policy: A Review and an Agenda." *Political Research Quarterly* 56.1. Pg 29-40.

¹⁰Monroe, Alan D. (1998) "Public Opinion and Public Policy, 1980-1993." *Public Opinion Quarterly* 62.1. Pg 6-28.

¹¹Hill, Kim Quaile, and Angela Hinton-Anderson. (1995) "Pathways of Representation: A Causal Analysis of Public Opinion-Policy Linkages." *American Journal of Political Science* 39.4. Pg 924-35.

¹²Geer, John G. (1991) "Critical Realignments and the Public Opinion Poll." *Journal of Politics* 53. Pg 434-53.

¹³Krosnick, Jon A., and Bo MacInnis. (2012) "Trends Between 2008 and 2010 in American Public Opinion Regarding Whether the U.S. Should Take Unilateral Action on Climate Change." Stanford University.

¹⁴Krosnick, Jon A., and Bo MacInnis. (2011) "National Survey of American Public Opinion on Global Warming." Stanford University.

¹⁵Sharp, Elaine B. (1999) *The Sometime Connection: Public Opinion and Social Policy*. Albany, NY: State University of New York.

Unique spaces, unique states of mind: the Thai forest monks and the Abhidhamma method of conscious states and meditation

BY BILLIE DASHAH CHEN
UNIVERSITY OF QUEENSLAND

Abstract

Forest monks are often venerated for skilled meditative and mystical powers while simultaneously remaining different, separate and mysterious to city dwellers and city monks. In the particular case of Thailand, forest monks are often worshipped as saints of Buddhist practice and can frequently be caught between the desire for an ascetic life and the demand for their services in the cities. Contrary to popular research on the topic, this article will not examine the forest monk tradition as an allegory of Buddha's enlightenment beneath the Bodhi tree; but will, instead focus on examining the unique space and state of mind that forest monks occupy as described in the Pali philosophical texts and commentaries surrounding the Abhidhamma Piṭaka. This article explores the attributes of forest monks as discussed in the Dhammasaṅgani and Puggalapaññatti and through analysis, elucidates common textual attributes of forest monks. The research for this article decodes tensions of the inner and outer lives of monks unique to the forest tradition. This article's textual analysis of Thai forest monks contributes to a greater understanding of their place not only geographically, but also in Theravada Buddhism and larger society.

The Thai Forest Tradition

The bearers of Sinhala Pali Buddhism were forest monks that forged amicable relationships with the Thai royals and elite thus enabling them to anchor the tradition in Thailand under the rule of King Kūēnā in the 1300s.^{1,2} However, not all Thai kings supported the integration of the forest tradition into institutional monasticism.¹ Under the kingship of Chulalongkorn, the Thai forest tradition was not awarded bureaucratic admission into the state's sangha act in 1902.¹ Later in the century, the tradition was recognized in the general order of the sangha but was still separate from the states institutional reach.¹ This highlights a hierarchy between approved 'high' Buddhism that is endorsed by the state and vernacular forest Buddhism that is seen as superstitious 'low' Buddhism of the peasantry. Despite unequal institutional relationships, the Thai sangha was categorized between village dwelling monks or *gāmaṇasīn* and forest dwelling monks or *ārañṇavāsīn* or *ariya*.^{1,2}

The forest *bhikkhu*'s tradition of reclusive practice is juxtaposed against the village monk's tradition of active engagement with the laity and Pāli scholarship.^{1,2} The *ārañṇavāsīn* or forest tradition operates in solitude, away from worldly interference, focussing on conducting experiential inward training of the mind through meditation and peripateticism.^{2,3} This bifurcation of inner versus outer is not unique to Thailand, as it is also evident in the early history of Buddhism. For instance, Sāriputta a disciple of Gotama, was acclaimed for his *Abhidhamma* commentaries that typified

two vocations for monks, the vocation of scholarship or *ganthadhura* and the vocation of meditation or *vipassanādhura*.¹ The *ganthadhura* vocation focused on learning or *pariyatti* and the *vipassanādhura* vocation was focused on practice or *pratipatti*.¹ Throughout these commentaries, the practical, meditative school of Buddhism is associated with forest *bhikkhus* or religious eremites, while the scholarly tradition is associated with the Buddhist elite.¹

The ascetic practices or *dhūtaṅga* followed by *ārañṇavāsīn* are aimed towards achieving *nibbāna* and becoming an *arabant* or noble *ariya*.^{1,5} A by-product of adherence to *dhūtaṅga* or ascetic practices and forest dwelling is the Thai laity's perceived ability for the forest monk to dispel ghosts or malevolent spirits with magical powers, powers that are given due to the fringe element of Buddhism in which they participate.^{1,6} Thai forest monks are often venerated as saints or *arabants* because of these abilities that stem from unique practices and a unique location outside of ordered society.^{1,5} When compared to city monks, homeless or wandering saints are often considered hierarchically superior and enlightened¹

The Unique Space of the Forest

Thai forest *bhikkhus* most often wander or settle on the margins of society in places separate from the state controlled sangha.³ The forest itself is perceived as antithetical to centralized and ordered civilization.³ The physical arrangement of people relates to a hierarchy of allure and civilization that systematically decreases the more one moves

away from metropolises and cities towards small villages, purlieus and finally, the forest.³ As notions of civilization and allure trickle farther and farther away from cities, conceptions of civility, attractiveness, safety and appeal become weaker and weaker.³ That is, the spaces farthest from cities are removed from the familiarity of city life, where everything is disordered and dangerous and the inhabitants are fearsome wild animals and immoral persons or entities.³ The forest is associated with chaos that spoils patterns of familiarity and order, as well as wildness and danger.³ Another contributing factor in the case of Thailand specifically is that Northern Thai forests are often linked to unlawful activities such as opium production and distribution and child trafficking and prostitution rings. These associations further contribute to greater society's general feelings of fear, apprehension and awe when regarding the forest and its inhabitants.³

The disorder and danger that would usually be attributed to forest dwellers manifests as magico-religious powers that allude to unconstrained potentiality in the case of the monks.³ The forest monk is perceived as endowed with these powers precisely because he dwells in the marginal and disordered space of society.³ The forest *bhikkhu* is filled with conflict when compared to the laity, who requires occupancy within the familiarity, safety and control of ordered life.³ In this way, forest monks operate in a unique space fraught with tension between ordered civilization and genteel sensibilities. They endure the untamed wild as they surpass worldly defilements in order to progress on

the noble path to spiritual achievement, sainthood or *arahantship*. It is due to these factors that they have been able to transcend the negative attributes of regular forest folk and maintain their aura of purity. They have sanctified the forest as a legitimate stage for spiritual development and achievement.³

Forest Practice

The *Visuddhimagga*, written by Buddhaghosa in the 5th century, is a treatise on Buddhist meditative practice in the *Abhidhamma* method.¹ The *Visuddhimagga* lists 13 types of ascetic practices or *dhutaṅga*, numbers eight, nine and ten are highly relevant to the forest practice in Thailand.¹ These three *dhutaṅgas* are described as the practice of dwelling in the forest, dwelling on a tree root and dwelling in open air.¹ The *Visuddhimagga* lists the *dhutaṅgas* as optional, but these particular practices are symbolic of forest *bikkhus* who emphasize rigorous practice and seclusion, particularly in a natural landscape.¹ Many forest *bikkhus* understand that these *dhutaṅgas* prescribe a better, harder and faster path to *arahantship* through a focus on seclusion and strict yet specific orthopraxy.^{1,2} As this text was written centuries ago, closer to the time of the Buddha than other texts, these ideologies and applications of Buddhism are often used by forest monks to legitimise their particular tradition and to classify themselves as 'true *bikkhu*' compared to other monastic traditions that stress different scholarship and orthodoxy.^{1,2}

The *Visuddhimagga's* *Abhidhamma* approach to meditative practice glorifies the role of solitary practice and claims that the first state of meditation or *jhāna* comes from secluded practice.¹ The text states further that psychic powers or *iddhi* are endowed upon achieving the four *jhānas* in solitude.¹ The *Visuddhimagga* does not denounce these *iddhis* as evil or sinful, but rather paints them as the occasionally dangerous fruits of concentrated meditative labour.¹ Forest *bikkhus* share many of the preferences listed in the *Visuddhimagga* as they practice several types of *dhutaṅga*, are gifted with *iddhis* or supernatural powers and live in secluded, naturalistic habitats that have been associated with landmark achievements of the Buddha.⁷ In this way, forest *bikkhus* not only operate within a unique physical space in Buddhist Thailand, but also utilise the *Abhidhamma* method of *dhutaṅgas* or ascetic practices to legitimise the correctness of their particular interpretation and application of Buddhism.

Unique States of Mind

The *Dhammasaṅgani* and the *Puggalapaññatti* are the second and fourth books of the *Abhidhamma Piṭaka* that list

different states of mind and human types in a Buddhist psychology.⁸ The states or frames of mind are types of conscious development that one may be in at any given time along a greater trajectory of spiritual development.⁷ These texts elucidate Buddhism's focus on the mind or *citta*, and mental factors or *cetasika*, and can assist in understanding the unique state of mind forest *bikkhus* employ in their practical interpretation of Buddhism.^{7,8} This analysis will start first with the *Puggalapaññatti*, as it provides a more methodical basis to describe specific types of application to Buddhism in mental states.

One state of mind in the *Puggalapaññatti* is the person who 'neither tortures himself nor others'.^{8,9} A person in this state of mind finds the householders or *gāmaṇīs* life tedious and restrictive, so he disregards his worldly aspirations and lifestyle for one more noble.^{8,9} He enters the homeless life of scarcity and follows strict monastic rules in the forest, or in another secluded place.^{8,9} The forest *bikkhu* also emphasizes the practice of meditation and absolves himself of mental defilements in a solitary milieu.^{8,9} From the practice of denying the senses and increasing the capabilities of inward reflection and meditation, the *bikkhu* understands the suffering or *dukkha* of the body through the supersession of cravings and desire.⁸ The forest *bikkhu* shares all the attributes of this Buddhist state of mind called 'one who neither tortures himself nor others' as he denounces the world of the *gāmaṇī*. He becomes homeless and starves his mind and body of desire and sensuousness to follow the monastic code and strict *Abhidhamm-ic* meditation in seclusion.^{1,8,9,10}

The *Dhammasaṅgani* is the second book of the *Abhidhamma Piṭaka* and shares a similar psychological analysis as the *Puggalapaññatti*, as it explores the different *khandhas* or aggregates of a human being.^{4,11} *Khandhas* often relate to blockages or negative behaviours that need to be passed through the application of practical Buddhism in order to spiritually progress.⁴ The focus of this inquiry will be the second *khandha*, the *khandha* of feeling and mental pleasure.¹¹ This analysis will explore how the unique states of mind *bikkhus* use to approach Buddhism create tension within second *khandha*.

The second *khandha* of sensation is the sensing positive or negative objects.⁴ Trungpa explains that the second *khandha* includes feelings of intoxication that may entail 'jumping to conclusions'.⁴ The body is always intoxicated on worldly desires, self-mortification, ideology or the solitude of the forest.⁴ While the laity or city monks are more closely linked with the struggles of denouncing worldly desires, forest *bikkhus* are removed from much temptation and

are instead intoxicated with the forest and solitude.⁴ That is, one can become desirous of anything, be it the desire to do something bad such as stealing, or to do something good like live in the forest for mediative reasons like the forest monks. Trungpa claims that the second *khandha* is also associated with 'jumping to conclusions and attaching oneself to them'.⁴ Perceptions of right or wrong ideology or practice is part of the second *khandha* and the forest *bikkhus* could be understood as having tension within the second aggregate. The forest monks have taken up extreme *dhutaṅga* or ascetic practices and have been captured and possessed with the ideology of forest Buddhism. As described in the *Dhammasaṅgani*, this type of attachment is negative as it denotes grasping, which can cause increased *dukkha* or suffering. Grasping also is problematic to the cessation of *dukkha* and spiritual progression.

Key Points

Figure 1: This diagram represents the contradictions and tensions of the inner and outer lives of forest monks. They are on the path to *arahantship* even though they are located in disordered and wild milieus that are usually seen as evil. They are enlightened beings who adhere to the unique state of mind that does not torment, but rather exhibits behaviours that insinuate they that torment themselves over 'correct' ideology within the 2nd *khandha*.

The forest *bikkhu's* state of mind is unique as this *Abhidhamm-ic* method of both psychological analysis and practice is the work for only the most tough-minded monks. The forest *bikkhu's* unique status can be divided into the inner and outer life. In the outer life the forest *bikkhu* is regarded positively as he is removed from worldly desire and on the path to *arahantship*, venerated by the laity (Tosa 2009, vol. 68: 240; McDaniel 2011: 24).¹² More negatively, he is located in the disordered chaos outside of civilization, camping with wild beasts, malevolent spirits and ghosts and thus is sometimes feared for his power and lifestyle.³

The inner life of a forest *bikkhu* is perceived positively as he is 'one who torments neither himself nor others' as per the types listed in the *Puggalapaññatti*.^{8,9} However, the *bikkhu* exhibits ideological behaviours that torment themselves over 'correct' ideology within the second *khandha*. The forest *bikkhu* latches on and attaches to ideological conclusions about the right application of Buddhism and further, he may be devoid of worldly pleasures. Instead of being intoxicated on illicit substances however, he is intoxicated on the forest and the power it represents.^{4,11} The second

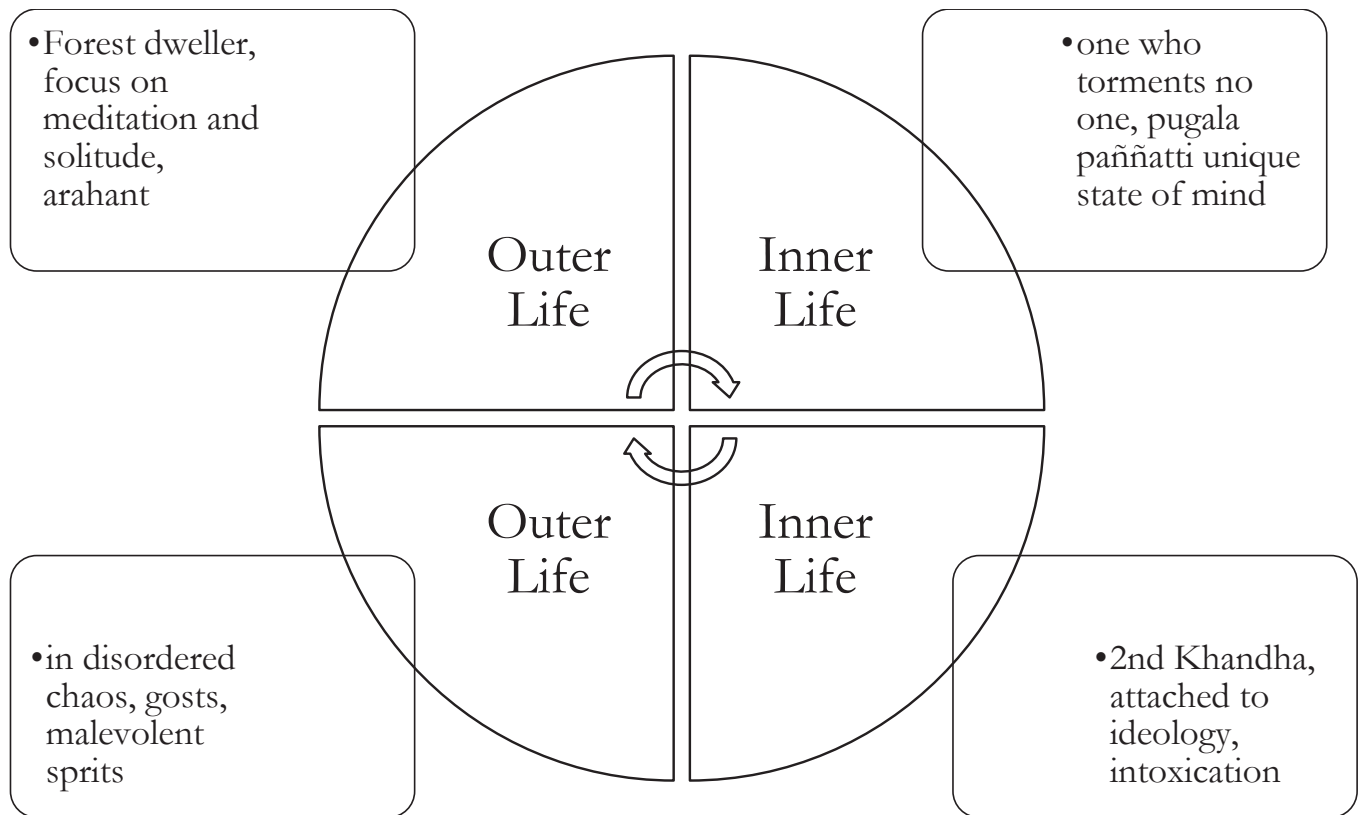


Figure 1. Key Points

khandha is of feeling and sensation and explains that a person will always be intoxicated on something, and it could be argued that at times, the forest monks show they are more intoxicated on the forest and the ideology of forest practice than on meditative concentration or salvation.⁴ These factors help to highlight the unique space and state of mind forest that *bikkhus* occupy in light of city dwellers. This article has carefully weaved together the ideological threads that forest monks use to maintain a unique tradition that is undertaken within a unique state of mind in a unique space. Additionally, this article utilizes various ancient Buddhist texts that have not been previously used in this way or on this topic to create a new discourse that explores the forest monk tradition.

References

- ¹Tambiah, S.J. (1984), *The Buddhist Saints of the Forest and the Cult of Amulets: A Study in Charisma, Hagiography, Sectarianism, and Millennial Buddhism*, Cambridge: Cambridge University Press.
- ²Taylor, J.L. (1993), *Forest Monks and the Nation State: An Anthropological and Historical Study in Northeastern Thailand*, Singapore: Institute of Southeast Asian Studies.
- ³Walter, P. (2007), 'Activist Forest Monks, Adult Learning and the Buddhist Environmental Movement in Thailand', *International Journal of Lifelong Education*, 26 (3) 329-345.
- ⁴Trungpa, C. 1985, *Glimpses of Abhidhamma*, Prajñā Press, Boulder.
- ⁵Tosa, K. (2009), 'The Cult of Thamanya Sayadaw: The Social Dynamism of Formulating Pilgrimage Site, *Asia Ethnology*, 68 (2), 239-264.
- ⁶McDaniel, J.T. (2011), *The Lovelorn Ghost and the Magical Monk: Practicing Buddhism in Modern Thailand*, New York: Colombia University Press.
- ⁷Johansson, R.E.A. (1985), *The Dynamic Psychology of Early Buddhism*, London: Curzon Press.
- ⁸Pathak, O.M & V. Gaur (2000), *Abhidhammapiṇṇake: Puggalapaññattipālī*, Delhi: Eastern Book Linkers.
- ⁹Law, B.M. (1969), *Designation of Human Types: Puggala-Paññatti*, Hertford: Pali Text Society.
- ¹⁰Jayasuriya, W.F. (1963), *The Psychology and Philosophy of Buddhism: Being an Introduction to the Abhidhamma*, Colombo: YMBA Press.
- ¹¹Rhys Davids, C. (1974), *A Buddhist Manual of Psychological Ethics: Dhamma-Saṅgāṇī*, London: The Pali Text Society.
- ¹²Kalupahana, D.J. (1987), *The Principles of Buddhist Psychology*, New York: State University of New York.

Judging emotion in reason: the effect of emotion in the Anglo-American legal system

BY DIANA KONTSEVAIA
MCGILL UNIVERSITY

Abstract

The social construction of emotion shapes communities' definitions of what is "appropriate" to feel in a given situation. The social construction of emotion is especially salient and imperative to understand in the context of the current Anglo-American legal system. In this system, the perceived cognitive separation between emotion and reason is accepted as commonly held understanding for evaluating people's behavior, which prescribes a set of expectations that in certain cases comes forth in gendered terms. This study in cognitive anthropology explores how perceptions of the human cognitive mechanism affect how people are treated even in the allegedly most rational parts of society such as the legal system. The legal system imparts judgement which is designed to be an objective manifestation of justice, while relying on subjective culturally-informed ideas about emotion and gender. These ideas result in a prevailing preference toward male over female and rational over emotional associations in the Anglo-American legal system and result in biased verdicts and inequality.

Introduction

Emotion, it is said, suspends reason. In traditional Western thinking, what is rational cannot at the same time be emotional. The role and importance of emotion, however, is viewed differently across cultures as well as in people's daily lives. The different perceptions of things such as how to deal with emotion are "folk models" that are formed by societies as ways to understand the world around them.¹ Each society will have their own folk model for the cognitive process and what role emotion plays, but they generally fall into two broad categories: emotion and reason either occur simultaneously as part of one cognitive process, or they occur in separate realms. In a society, such as the traditional Anglo-American society that privileges rationality, rationality is seen as more dominant, powerful, and preferable to emotion. The domination of one part of the cognitive process over the other has historically become associated with the more dominant gender.² As a result, the very concept of "emotion vs. reason" has, over time, taken on gendered meanings. While men are considered to be rational, protective, and stable, women are considered to be irrational, vulnerable, and insecure emotional beings.

This paper attempts to trace culturally-ascribed meanings of emotion as well as the implications and consequences of the emotional-rational dichotomy in the U.S, drawing on scholarship and literature pertaining to cognitive anthropology. Specifically, the paper will look at how certain parts of the U.S. legal system deal with questions of emotion and the consequences

the emotional-rational dichotomy has for male and female defendants. The present analysis is not a comprehensive sociological or psychological examination of the inner workings of the legal system, although the topic would certainly benefit from further systematic and quantitative inquiry. The paper outlines where the emotional-rational dichotomy is most apparent by analyzing trends in legal cases that attempt to regulate emotional crimes, such as homicides caused by a sudden rush of emotions. These trends bring to light the unequal and subjective facets of the legal system and how it delineates the boundaries of the legal discourse in terms of gendered biases. Judgments of emotion on the part of jurors and people surrounding the trials highlight the legal system's dependence on social norms. Specifically, the legal system is affected by the widespread acceptance of the division of emotion and rationality, as well as from historically unequal power relations between women and men. Despite the fact that the cognitive process, in general, incorporates both rational and emotional components prior to action, in some instances the U.S. folk model of cognition accepts the division between the rational and the emotional, which has an impact on how legal cases are handled.^{2,3,4}

Using rational processes, the people involved in the legal system, such as judges, lawyers and jurors, attempt to understand irrationality on the part of defendants. Jurors evaluate how "reasonable" a defendant's action was during their irrational moment, often based on their own pre-conceived notions of what is and is not acceptable. Irrational behavior can come from anyone,

yet in the legal setting, the gender of the defendant has an effect on the verdict of the case. The verdict is affected by how irrational behaviour is judged and depends on how jurors view the emotional and rational cognitive mechanism and which folk model of cognition they rely on. Although verdicts sometimes adhere to the rational/emotional folk model, nowadays they can also exhibit a paradigm that accepts a combination of the two. When the rational and the emotional are seen as one mechanism, the verdict assigned to the perpetrator is much different than when the two are viewed as separate. When the rational and the emotional are considered separate, verdicts tend to excuse certain kinds of behavior—but only for certain actors. The choice of which framework is used and when depends on the gender of the defendant. In other words, having two competing understandings of the cognitive process can lead to different treatments and verdicts for the defendants.

In order to explain how human perceptions of emotion and cognitive functions affect the results of legal proceedings, it is first imperative to understand the role emotion plays in the human cognitive process. Then, the relationship between rationality and emotion will be explored by looking at the impact of culture, specifically, the social construction of emotions and the transmission of gender norms. These topics will then be explored in the context of the U.S. legal system. After a brief overview of the development of the legal view of emotions, the paper will look at some cases that exemplify the role of emotion in the legal system; specifically

the paper identifies instances of homicide cases caused by crimes of passion or self-defense after domestic violence that illustrate the variable application of folk models in judgments and their effect on verdicts. The trends in verdicts outlined below, based on the gender of the defendant, highlight the consequences of social folk models of emotion. In the future, to further solidify ideas presented in this paper, it will be beneficial to conduct a more comprehensive study of U.S. homicide cases resulting from crimes of passion and the consequent uses of the defense strategies of provocation and self-defense to evaluate the existing gender (and other) bias. The last part of this section turns to jurors to discuss how the social parts of the legal system disrupt the rational and objective assumptions of law. The paper concludes by detailing the limits that exist within common cultural definitions of "human reason" and the negative effects non-white*¹non-male participants can experience in the legal system.

Part I: Emotion and Cognition

Folk theory of emotion: the role of emotion in cognition

Emotion is often viewed in opposition to rationality. This opposition is as persistent as the "nature vs. nurture" divide and has captured many people's imaginations.⁵ Some cognitive scientists have theorized that the region of the human brain that processes individual emotion is separate from the region associated with rational decisions.⁶ Although the physical places in human brains are separate for the two processes, they constantly work together to generate thought.³ The assumed division between rationality and emotion contends that, although these two parts constantly interact to generate thought, together they do not constitute one whole. In other words, the division supposedly works in such a way that emotion can inform rationality, but if it is too strong it can overpower rationality and shut down rational thought completely and allow an irrational action such as murder.⁴ This means that it is perceived that if someone is too emotional, they can no longer act rationally and engage in irrational acts.

This folk view of emotion is problematic for two reasons. First, emotion is an inherent part of the cognitive process, not just a distant influence. Second, the separation between emotion and rationality justifies and perpetuates other socially constructed biases, such as the view that women are more

emotional and consequently less rational than men.² As we will see in the second half of this paper, the emotionality of women and the assumed rationality of men warrant unequal legal punishments for the two sexes, with men more likely to receive lenient sentences if they use the defense that they had been provoked and were acting following an emotional shock.⁴ On the other hand, it is perceived that since women are already more emotional, they are more accountable for their actions in unprecedented situations, and therefore more likely to receive harsher sentences.⁴ In effect, men can say they were provoked and could no longer control their emotions as part of their defense for committing a crime of passion, while women are held more responsible for their emotions and receive different punishments as result.

The first problem of the folk view is that it sees the emotional and the rational as separate entities. At the very extreme, the emotional part of the brain is seen as disruptive to rational thinking. Criticizing this "disorganization theory", V.J. McGill argues that emotions do not disrupt, or "disorganize" perception of social situations.⁷ The view of disorganization theorists is that while emotion disrupts rationality, it is at the same time adaptive in emergencies and can help people survive.⁷ Emotion, therefore, cannot be disruptive to the cognitive process. On the contrary, emotion is a crucial part of the cognitive process as it allows humans to appraise everyday situations and react appropriately. This means that actions can never be unmotivated.⁷ In other words, the view that due to emotions "things just happen" is invalid. The two mechanisms work together in order to give an appraisal of the situation and evaluate what sort of action needs to be taken.³ Emotional responses are the result of picking up certain cues and paying attention to them in a specific way. The cues that were picked up are still part of the cognitive environment of an individual. Feeling emotions is the most basic way in which an individual is capable of responding to their environment. Even in times of "failed communication", when another person's intention is misunderstood, these moments are not caused by emotions disabling the rational and cognitive abilities of an individual. Rather, emotions, even if mild, influence how people react to given situations.³ Emotional responses come first and are an integral part of the cognitive process. In effect, emotion helps people be rational because it helps evaluate a given situation; emotion does not make humans less capable of thought or less rational. Even impulsive behavior is a consequence of people's perception and evaluation of the situation, not a disruption of their cognitive

process.

While emotion is part of the cognitive process, the appraisal of situations and the reactions to them change depending on the environment of the person, and can be influenced by social factors. For example, while fear when faced with a life-threatening situation (fight or flight) may create a similar physiological response in human beings everywhere, the understanding of what to be afraid of is often different from culture to culture.¹ Furthermore, Robert Levy, who studied the Tahitian conceptualization of emotion, argues that the cognitive evaluation of emotions occurs in two steps.⁸ The first appraisal operates out of an awareness of a relationship with something in the outside world. "It is knowledge that mobilizes the culturally influenced systems of percepts, concepts, words, values etc."⁸ In simple terms, if a person loses someone they care about, they will know that they have experienced a loss, but how they experience the emotion is based on their environment and culture. For example, a Tahitian, upon feeling loss will interpret that loss as "feeling heavy" because that is the culturally appropriate response.⁸ The first appraisal and the knowledge of emotion is learned through random experiences that become more and more structured later in life in a way specific to the culture in which one lives.⁸ The influence of culture on the first appraisal is much more limited than culture's influence on the second appraisal. The first reaction to emotion triggers the second cognitive appraisal of the situation, which will follow a specific learned cultural program.⁸ The second appraisal allows the person to classify, name and understand their knowledge. This understanding occurs in a learned system of meaning that was taught to the individual throughout their life.⁸ The reference to "cultural" in this passage is used to refer to the shared experiences that shape individual reactions. Consequently, the reaction may be different if the individuals were in another community.⁸ Emotions are therefore multifaceted: they are an inherent part of the cognitive appraisal process but are also influenced and structured by society and experience.

Social construction of emotions

"In processing people, the product is a state of mind."⁹ People's minds are affected by the various processes that surround them, and as a result the societies they live in affect various parts of their lives. Given the evidence previously described, emotions and emotional responses are socially constructed. Emotions are preceded by experiences that are evaluated with the help of emotional responses. This evaluation has

*I state non-white and non-male because literature suggests these two categories are similar in the treatment they receive in the Anglo-American legal system. Though the concept of ethnicity is deserving of similar examination, it is beyond the scope of the present analysis.

to come from what the person has learned. The learning is generally influenced by the people, environment, and the community that surround an individual.¹⁰ In other words, emotions are cognitively evaluated with the knowledge that a person has learned through their environment.⁸ This idea is further complicated by the fact that everyone who participates in a community does not construct an appropriate emotional response in the same way.

In the case of gender, the social construction of emotion corresponds to the structures of power within the society.² In Western conceptions, women are seen as more vulnerable and therefore more emotional.¹¹ Moreover, women are expected to show positive emotions, and “are allowed to express negative emotions as long as these expressions do not hurt others.”¹¹ On the other hand, men are seen as more powerful and are not supposed to express weak or negative emotions, although this trend has been somewhat changing in recent years due to the rise of emotionality in the West.¹¹ Interestingly, depending on the situation it is still less acceptable for a man to cry than a woman, although crying men are generally more well liked than their non-crying counterparts.¹¹ While generational and behavioral changes do exist, there are still major differences in how male and female behaviors are constructed.² Since women are seen as lacking power, they become associated with various aspects of culture that are less valued.² Since in some instances rationality is privileged over emotion, women are viewed in opposition to rationality, as weaker, more emotional beings.

The way emotion is shaped by society thereafter informs how emotions are individually experienced and which emotions will be felt at any given moment.² In some societies, women are perceived as emotional, ruled by passion and therefore more irrational, while men are perceived as logical and rational. This development reflects the power and status dynamic found in gender relationships.² Social sanctions will usually follow if a boundary of appropriate emotional conduct is crossed (and will depend on the power of the person among other things), which in turn means that the acceptable socially constructed emotions become reproduced in a self-perpetuating cycle.² The cycle therefore, not only prescribes how people should behave, but also how people should conceive of themselves, their gender, and their emotions. When people go outside their prescribed boundaries—or “cross the line” so to speak—such a transgression results in social repercussions. These gender-based consequences take on strikingly more evident characteristics in the context of the

Anglo-American legal system. Gendered assumptions about the way women and men should express their emotions and which reactions are appropriate have an impact on how homicide cases are judged in the courtroom and their verdicts.

Part II: Emotion and Law

Criminal law, rationality, and justifications for murder

For the sake of clarity, a brief overview of criminal law, its history, development, and application, is presented here. Of particular relevance to the present analysis are cases of homicides caused by crimes of passion or executed as acts of self-defense. In each, the evolution of emotion and the circumstances of the victim's death play a crucial role in the final verdict. There are three degrees of murder that a person can be sentenced to in the Anglo-American legal system. First degree murder refers to the pre-mediated act of killing someone; a particularly well-planned, tortuous, or cruel way of taking someone's life. Second degree murder refers to a premeditated murder committed with an intention of personal gain (but not the intention of killing someone). Finally, third degree murder has two distinctions: either involuntary or voluntary manslaughter. Involuntary manslaughter is the result of negligence or an accident resulting in someone's death. It is the second of these distinctions that is of keen interest to the present analysis: voluntary manslaughter. Voluntary manslaughter encompasses murders that were committed in the spur of the moment or in self-defense. Third degree voluntary manslaughter refers to cases where there is no premeditation for the crime but the murder was nonetheless intentional. In the context of criminal charges, third-degree voluntary manslaughter is considered to be a lighter sentence with more lenient punishments. Many defendants use the defense of provocation (in cases of crimes of passion) and self-defense (in cases of domestic violence) in order to attain the lighter sentence of voluntary manslaughter in homicide cases. While the three-degree process for evaluating a homicide exists objectively on paper, in practice the court's conduct while reviewing homicide cases is questionable. The judging process and results are inconsistent because of involvement of subjective jurors, judges and direct coaching by attorneys—all of whom may rely on a variety of folk models and apply them to the case's evidence differently.

The evaluation process opens a door for gender disparity in the applications of sentences, basing judgements on defendants themselves and the type of murder conducted. The boundaries between the

three types of murder are often ambiguous and are judged on a case-by-case basis with jurors' and attorneys' emotions and pre-existing convictions permeating each case. While the legal codes have been written to limit the influence of emotions to help jurors arrive at a sentence in an objective manner, the legal system and actors within it, such as judges, juries, attorneys and defendants themselves are still a product of society and thus subject to social standards. The legal process is not immune to external social processes while judging cases, especially in regards to attitudes towards gender and emotion.

Since the founding of the legal system, there have always been issues with adjusting the legal code to the uncertain and changing reality of the human world.¹² Nevertheless, it is the purpose of the law to contain human behavior in order to foster an ordered and just society. The legal system essentially delineates what is just or unjust in a given society.¹³ In *Doctrine of Right*, Kant outlines three cases where it is acceptable to kill.¹⁴ The three cases are the right of necessity, killing in a military duel, and bastard infanticide.¹⁵ The first of the three, the right of necessity (to preserve one's own life), is most ambiguous and problematic in contemporary criminal law.¹⁵ The justification to kill in the name of necessity exists explicitly because of an understanding that not everything in human life can be “rationally” controlled. This means that there will be things that do not fit neatly into the rational categories of behavior outlined by law. The irrationality, however, is not due to an overwhelming reliance on emotion. Rather, it is due to an unforeseeable convergence of situations and reactions that result in irrational consequences, in which the first cognitive appraisal is nevertheless still emotional.⁸ Emotions are thus not irrational, but they are not necessarily desirable or follow logically the correct social prescription.² The courts acknowledge this, and the legal system was created partially to regulate the irrationality of human life.¹² Yet in the Anglo-American legal system, irrational and emotional were soon clumped together because of social factors such as gender and as a result it currently fails to justly arbitrate unfortunate and unpredictable circumstances.⁴ Emotions reflect the situation by including a cognitive component and a readiness to act:

“Rationality and adaptive value depends on the adequacy of these two components in the given situation... foreseeing that an object promises good or ill and the knowing, or not, how to deal with it, determines the attitude toward it, and also the feeling.”⁷

Rationality and emotion work together to appraise the situation and determine a person's feeling and reaction towards a situation. The "rational and emotional divide" present in the legal system, brought in by jurors, judges, attorneys and defendants themselves, often does not describe the cognitive appraisal system in an accurate way, because there is no divide. Although the response may not be appropriate, it does not mean that it lacks rationality based on cultural premises and previous experience of the individual. Action, therefore, can never truly be unmotivated, since it is responding to something external and motivation comes from a cognitive appraisal. In order to arrive at a response to a given situation, an individual uses emotional appraisal as an inherent part of the cognitive process.

Separating the rational and emotional, therefore, does not present a realistic view of the cognitive process. In the case of the Anglo-American legal system, the separation unnecessarily privileges the rational part of the cognitive process over the emotional part, though in reality the two work in tandem. Individual cognition is, first and foremost, based on an emotional evaluation and only then it is informed by a rational response.³ The emotional evaluation itself is not a random response, rather it is subject to the rules of the society that surrounds the individual and the emotional propriety must be evaluated against social norms.⁴ Emotions are an inherent part of the cognitive process and are a necessary component in arriving at a response and ability to act, despite the fact that the action may be irrational.

Emotions are thus valid cognitive responses to the outside world and should be judged in a manner that corresponds to their importance in the cognitive process. They are an integral part of action, and should not be evaluated as separate when judging a person's action. They are not merely an excuse for hard situations, but rather they function as a guide that prescribes a consistent understanding of acceptable responses to certain situations. In attempts not to regard emotions as invalid and irrational, some scholars suggest emotions should be judged based on how well they adhere to social standards and how acceptable they are in similar situations: whether they are reasonable or unreasonable.¹⁶ This approach, however, threatens to bring more bias into the legal system.

While evaluating the validity of emotions based on social standards, the question of how the legal system should handle emotion becomes particularly relevant. Is there a reasonable emotion and set of experiences that can lead to an excusable homicide? In a society that values rationality over emotion,

a man is still required to exercise control over his actions, since emotions are seen as disrupting rationality.¹⁶ Essentially, people are being measured to what is socially acceptable. As a result, the "social rationality", which is created by social norms, enters the legal system. Social rationality abides by what is common-sensical for the society, rather than the consequences of hard, cold logic. Nevertheless, the legal system maintains its insistence that it is objective and logical, despite the fact that it reflects the power relations of the society it is based on (since it is also the product of the same social rationality). It is thus unsurprising to find that the legal system contains inherent prejudices.

The confusion surrounding the consequences of emotional actions and the subjective judgement of emotions means that it has so far received inconsistent treatment in court.¹⁶ Rather than basing judgements on cognitive appraisals and emotional effects being identical for human beings as a whole, the legal system judges each emotional homicide case based on the person accused rather than the action, opening its allegedly objective judgments to prejudiced and gendered perceptions. To understand whether what the defendant was feeling was an appropriate response to a given situation, the court evaluates the personal relevance of the individual towards the defense they chose to use, which results in inconsistent treatment of homicide cases.¹⁶ For instance, in two similar cases where both defendants committed a homicide, the two cases will be judged differently depending on whether it is realistic that the specific individual could feel those emotions and what potential impact on their rationality the emotions may have had. In other words, because of the emphasis on rationality, the legal system is ill-equipped to judge emotional homicidal cases consistently—especially when defendants use defense strategies such as defense of provocation and defense of self-defense.

Defense of provocation: crimes of passion

The defense of provocation is used in cases where the defendant has committed a crime because the victim provoked an unstable emotional response from them. The role of emotion in reason is the central question when assessing the sentence a defendant receives after committing a crime of passion. Considering the role of emotion and the rationality of the defendant at the moment of the crime reveal the way people involved in the case (juries, lawyers, judges) perceive emotion. In the Anglo-American legal system, rationality is no doubt privileged, but it is recognized that irrational things do still occur. This is where defense of provocation comes into play. Defense of

provocation is a way for the judicial branch to let society know that certain conduct is not acceptable, while at the same time releasing the perpetrator. In a way, the defense of provocation describes the limits of human rationality.¹³ When people who murdered their spouse "in the heat of the moment" are charged with murder, they can use the claim of being too emotional (and by default too irrational to think otherwise) in order to soften their sentence. As a consequence, the rationality of the person and appropriateness of their response (reasonableness of the provocation) are evaluated by the jurors. When a man commits a crime of passion and then proceeds to use the defense of provocation, his own rationality is considered. If the man has had a history of violence, it is unlikely that he will receive a light sentence. If, on the other hand, this act was a complete departure from the usual conduct of the individual, then a lighter sentence may be expected.¹⁶ As we will see, because of the conception of rationality and emotion, men are able to use this excuse more successfully than women.

Regardless of his feelings, the defendant may have acted rationally depending on his evaluation of the case, given the information available at the moment. The rationality of the individual's action thus has to be evaluated based on the context of his situation and the defendants' previous behavior. As a result, the timing of the passion crime becomes central to the decision of the jury. Generally, if the defendant had time to "cool off" between the initial emotional provocation and the murder, then the murder is more likely to be viewed as premeditated. If, however, jurors perceived that cognition was informed by both emotion and rationality, this would not be necessary, as all action would be seen as premeditated already. Since that is not the case, the evaluation of the situation as well as the character of the accused in homicide cases, seems to lead to different sentences for men as opposed to women. Men in these situations are often compared against the "reasonable man" standard, whereas women, viewed as more emotional, are seen as "unreasonable women".⁴ Men are more able to benefit from the defense of provocation than women and as a result are more likely to achieve lighter sentences. Although more statistical evidence needs to be gathered before suggesting the degree of this problem, the current social trends suggest that such inequality within the legal system does exist.

Defense of self defense: battered women and domestic violence

The difference in judging male and female perpetrators is also evident in the

results of cases in which women murder their husbands after experiencing domestic violence. These women often use “battered women syndrome” (BWS) as a justification for self-defense.¹⁷ Most murders by abused women occur when the husband is immobile (for example, sleeping) and no provocation had taken place, and therefore, a defense of provocation cannot be used. Instead, the defendants appeal to self-defense to try to soften their sentence to voluntary manslaughter.¹⁷ In this sense, the right of necessity to defend one’s life is justified because of the emotional, psychological, and physical consequences of husbands’ abuse. Nevertheless, the defendants in these positions are judged similarly to those who committed a crime of passion. Whereas the evaluation of the provocation is waived because of the circumstances of the crime (which are often premeditated BWS self-defense cases), the jury looks at the character of the woman rather than the actions. In domestic violence cases, the jury evaluates the validity of her BWS and her previous resistance to her husband’s beatings. If the case is considered to be “typical”, the woman is likely to get a more lenient sentence. A typical case means that there was an imminent danger to the woman’s life, but more importantly, that she acted as a typical woman and did not have a history of active resistance.¹⁷ To evaluate cases where the defendant claims self-defense due to domestic violence, judges and juries have to look at the emotional composition of the female and her history of active or passive resistance.

Making judgments

In Anglo-American law, emotions are viewed as being capable of overwhelming the rationality of a man (and not a woman) because of the socially constructed division between emotion and rationality. As a result, male momentary irrational behavior is more excusable and can often receive a more lenient punishment, because they are seen as more rational and therefore more likely to be overwhelmed by emotion. The application of a lighter punishment because of a loss of rationality, however, does not apply to all members of society. The evaluations of the types of criminal cases outlined above roughly depend on two considerations: the evaluation of the experience and the evaluation of the person. In the case of crimes of passion, the experience is evaluated in terms of the feasibility of the provocation; for self-defense claims, the experience is based on establishing whether domestic violence took place. When evaluating experience, therefore, the possibility of the provocation and the defendant’s reaction

to that provocation are both evaluated. The jurors analyze the circumstances of the crime and the appropriateness of the emotional state of the defendant to understand whether the victim has received a response that they themselves provoked.¹³ The provocation itself can become gendered, as social norms make provocation by women look different than provocation by men.

The biggest part that emotion plays in judgement is in the evaluation of the person. It is common in both instances to evaluate the rationality of the person and whether or not their emotional state was morally excusable. The evaluation of the character of the person plays a much bigger role in the decision making process than the evaluation of the experience. Judging what is emotionally appropriate for the person means that the jurors themselves rely on the social context to evaluate the evidence.⁴ This becomes especially problematic since jurors judge based on their own biases. Although the judgment is intended to be just and objective, because of pre-conceived notions of emotion as it relates to rationality among other things, judgments reflect social power divisions like those observed between genders. Essentially, thought process and conclusions are “not neutral but rather reflects the dominant social interests and values.”¹³ Gender stereotypes are thus perpetuated while also being considered just.

The evaluation of the emotional status of the person on trial can be analyzed by looking at two things. First, the jurors will consider the consistency of the character of the person (in other words, whether or not they have committed a similar crime in the past). The second dimension for evaluation considers the social norms directly by comparing the defendant to social mores. In the case of crimes of passion, the defendant is considered against the “reasonable man” norm, and although it has now become known as “reasonable person”, it largely relies on the same set of assumptions that a man is more powerful.⁴ If the situation involved self-defense at home, then cases are compared to other similar instances of domestic violence.

The jurors will first consider the character of the defendant. There is a need to understand whether the defendant usually acts this way and thus needs to be incarcerated, or whether this was a single, isolated event in their lives. In other words, the law will only excuse a homicide when it is a singular incident, and not part of a bigger behavioral problem.¹³ The consideration of the individual in a given situation is thus crucial, especially in cases of provocations and self-defense. If the jurors recognize the behavior as out of the ordinary, the defendant

is likely to get a lighter sentence.¹⁸ On the other hand, this also makes the appeals to provocations or self-defense gendered, since it allows for jurors’ perceptions of what is socially “ordinary” to judge the character of the individual (and even compare to gendered social norms) rather than adhering solely to the facts of the situation.

As a result, jurors often base their decision on whether or not the defendant acted as any “reasonable person” placed in the same situation.¹³ This is the pinnacle of the crime of passion defense. Judging whether or not this act adhered to social standards and if any other reasonable individual would do the same becomes an extraordinarily difficult task to accomplish objectively and equally. Still in hopes of eliminating bias, jurors rely on the “reasonable person” standard. This standard, however, is already infused with pre-conceived notions of what is “reasonable” (in effect rational and acceptable) conduct. In many courts, the term is not very well defined; leaving judges and jurors to conclude for themselves what constitutes “reasonable” behavior. The pre-conceived notions generally lead to the assumption that people who acted rationally are blameless whereas people who acted irrationally are blameworthy.¹³ The evaluation of the rationality of people’s actions, however, is not applied equally to everybody because of the existence of a pre-conceived understanding of who in society is likely to act rationally when comparing them to the “reasonable person” standard. As a result, women are still most often considered to be irrational, to be less “reasonable”, in comparison with the “reasonable person” standard, and thus they cannot reap the benefits of a more lenient sentence in a way that men can.¹³

Women do not have the same access to the benefits provided by the “reasonable person” standard because a woman killing her husband out of jealousy or anger over infidelity is considered to be an “unreasonable woman”. If she were a reasonable woman, she would not have taken such drastic action, because that is not how women are assumed to behave. To illustrate this dynamic, when Hilary Clinton’s husband publicly cheated on her with his intern, she did not retaliate and was expected to stand by her husband.⁴ Throughout the ordeal, an improvement in Hilary Clinton’s approval rating was observed. If she had reacted by publicly humiliating her husband, she would most likely have been viewed as petty.⁴ Such subdued behavior is expected of women in general.² Similar conduct would hardly be expected of men, for whom bearing the humiliation of a cheating wife without doing anything about it would be seen as

foolish.¹¹ We see in these cases that there are prescribed ways that women and men are expected to react to events, and in homicidal cases these responses are closely scrutinized and are evaluated differently. Violence seems to be a permissible way to react for white males whereas women are expected to react in a more positive, subdued, and submissive way.¹³

People who perceive the world rationally, but whose responses are inadequate compared to the mainstream social norms are thus not very well understood by the legal system.¹⁰ This is because, the legal system, despite attempting to be rational, is still based upon social mores in the application of its laws. Thus, if a person's social response to an event is not something the court would sanction as acceptable or "reasonable", their sentence is likely to be stricter.

The unequal treatment of what is and is not "reasonable" stemming from social assumptions is the chief reason the U.S. legal system does not treat all cases equally.¹³ Since white men are socially viewed as more rational beings, they are more often excused when they suddenly and temporarily "lose" their rationality. When men are emotionally provoked, such as after finding out that their spouse has been cheating on them with their best friend, the sentence they receive for murdering both people may be that of voluntary manslaughter (a fairly lenient sentence), based on the fact that the circumstances merited a huge departure from their "normal" state.¹³ Others are not as successful at using the same defense because they are not considered to be rational in the first place. It cannot be excusable to give women a lighter sentence based on the provocation defense, because if she does kill her husband after discovering his infidelity, she has engaged in a behavior that is reserved to more powerful actors, and thus her behavior is unacceptable and socially unreasonable—she ceased being a subdued being and became an active, violent actor. Women's actions tend to be punished with stricter verdicts. Since women are viewed as being more irrational, it may seem like the courts should excuse their behavior even more readily than men. Yet women cannot be excused based on the provocation argument, because they cannot be excused for losing something they did not have to begin with. Moreover, when women behave violently and cross the gendered-behavior boundary, they are further vilified by the society that surrounds them (in stark contrast to "crying men" mentioned earlier, for whom it is becoming more acceptable and preferable to take on certain female traits).

The divide in the consideration of what is considered "reasonable" and excusable

exemplifies the problem presented by the emotional and rational split that exists in the Anglo-American legal system today. Since men are considered to be irrational when they are emotional, their emotions can "disrupt" their reason, allowing them to commit the crime and walk away with a lighter sentence. The lack of rationality in that moment means that there was a lack of premeditation, and as a result the killing can be judged as voluntary manslaughter. The same logic does not apply when the perpetrator is a woman. Women are not always excused based on the fact that they are momentarily irrational. Their alleged irrationality in everyday conduct means that they are responsible for their irrational acts, which in turn implies that the emotional and rational capacities of women are much less conceptually divided. In a sense, the general lack of rationality in women means that they are much better positioned to premeditate a murder when in an emotional state. Women are thus held more responsible for their emotional actions than men. This shows the inherent inconsistency in the U.S. legal system and exposes the limits imposed on the legal discourse by outlining which actors are more able to benefit and which conducts are accepted within the discourse. The rational white male, it seems, enjoys the greatest benefit in the contemporary legal system.

The juror problem

The U.S. legal system depends on a pre-defined number (for example a single judge or a jury of twelve) of carefully selected jurors to decide whether a defendant will be found guilty or not-guilty. The jury itself is perhaps the most crucial part of the criminal trial. In his analysis of mock-jurors' judgment proceedings, Matthew Spackman describes how the relationship between emotion and rationality affected whether they chose the sentence of murder or manslaughter.¹⁸ The jurors who adhered to the idea that emotional and rational parts of the brain operate simultaneously were more likely to charge the defendant with murder. In contrast, jurors who thought of emotion and rationality as separate and disruptive parts of the brain were more likely to vote for manslaughter—a more lenient sentence.¹⁸ Adhering to the cognitive conception of emotion and rationality and the idea that they function together allows the jurors to judge the act committed rather than the emotion and person behind it. While it is hard to say which approach is more objective and just, it is pertinent to note that there is a disparity between how jurors view the relationship between emotion and rationality and the votes that they cast. Since men are seen as rational most of the time,

they are more likely to be excused when they act based on emotion; women are seen as always acting on emotion, meaning that they are held more responsible for their actions even in an emotional situation and thus are likely to receive a tougher sentence.

One of the reasons why it is hard to say which approach to the emotional-rational divide would ultimately be more just is because these paradigms are arbitrarily applied to cases by the jurors themselves—in that they are not sanctioned, controlled, or checked by the "objective" court system and therefore cannot be used to attain objectivity and equality in all court cases. As a result, the way jurors conceptualize emotion is crucial to the outcome of the trial. Therefore, analyzing the role that jurors played and the views of emotions that they use to evaluate can be particularly fruitful, as they reveal the inherent prejudices among the jurors. It is revealed that as a way to arrive at decisions, jurors often judge the emotional appropriateness instead of the rationality of the act itself.⁴ Judging emotional responses allows jurors to bring in their own conceptions of what a reasonable emotion and acceptable response for a given situation may be.

There are two main problems with jurors relying on their own judgments rather than the evidence of the case. First, the jurors bring learned social beliefs and an a priori understanding of the legal process and its consequences. Second, they often use their own conceptions early on in the trial to judge the outcome.¹⁸ For example, in the OJ Simpson case, the jury was chosen in a way so as to secure a more lenient verdict for the defendant.⁶ While the actual mechanics of how the jury was chosen will be left aside in the present argument, the jury that presided over OJ Simpson's trial came from a demographic that was surveyed to have sympathetic feelings towards Simpson's position in the trial—namely middle aged black women.⁶ The possibility of such a pre-conceived bias goes against the alleged objectivity of the court system, and is therefore highly undesirable.⁶

The persistent "problem" of jurors drawing on their emotions has been of interest to many lawmakers. They represent the ultimate entry of "human irrationality" into the legal system. As he analyzed the Simpson trial, Thagard concluded that the influences of the jurors' biases needs to be further reduced. He proposed that it is possible for people to employ different emotions and attitudes at work than at home, and that the same thing should be practiced by judges and lawyers.⁶ Although, suggesting that an emphasis on "work" emotions is possible assumes that emotional and rational

parts of the brain are separate entities. While the individual will perceive different things when they are in different realms of “operation”, they are still a whole person, filtering their understanding of the world through a particular point of view.¹⁹ The legal system, therefore, is seen as having a very specific set of emotions that are allowed within its discourse. In addition, it relies on a very specific set of folk theories to make universal judgements about social conduct. Although Thagard concedes that getting rid of all emotional biases is impossible, he still supports the idea that the courthouse is no place for strong emotions and emotional biases. Instead of blocking emotions and subjectively choosing which emotions are valid, it may be more beneficial to view emotions and rationality as part of the same mechanism, allowing for a more coherent view of the individual and their actions.

The legal discourse and effects on gender

The legal process further creates precedents that have huge implications for what society views as appropriate and just. Currently, the legal system privileges the rational system over the emotionality of humans and allows gendered bias. Although it recognizes that emotions exist in humans, the limits on the discourse were created to differentiate between the emotional and the rational. Dealing with emotional cases that involve crimes of passion or self-defense constantly forces lawmakers to come into contact with the irrational. The provisions that the legal system creates for passion in crime delineates the limits of reason.¹³ The discourse, limited by its own proceedings and assumptions, drastically minimizes what the legal system can and cannot do and limits the kind of justice that the courts are able to exercise. “Even where courts imagine themselves engaged in expansive social inquiries...they fail to see the ways in which their investigations are drastically and specifically reduced before they begin.”²⁰ A court’s approach to dealing with emotions is prescribed beforehand. This has less to do with legal doctrines than with their applications.¹³ The entrance of socio-emotional factors furthermore limits the kinds of judgments the court can make. The court affects people’s behavior, but the people who participate in them also affect the courts. As a result, the legal discourse is constantly affected by larger societal conceptions like gender.

The limitations created by the legal system also demarcate specific subjects that can participate in the discourse and in what way these subjects are presented. As explained above, men are better positioned to receive lenient sentences because of the assumption

that they are more “rational” while women are more “emotional”. The extent to which women are able to participate in the legal discourse therefore depends on how their emotional responses are socially constructed. Since they are taught to view themselves in a certain way – namely as more emotional—women have begun to present themselves as such.² As a result, their capacity to represent themselves in the court system and attain same sentences as men is further hindered.

“Women’s capacity to represent themselves has always been severely limited by the manner in which they tell stories about themselves, the conditions under which they can tell those stories and the spaces to which their storytelling has been confined.”²¹

Women have to tell stories about themselves in a very specific way when they are in court, which severely limits their fair representation, especially if they want to be viewed as “reasonable”. While men are also restricted in the way they are perceived in court, the standard as it exists seems to favor men over women. In both cases, when norms such as killing another person are broken, social sanctions ensue. In cases involving a female perpetrator of violence however, the norm is broken automatically because women are not supposed to be violent, regardless of their emotions at the time. In extreme cases of domestic violence, where a woman—uncharacteristically and unreasonably—decides to kill her husband, she is more prone to receive a harsher punishment than a man in the same situation because of the limited view through which the court sees her.^{4,17,21}

Conclusion

The division between the rational and the emotional is socially constructed to reflect dominant societal interests, which in turn translates into gendered stereotypes and different treatment of women and men in court. The legal system—though supposedly an objective actor in serving justice to society—implicitly operates based on societal divisions, and as a result does not deliver justice to men and women equally. Indeed, the legal system attempts to do away with inequality, while allowing the use of an emotional/rational split that perpetuates inequality. The actors within the legal system need to reconsider the role of emotion in rationality and recognize that emotion is a key part of cognition of all human beings. In cases where the defendants are using the defense of provocation or self-defense, the pre-conceived notions about the role of emotion in reason allow the

courts to excuse more violence for men. In contrast, the courts tend to punish women for not acting as proper, emotional women. Lawmakers need to accept the social origins of the legal system and recognize the hidden biases within it. Since society perpetuates the emotional and rational division, the implications of this division affect the current legal system despite attempts to be objective. If the ultimate goal of the legal system is to reach objective truth and justice, it would benefit from recognizing these divides and attempting to limit the ways in which the system disseminates inequality.

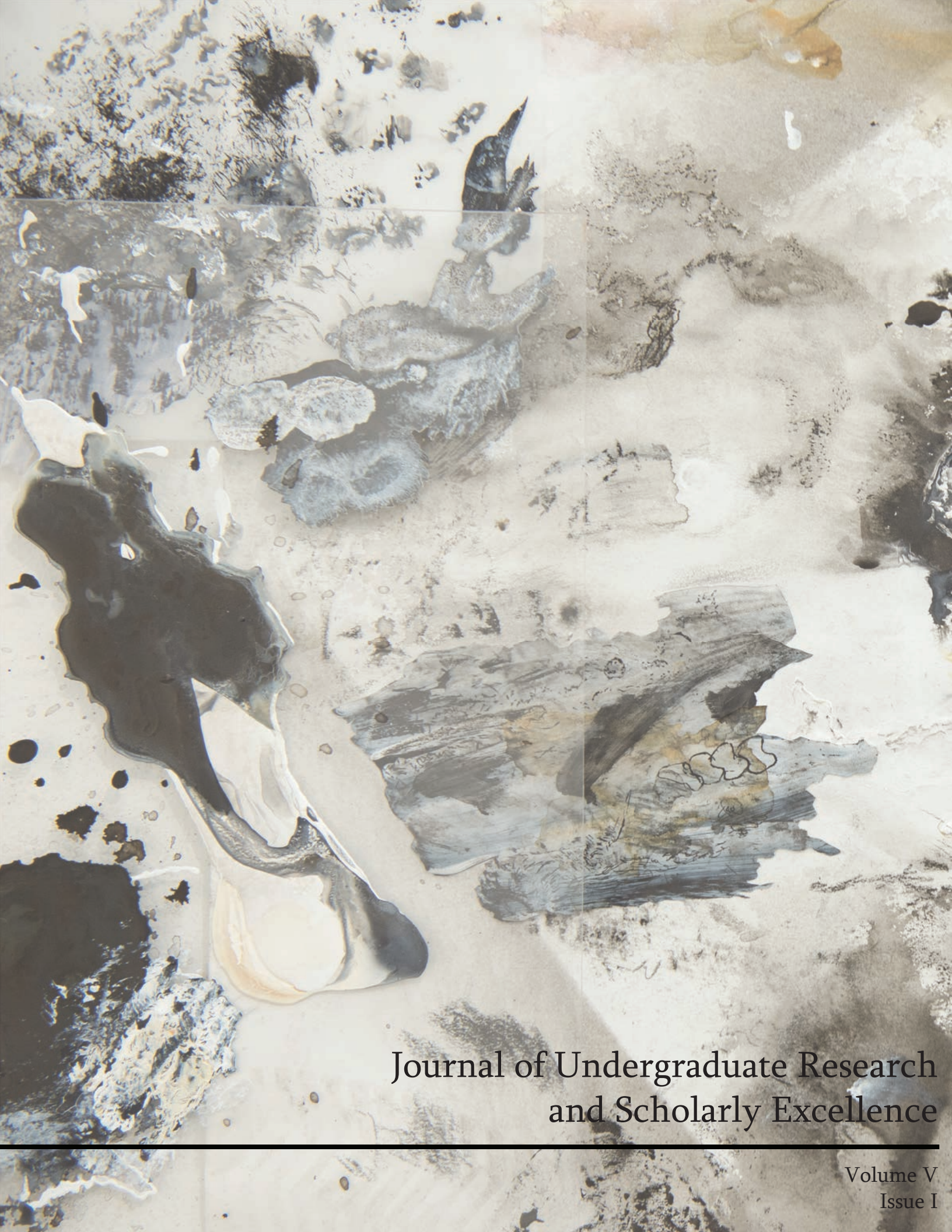
References

- ¹D’Andrade, R. G. (1995) *The Development of Cognitive Anthropology*. Cambridge University Press.
- ²Citrin, L. B., Roberts, T. and Friedrickson, B. L. (2004) “Objectification theory and emotions: a feminist psychological perspective on gendered affect.” In *The Social Life of Emotions*. Tiedens, L., Cambridge University Press. Pg 203-223.
- ³Whitehouse, H. (1996) “Jungles and Computers: Neuronal Group Selection and the Epidemiology of Representations.” *Journal of the Royal Anthropological Institute*. 2.1. Pg 99-116.
- ⁴Lee, C. (2003) *Murder and the Reasonable Man: Passion and Fear in the Criminal Courtroom*. New York University Press.
- ⁵Lutz, C. and White, G. M. (1986) “The Anthropology of Emotions.” *Annual Review of Anthropology*. 15. Pg 405-436.
- ⁶Thagard, P. and Kroon, F. (2006) *Hot Thought: Mechanisms and Applications of Emotional Cognition*. MIT Press.
- ⁷McGill, V. J. (1954) *Emotions and Reason*. Thomas.
- ⁸Levy, R. I. (1984) “The Emotions in Comparative Perspective.” In *Approaches to Emotion*. Scherer, K. R., and Ekman, P. L. Erlbaum Associates. Pg 397-412.
- ⁹Hochschild, A. R. (1983) *The Managed Heart: Commercialization of Human Feeling*. University of California Press.
- ¹⁰Jones, D. W. (2009) “A Psychosocial Understanding of Personality Disorder: The Historical Problem of Moral Insanity” In *Emotion: New Psychosocial Perspectives*. Slater, S. D. Palgrave Macmillan. Pg 212-226.
- ¹¹Timmers, M., Fischer, A. and Manstead, A. (2003) “Ability versus vulnerability: beliefs about men’s and women’s emotional behaviour.” *Cognition & Emotion*, 17.1. Pg 41-63.
- ¹²Gelsthorpe, L. (2009) “Emotions and Contemporary Developments in Criminology.” In *Emotion: New Psychosocial Perspectives*. Slater, S. D. Palgrave Macmillan. Pg 183-196.
- ¹³Warrick, C. (2011) “Not in Our Right Minds: The Implications of Reason and Passion in the Law.” *Polit. Gender Politics and Gender*. 7.2. Pg 166-192.
- ¹⁴Kant, I. (1797) *Doctrine of Right*.
- ¹⁵Murphy, J. G. (2012) *Punishment and the Moral Emotions: Essays in Law, Morality, and Religion*. Oxford University Press.
- ¹⁶Spain, E. (2011) *The Role of Emotions in Criminal Law Defences: Duress, Necessity and Lesser Evils*. Cambridge University Press.
- ¹⁷Russell, B. and Melillo, L. (2006) “Attitudes Toward Battered Women Who Kill.” *Criminal Justice and Behavior*. 33.2. Pg 219-241.
- ¹⁸Spackman, M., Belcher, J., Cramer, L. and Delton, Y. (2006) “A Qualitative Investigation of Mock-Jurors’ Theories of Emotion and Reason.” *Cognition and Emotion*. 20.5. Pg 671-693.

¹⁹Schutz, A. (1945) "Multiple Realities." In *Rules and Meanings*. Douglas, M. Penguin. Pg 227-231.

²⁰Zylan, Y. (2011) *States of Passion: Law, Identity, and the Social Construction of Desire*. Oxford University Press.

²¹Heinzelman, S. and Wiseman, Z. (1994) *Representing Women: Law, Literature and Feminism*. Duke University Press.



Journal of Undergraduate Research
and Scholarly Excellence

Volume V
Issue I