# Table of Contents

Message from the Editor .................................................................................................................. ii
The Editorial Board ........................................................................................................................... iii
New to this Volume: Best Student Paper Award Competition ................................................. v
Save the Date: 11th Annual SC Upstate Research Symposium ............................................. v
Grant Writing: Recent Big Winners! ............................................................................................... vi
Student Spotlights ............................................................................................................................ vii

An Improved Synthesis of an Alkynyl-Bacteriochlorin .............................................................. 12
Ryan Dolewski, Steven Kerbs, and Dr. Joshua Ruppel

Sewer Line Salamanders: Sewer Pipeline Impacts on Spotted Salamander ........... 22
(*Ambystoma maculatum*) Breeding Activity
Taniya Mathew, Samantha Poarch, Dr. Briget Doyle, and Dr. Melissa Pilgrim

Survey Protocol and Interspecific Variation in Calling Activity Interact ..................... 34
to Impact Anuran Detection in the Piedmont Region of South Carolina
Adrian Hayes, Elliott Gibbs, and Dr. Melissa Pilgrim

Urban Greenways Support Communities of Native Small Mammals .................. 44
Derek Kunda, Joey Morrissey, and Dr. Jon Storm

Factors that Lead to the Successful Completion of a College Degree by ........... 52
Individuals with Disabilities
Alice Setzer and Dr. Tina Herzberg

Creating Images with Sound: Phonosymbolic Representations in ....................... 61
*A Clockwork Orange*
Frederick Wood and Dr. David Marlow
MESSAGE FROM THE EDITOR

USC Upstate is proud to announce the publication of the sixth volume of the USC Upstate Undergraduate Research Journal. Our journal provides a glimpse into a few of the many high quality research activities conducted by talented faculty and students at USC Upstate. The journal is a compilation of outstanding papers from numerous disciplines submitted by undergraduate students who have been involved in faculty- mentored research, scholarly, or creative activities. Undergraduate students involved in faculty- mentored, extra-curricular projects enter the work-force with an enhanced skill set, including better problem solving, critical thinking, and team-working skills. Since many students who are educated at USC Upstate become employed in the region, support of academic research has a direct and positive impact on the Upstate of South Carolina.

I would like to thank the contributing authors for providing such a rich variety of outstanding articles on a broad range of exciting topics. In addition, I would like to express my extreme gratitude to the journal’s Editorial Board (see pages iii and iv to learn more about them). In a world where time is so very limited, their commitment to reviewing article submissions and providing constructive feedback to authors provides invaluable assistance in successfully producing our journal volumes and in mentoring students in their writing endeavors. A special thanks to Veronica Quick, Graphic Design Artist in the USC Upstate University Communications Office, for designing the outstanding cover of this volume of the journal. Thanks also to Les Duggins for taking many of the pictures of campus and our contributing authors. Many thanks to Elaine Marshall, Director of Sponsored Awards, for making the grant writing process at USC Upstate a smooth and often fruitful process. Finally, we would like to take this opportunity to thank Dr. John Masterson, Senior Vice Chancellor for Academic Affairs at USC Upstate, who is dedicated to enhancing faculty and student research efforts at USC Upstate.

If you have any questions or comments about the journal, or would like to receive a printed copy of the most recent volume of the journal, please contact me at (864) 503-5781 or mpilgrim@uscupstate.edu. The journal is also available online at the website: http://www.uscupstate.edu/ResearchJournal.

Enjoy!

Melissa Ann Pilgrim
Editor & Director of Research
Office of Sponsored Awards and Research Support
University of South Carolina Upstate
800 University Way; Spartanburg, SC 29303
THE EDITORIAL BOARD

**Dr. Melissa Pilgrim**  
**Editor-in-Chief**

Dr. Pilgrim is an Associate Professor of Biology and the Director of the Center for Research and Scholarship Support. Her primary research focus involves an integrative approach to investigating how ecosystems respond to environmental change (natural and anthropogenic). She uses herpetological systems as her animal models and currently has an army of undergraduate students working with her in a research group called Upstate Herpetology. She has published works in several journals, including the following: *Isotopes in Environmental and Health Studies; OIKOS; Copeia; and Southeastern Naturalist.*

**Dr. June Carter**  
**Associate Editor**

Dr. Carter is a Professor of Spanish and Director of the Center for Teaching Excellence. Her research interests include Latin American narrative and film; Afro-Hispanic literature; Latin American female writers; US Latino/a literature. She has published works in several journals, including the following: *Anuario de Letras; Latin American Literary Review; Caribbean Quarterly; The Rocky Mountain Review; Prismatic Cabral; and Studies in Afro Hispanic Literature.*

**Dr. Michael Dinger**  
**Associate Editor**

Dr. Dinger is an Assistant Professor of Management. His research interests include information security and IT workforce management. He has published his work in several journals, including the following: *MIS Quarterly; Information Systems Research; IEEE Transactions on Engineering Management; and Journal of Organizational Computing and Electronic Commerce.*

**Dr. Gamal Elnagar**  
**Associate Editor**

Dr. Elnagar is a Professor of Mathematics. His research interests include Optimal Control Theory in Climate Modeling and Economic Applications, Numerical Solution of Nonlinear Conservation Laws. He has published works in several journals, including the following international journals: *Computer Mathematics; Numerical Functional Analysis & Optimization; Computational & Applied Mathematics; and Differential Equations & Applications.*
**Dr. Lynette Gibson**

*Associate Editor*

Dr. Gibson is an Associate Professor of Nursing and the Director of Research in Nursing at the Mary Black School of Nursing. Her primary research is focused on increasing health equity in ethnic minorities. She is testing the effect of a community-based intervention on screening mammograms by African-American women. She has worked with several undergraduate nursing students in conducting and presenting this research. She was a 2014 Summer Nursing Research Institute Fellow at the Institute for Health Equity at the School of Nursing, University of Pennsylvania. She has published articles in *Applied Nursing Research, ABNF Forum, Journal of the National Black Nurses’ Association,* and *Clinical Nurse Specialist™.*

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**Dr. Tina Herzberg**

*Associate Editor*

Tina Herzberg, Ph.D. is an Associate Professor of Special Education and currently serves as Director of Graduate Programs for the School of Education. Her primary research interests are braille literacy and preparation of tactile materials for students who are visually impaired. Her research began with the exploration of quality in literary braille materials and has now transitioned to exploration of quality in math braille materials. Her work has primarily been published in the international peer-reviewed *Journal of Visual Impairment & Blindness.* Prior to her arrival at USC Upstate, she served as a general education classroom teacher, an itinerant teacher of students with visual impairment, specialist for a regional service center, and adjunct instructor.

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**Elaine Marshall**

*Associate Editor*

Elaine Marshall is the Director of Sponsored Awards at USC Upstate. She has been with the University since 1996 and works with all faculty and staff on the Upstate campus who pursue and receive grant funding. Elaine holds a national Certified Research Administrator designation from the Research Administrators Certification Council. She also has a BA in English and History, and a MA in English Literature from Clemson, where she also taught full-time before coming to USC Upstate.
2013 was the inaugural year for our journal’s Best Student Paper Competition! Submissions with an undergraduate student as the first author were reviewed and ranked by our Editorial Board. The award program and review rubric are described at: http://www.uscupstate.edu/researchjournal/. We had a tie this year and awarded two prizes; the winning submissions were the Dolewski et al. 2013 and Mathew et al. 2013 articles, which are marked by a ⭐ in the Table of Contents.

SAVE THE DATE!
APRIL 17TH, 2015
11TH ANNUAL SC UPSTATE RESEARCH SYMPOSIUM

Many of our journal articles represent expanded projects initially presented by our students as poster or oral presentations at the annual SC Upstate Research Symposium. The symposium is a regional event that provides a forum where both faculty and students from primarily undergraduate institutions can interact to discuss and share information regarding their research, scholarly and/or creative endeavors with each other, local high schools, and a variety of business and community leaders. Please plan on joining us on USC Upstate’s campus for the 11th Annual SC Upstate Research Symposium on April 17th, 2015. To learn more and review past programs see http://www.uscupstate.edu/symposium/default.aspx?id=12604.
GRANT WRITING: RECENT BIG WINNERS!

Universities benefit substantially when faculty members are awarded external grant monies for research or service projects. Applying for grant opportunities is a very time consuming and tedious process which often times goes unrewarded since most opportunities are highly competitive with only a small percentage being funded. Grant monies are often used to support student research assistants and thus can have a very positive impact on a student’s academic experience. We would like to congratulate all USC Upstate faculty members who have recently been funded.

All Grant Winners (2013-2014)

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**Total $1,430,268**
NON-TRADITIONAL STUDENT SPOTLIGHT: ELLIOTT AND LISA GIBBS

Lisa and Elliott are non-traditional students who chose to come back to school after being in the work force for over 5 years after graduating high school. Wanting to find more fulfilling careers and feeling a little stuck in their current positions, they both used their love of animals as a starting point into the sciences. Two years into their degrees, they were blessed with a beautiful baby boy named Jonah who has provided both new challenges and motivation to succeed in their new career paths.

During her second semester at USC Upstate, Lisa quickly discovered a real talent for chemistry. With the encouragement of Dr. Chris Bender, Lisa declared she would seek a chemistry degree. Over the next four years she excelled at all of her classes and served as a Supplemental Instructor for General Chemistry courses. Recently she started working as an adjunct professor at Spartanburg Methodist College, where she instructs general chemistry labs. In her journey towards her chemistry degree, Lisa discovered an interest in pharmacy. After hearing several pharmacists give talks at the USC Upstate Chemistry club meetings, Lisa found a job working as a pharmacy technician at Target pharmacy. She quickly fell in love with the work, and found a passion for understanding the chemistry behind the drugs she saw on a daily basis. Lisa is currently staying active as the USC Upstate Chemistry Club president, taking challenging upper level chemistry classes, working three jobs and raising her 2 year old son. Excitingly, Lisa has been accepted into the Presbyterian College of Pharmacy and begins her program of study in August of 2014.

Elliott quickly found a love for ecology in his studies of biology. He began doing research outside of class, and worked with Dr. Jon Storm on urban predator ecology his first summer at USC Upstate. The following fall he became a volunteer for the North American Amphibian Monitoring Program (NAAMP) under the supervision of Dr. Melissa Pilgrim. Elliott’s participation in NAAMP gave him an opportunity to study a group of animals he has loved since he was a child — an interest encouraged by his late uncle who showed him the world of “boy herping.” Elliott also enjoys volunteering as a sound engineer for local music groups. During the end of his second year, Dr. Pilgrim approached him with a chance to combine both his love of sound with his love for amphibians. Elliott competed for and was awarded a Magellan Scholar grant to study anuran (i.e., frogs and toads) acoustics in the upstate of South Carolina. The ongoing project has resulted in an opportunity to present his research at the World Congress of Herpetology in Vancouver, British Columbia and has catapulted Elliott into work centered on automated recognition of frog calls from sound files. Elliott is hoping to use his love of science, experience from the field, and years as a Supplemental Instructor to impart a love of science to others in the classroom. He hopes to stay active in his research after graduating this spring. Recently, Elliott was hired as a Production Chemist with New Life Chemical & Equipment, Inc.
ALUMNI SPOTLIGHT: ESMAEL MAYAR

I came to USC Upstate after completing my first two years of pre-medical undergraduate work at Temple University. I finished my last semester at Temple with poor grades, which made starting out at a new school a little more of a daunting task. In addition, I had Dr. Pilgrim as my advisor who didn’t sugarcoat my situation. She told me with a very straight face that I could kiss my dreams of medical school goodbye if I continued my poor academic performance. Thanks to her sincere advice, I worked hard and excelled in all of my courses.

However, course work was simply not enough to get me into medical school. This led me to propose a research project to Dr. Turner, who welcomed me to Upstate, agreed to supervise my research, and has helped me on my road to medical school ever since. I performed my research on antibiotic resistant *E. coli* in wastewater treatment plants, and presented my findings at the 2013 South Carolina Upstate Research Symposium where I was awarded the Best Student Presentation Award. I was also fortunate enough to complete research with Dr. Damrel in the Religion department, another outstanding professor at Upstate who has helped me very much. This research was on the destruction of Muslim shrines by Fundamentalist groups. My hobbies mainly consist of reading books about history and religion. Therefore, I jumped at this opportunity to learn about a subject I was interested in and be able to present my work to others. I was awarded a Magellan Scholar Grant to complete my research with Dr. Damrel, and presented my findings at USC Columbia’s Discovery Day where I was awarded 1st place for Best Poster Presentation.

I had pretty much prepared myself to get into medical school, but I still wasn’t sure whether I wanted to practice medicine or pursue a more research oriented career in medicine. Therefore, instead of going to medical school right after graduating in May 2013, I decided to go to the University of Pennsylvania where I could take upper level science courses and perform research. Currently I am a post-baccalaureate student at the University of Pennsylvania, performing clinical research on the effectiveness of cancer care, and working as an Emergency Medical Scribe. I can say without a doubt that I would not have accomplished so much without the entire superb faculty at USC Upstate!
I transferred to USC Upstate in 2010 with hopes of becoming more than just a number at a university. I had spent my previous three years at Arizona State University (ASU) disappearing into the crowd of thousands of students; I received very little direction and was clueless as to how to achieve my goals. I wanted a more personal experience, I wanted a chance to stand out, and most of all I wanted my classmates and professors to know who I was. What I ended up receiving from my time at USC Upstate was unimaginable and more than I could have ever asked for. The “how” and “why” that effects a person’s choices in life differ for each individual; however, mine were influenced by the usual stress that a college student undergoes, the self-awareness that stress brings, and two influential professors. Dr. Melissa Pilgrim and Dr. Andrew Beer inspired me and gave me the knowledge, skills, and experiences that have led me to where I am today.

My first semester at USC Upstate I became a student of Dr. Pilgrim’s and was subjected to the hardest class of my college career. Dr. Pilgrim is well-known by the student body to be tough and to give monstrous tests. At ASU I was never required to write a research paper, and the only tests I took were multiple choice, so needless to say, I was completely unprepared for her class. I began going to her office for help, and she even invited me to join her and other students on a trip to Florida. I often think of that trip as the beginning of my journey to success because it opened my eyes to the possibilities of the world around me and my future in that world. Over the course of our time together, I sought out her wisdom numerous times. I was inspired by her dedication to her work, her independence, and how much she enjoyed what she does; I wanted that. Another thing I always appreciated and respected about Dr. Pilgrim is that she always told me the truth, even when it was hard to hear. That truth is what helped me strive to be better, to acknowledge my strengths and weaknesses, and understand that I should be pursuing a career that I enjoyed and loved. After many hours of laughing, crying, and panic attacks, I understood that being a biology major was not making me happy and it was no longer my strength. It is funny how life can affect your abilities over time, but after looking at myself and my interests, I realized that I am much better at understanding the human mind, than the human body. At the end of my first year, I changed my major to psychology; and although I was no longer in her department, Dr. Pilgrim continued to help and support me as always and aided me in my quest in applying for graduate school. Dr. Pilgrim and I joke about the time she saved my life on the Florida trip, when she blocked me from stepping on a moving rattlesnake; however, I know that it was her actions after that trip that impacted my life the most.

My second year at USC Upstate, I began as a psychology student and started over as the new kid in the department. This meant that none of the professors knew me and I would have to stand out and make a name for myself. I was filled with both excitement and anxiety to start my journey towards my new career and to be able to study a subject that was so fascinating to me. Dr. Beer was my Psychology of Personality professor and I remember always being eager to go to his class because I thought he was hilarious. He had a knack for engaging our class, making even the dullest parts of personality fun and interesting. After excelling in his class, I approached him to ask about research opportunities, and he gave me the chance to work on many projects with him and taught me everything I know about research. He was another professor that was not known to be “easy,” but I continued to take classes with him.
because I respected that characteristic in my professors. I knew graduate school would not be easy and I wanted a professor that would prepare me for it. As his student, I wrote many research papers, was subjected to more tough tests, and even learned how to develop my own research project. Much like Dr. Pilgrim, he gave me support and believed in me, even when I was unsure of myself. Although he did not teach counseling, nor go to school for it, his research program and knowledge pushed me towards this field. Through him, I found how fascinating “normal” people are to study and understand. These “normal” people are the ones I wanted to study and help because they are the ones that are often written off and forgotten because they don’t have unusual characteristics such as being a serial killer. Dr. Beer helped me through the graduate school process step by step, and made me feel like I was good enough to be anywhere; as if any program would be lucky to have me, not the other way around.

In the fall of 2013, I started my graduate career at the University of Florida. I am currently pursuing my Masters in Counseling, and because of these two people, I get the privilege to do it at one of the top counseling programs in the country. Sometimes I wonder where I would be if I had stayed at ASU, but I shudder at the thought of it. I know for a fact that I would not be here at UF, and I am not sure if I would have even figured out that my true passion was counseling. At the end of each semester, I receive feedback from my professors regarding my performance; so far I have impressed them with my dedication, work ethic, and was specifically commended on my writing skills. Dr. Pilgrim, Dr. Beer, and USC Upstate gave me the knowledge, skills, and experience I needed to achieve my dreams. For that, I will always be grateful and continue to make them proud.

ALUMNI SPOTLIGHT: RONNETTA SARTOR

RONNETTA SARTOR is currently a freshman at the Medical University of South Carolina’s College of Dental Medicine. As a freshman biology student at USC Upstate, she was approached by Ms. Bannan with the opportunity to conduct undergraduate research with Dr. Storm. “I was honored to be given such an opportunity. As I conversed with Dr. Storm about his cricket research, I immediately became interested and eager to learn more about the subject.” Through her research project, Ronnetta learned the importance of accurate procedure, data collection and analysis as well as knowledge on the presentation of scientific findings to the public. “Through my research experience, I have gained an enhanced appreciation for the world of science through my experimentation. The research experience that I gained at USC Upstate encouraged me to participate in South Carolina Area Health Education Consortium’s Summer Careers Academy as a Dental Fellow where I received my first taste of evidence-based dentistry and dental related research. I also plan to further my experience in this realm of research in the summer of 2014 by participating in summer research at Medical University of South Carolina. I am very grateful for the nurturing and education that I received at USC Upstate and through my undergraduate research with Dr. Storm.”
An Improved Synthesis of an Alkynyl-Bacteriochlorin

**ABSTRACT.** The use of photodynamic therapy (PDT) as a viable treatment for cancer has been hindered by the many limitations of the photosensitizers used in this therapy, including solubility in biological fluids, weak absorbance at clinically useful excitation wavelengths (NIR), and selectivity. Recently, carbohydrate bacteriochlorin conjugates (CBCs) have gained attention for their ability to address several of these short comings. Advances in the development of a concise route for the synthesis of brominated bacteriochlorins have allowed for the development of alkynyl-bacteriochlorin derivatives that can be utilized in 1,3-dipolar cycloaddition reactions to produce the aforementioned CBCs. As part of our ongoing efforts to generate CBCs, we report an improved synthesis of an alkynyl-bacteriochlorin using the Sonogashira reaction.

**Ryan Dolewski** is a senior at USC Upstate pursuing a Bachelor’s Degree in Chemistry and a Minor in Biology. He began working with Dr. Joshua Ruppel in the summer of 2012. The focus of their research was to synthesize carbohydrate-bacteriochlorin conjugates (CBCs) that may serve as a new class of selective photosensitizers with applications in photodynamic therapy (PDT). Since the spring of 2013 their focus has been on synthesizing CBCs via Cu(I)-catalyzed azide-alkyne 1,3-dipolar cycloaddition reactions. Their research has resulted in three research presentations at local and national meetings. In addition, Ryan plans on attending graduate school in the fall of 2014 to begin work on a Ph.D. in organic chemistry. Currently his future goal is to ultimately work in industry or academia.

**Steven Kerbs** graduated from Greenville Technical College and most recently from the University of South Carolina Upstate in the spring of 2013. Steven earned an A.S. and a B.S. degree in Biology, and is currently pursuing his goal of entering a physical therapy program. During his senior year at USC Upstate, he participated in undergraduate chemistry research with Dr. Joshua Ruppel. His research focused on the synthesis of bacteriochlorins and metallated porphyrins. He also spent time volunteering with Spartanburg Regional Hospital in the Endoscopy Department and Sport Spine & Industrial therapy clinic. Steven plans to complete a personal training certification and attend graduate school for physical therapy.

**Dr. Joshua V. Ruppel** is an Assistant Professor of Chemistry at USC Upstate. He earned his Ph.D. from the University of South Florida and has published in journals such as the Journal of American Chemical Society, Langmuir, Organic Letters, Journal of Organic Chemistry, and Chemical Communications. Professor Ruppel has also authored book chapters in The Porphyrin Handbook and most recently in Heterocyclic Chemistry in Drug Discovery. His research
interests include the medicinal, catalytic, and material applications of porphyrins, metalloporphyrins, and related heterocyclic compounds. In addition to his work with undergraduate research at USC Upstate, Dr. Ruppel co-organizes an undergraduate research symposium at the spring American Chemical Society national meeting.

1. Introduction

Photodynamic therapy (PDT) has gained popularity as a viable and noninvasive alternative to surgery, radiation therapy and chemotherapy in the treatment of solid cancers of the head and neck, brain, lung, breast, prostate, pancreas, skin and intraperitoneal cavity [1]. Photodynamic therapy involves administering a photosensitizer via intravenous or intraperitoneal injection to the patient. Following a period of time necessary to maximize the differential uptake of the photosensitizer between neoplastic and healthy cells, the area of the body containing the tumor is irradiated with specific wavelengths of visible or near-infrared light. This results in the production of reactive oxygen species (ROS) and other reactive intermediates that destroy the tumor [2]-[6].

Despite the progress that has been made in the design and development of PDT photosensitizers, there are still several major shortcomings [7]. First, the majority of photosensitizers, such as Photofrin (porphyrin based), are nonpolar aromatic compounds that exhibit very poor solubility in biological media (water), causing aggregation and ultimately a reduction in the ROS produced. A second major limitation is weak absorbance at clinically useful excitation wavelengths (near-infrared, NIR), preventing the treatment of deep seated tumors and sizeable lesions [8]-[10]. A third limitation is limited selectivity, which may lead to the damage and destruction of healthy cells.

Bacteriochlorins, an aromatic hydrocarbon (a close relative to porphyrins) which absorbs in the NIR between 700-800nm, have shown significant promise as next generation photosensitizers [11]. While solubility and selectivity issues continue to remain problematic with this class of compounds, bacteriochlorin conjugation to water soluble molecules such as carbohydrates can be used to obviate these challenges. In addition to imparting solubility in biological media (water), carbohydrate ligands can be designed to bind specific proteins involved in tumor transformation and metastasis. The resulting carbohydrate bacteriochlorin conjugates (CBCs) could be considered a new class of selective photosensitizer with direct applications as a photosensitizer for PDT.

In the past twenty-five years only two examples of CBCs have been reported [12]-[13] and of those examples only one report provided limited data on the potential of these compounds to serve as photosensitizers [13]. Therefore, significant work remains in order to realize the full potential of this class of compounds. One major factor limiting progress in this area is the lack of a modular synthetic approach for the rapid and high yielding synthesis of CBCs bearing different carbohydrate ligands. One possible method of generating CBCs is through Cu(I)-catalyzed azide-alkyne 1,3-dipolar cycloaddition reaction which involves the coupling of an azido-carbohydrate and an alkynyl-bacteriochlorin.

Recent advances in the development of a concise and high yielding route for the synthesis of brominated bacteriochlorins [14]-[18] has allowed for the development of...
alkynyl-bacteriochlorin derivatives that can be utilized in 1,3-dipolar cycloaddition reactions to produce the desired CBCs for future study. Of the known pathways for synthesizing alkynyl-bacteriochlorins (i.e., methodologies that employ a palladium catalyst to form a carbon-carbon bond between a terminal alkyne and an aryl halide) Sonogashira cross-coupling methodologies present an attractive and potentially high yielding approach. In this study, we report an improved synthesis of an alkynyl-bacteriochlorin using the Sonogashira reaction.

2. Experimental Methods

General Considerations: The synthesis of bacteriochlorin 10 was performed following procedures reported by Lindsey and co-workers [14]-[18] with several modifications. All reagents were purchased from commercial sources and used without further purification. Anhydrous solvents purchased from commercial sources were further dried over 4 Å molecular sieves. Thin layer chromatography was performed on Merck TLC plates (silica gel 60 F254). Flash column chromatography was performed with Merck silica gel (60 Å, 230-400 mesh, 32-63 μm). 1H NMR was recorded on a Bruker 400 MHz spectrometer with chemical shifts reported relative to residual solvent (CDCl3, unless otherwise noted). All compounds synthesized were confirmed by comparing 1H NMR spectra with known literature values.

(E)-ethyl 3-(p-tolyl)acrylate (2). [14] A solution of 1 (15.7 g, 131 mmol) and triphenylphosphorane (50 g, 144 mmol) in methylene chloride (165 mL) was refluxed for 24 h. The reaction mixture was cooled to room temperature and filtered. Filtrate was then concentrated and diluted with diethyl ether. The mixture was washed (brine), dried (Na2SO4), concentrated, and chromatographed [silica, hexanes/ethyl acetate (3:1)] to produce a colorless oil (24.9 g, 99%, lit. 97%). TLC analysis: hexanes/ethyl acetate (3:1) Rf = 0.83. 1H NMR δ 1.36 (t, J=7.1 Hz, 3H), 2.40 (s, 3H), 4.29 (q, J=7.1 Hz, 2H), 6.39 (d, J=16.0 Hz, 1H), 7.22 (d, J=8.2 Hz, 2H), 7.44 (m, 2H), 7.66 (d, J=16 Hz, 1H).

3-(Ethoxycarbonyl)-4-(4-methylphenyl)pyrrole (3). [14] A solution of TosMIC (26.04 g, 133 mmol) and 2 (24.25 g, 127 mmol) in diethyl ether/DMSO (3:1) (260 mL) was added dropwise under nitrogen to a stirred suspension of NaH (6.1 g, 254 mmol) in diethyl ether (130 mL). The reaction mixture stirred for 3 h at room temperature at which time water was added slowly. The organic phase was extracted with ethyl acetate, dried (Na2SO4), and concentrated to afford a brown solid. The brown solid was suspended in diethyl ether and filtered giving a tan solid (19.9 g, 69%, lit. 71%). TLC analysis: hexanes/ethyl acetate (2:1) Rf = 0.55. 1H NMR δ 1.29 (t, J=7.2, 3H), 2.39 (s, 3H), 4.25 (q, J=7.2, 2H), 6.77 (m, 1H), 7.15 (d, J=8.02, 2H), 7.43 (d, J=8.0, 2H), 7.49 (m, 1H), 8.51 (b, 1H).

3-(4-Methylphenyl)pyrrole (4). [14] A solution of 3 (19.4 g, 85 mmol) and ethylene glycol (188 mL) in a 500 mL round-bottom-flask was bubbled with nitrogen for 10 min. After an addition of NaOH (33.9 g, 850 mmol) to the previous solution, the reaction mixture was heated with stirring at 120 °C for 30 min and then heated at 160 °C for 3 h. The reaction mixture was allowed to cool to room temperature, whereupon brine (400 mL) was added. The organic phase was extracted with methylene chloride, dried
(Na₂SO₄), concentrated, and chromatographed [silica, methylene chloride] to afford a pale yellow solid (12 g, 94%, lit. 93%). TLC analysis: methylene chloride Rₚ = 0.73. ¹H NMR δ 2.37 (s, 3H), 6.56 (m, 1H), 6.85 (m, 1H), 7.02 (m, 1H), 7.15 (d, J=8.08, 2H), 7.43 (d, J=8.08, 2H), 8.29 (b, 1H).

**Formyl-3-(4-methylphenyl)pyrrole (5).** [14] A mixture of 4 (11.5 g, 73 mmol), DMF (21.3 mL, 293 mmol), and methylene chloride (549 mL) in a 1000 mL round-bottom-flask was cooled to 0 °C under nitrogen. POCl₃ (8.19 mL, 88 mmol) was then added to the reaction mixture via dropwise addition. After 1 h, the ice bath was removed and the reaction mixture was allowed to stir for 18 h. The reaction mixture was then cooled to 0 °C whereupon 2.5M NaOH was added. The aqueous phase was washed twice with methylene chloride. The organic phase was dried (Na₂SO₄), concentrated, and chromatographed [silica, methylene chloride/ethyl acetate (9:1)] affording a yellow solid. The yellow solid was dissolved in ethyl acetate. Hexanes were added to cause precipitation, and the resulting mixture [containing hexanes/ethyl acetate (3:1)] was cooled at -20 °C with stirring. The mixture was filtered and afforded a pink solid (7.13 g, 53%, lit. 67%). TLC analysis: methylene chloride/ethyl acetate (9:1) Rₚ = 0.57. ¹H NMR (400 MHz, CDCl₃) δ 2.42 (s, 3H), 6.46 (m, 1H), 7.11 (m, 1H), 7.26 (d, J=8.0, 2H), 7.42 (d, J=8.0, 2H), 9.66 (s, 1H).

**3-(4-Methylphenyl)-2-(2-nitroethyl)pyrrole (6).** [14] A solution of acetic acid (6.41 mL, 112 mmol) and anhydrous THF (6.32 mL) was cooled to 0 °C under nitrogen whereupon n-propylamine (8.45 mL, 103 mmol) was added. After 10 min the n-propylammonium acetate mixture was added dropwise to a solution of 5 (17.3 g, 93 mmol) and nitromethane (30.52 mL, 560 mmol) in anhydrous THF (87 mL) at 0 °C. After 30 min the reaction mixture was allowed to stir at room temperature for 3 h. The reaction mixture was diluted with methylene chloride and washed with aqueous sodium bicarbonate. The organic phase was dried, concentrated, and then dissolved in chloroform (419 mL)/2-propanol (197 mL). Silica was added to the mixture and stirred vigorously. Sodium borohydride (7.09 g, 187 mmol) was then added all at once to the mixture and allowed to stir for 3 h. After filtration, the filter cake was washed with methylene chloride and the filtrate was concentrated. The residue was chromatographed [silica, methylene chloride] to afford a brown solid (7.97 g, 37%, lit. 45%). ¹H NMR δ 1.57 (s, 3H), 2.39 (s, 3H), 3.46 (t, J=6.6 Hz, 2H), 4.57 (t, J=6.6 Hz, 2H), 6.30 (m, 1H), 6.76 (m, 1H), 7.23 (m, 2H), 7.28 (m, 2H), 8.28 (b, 1H).

**1, 1-Dimethoxy-4-methyl-3-penten-2-one (7).** [14] A 500 mL round bottom flask, equipped with stir bar with was treated with nitrogen. 2-methyl-1-propenyl magnesium bromide (0.5 M solution in THF) was transferred via cannula into the flask. The solution was allowed to stir at 0 °C for 30 min under nitrogen. The bright yellow-orange solution was treated with saturated aqueous NH₄Cl. After stirring vigorously for 2 h, the aqueous phase was extracted with EtO₂, and each organic extract was washed with brine. The organic extract was dried and concentrated. Bulb-to-bulb distillation (95 °C/0.05 mmHg) produced a pale yellow oil (4.5 g). 7 was used directly in the following step. ¹H NMR δ 1.97 (m, 3H), 2.22 (m, 3H), 3.43 (s, 6H), 4.5 (s, 1H), 6.38 (m, 1H).
**Synthesis of 8.** [14] A solution of 6 (1.97 g, 8.6 mmol), 7 (1.49 g, 9.43 mmol) and DBU (3.85 mL, 25.7 mmol) was allowed to stir at room temperature for 16 h. The reaction mixture was then diluted with ethyl acetate, washed with water, dried over anhydrous sodium sulfate (Na₂SO₄), and concentrated. The residue was diluted with hexanes/ethyl acetate (3:1) and treated with 1% triethylamine allowing precipitation. The precipitate was filtered to afford a brown solid (2.64 g, 79 %, lit. 63 %). ¹H NMR δ 1.11 (s, 3H), 1.21 (s, 3H), 2.39 (s, 3H), 2.53, 2.75 (AB, 2J=18.7 Hz, 2H), 3.23 (m, 1H), 3.40 (m, 1H), 3.43 (s, 3H), 3.43 (s, 3H), 4.35 (s, 1H), 5.22 (m, 1H), 6.26 (m, 1H), 6.70 (m, 1H), 7.22 (m, 2H), 7.28 (m, 2H), 8.09 (b, 1H).

**Synthesis of 9.** [14] A solution of 8 (2.57 g, 6.62 mmol) and anhydrous THF (66.2 mL) was bubbled with nitrogen for 10 min. The mixture was treated with NaOMe (1.79 g, 33.1 mmol) and was allowed to stir at room temperature for 1 h. In a second flask, TiCl₃ (74.5 mL, 33.1 mmol) and water (265 mL) were mixed and bubbled with nitrogen for 15 min. NH₄OAc (204 g, 2.56 mol) was added to the second flask to adjust the pH to 6.0, and then THF (20 mL) was added. The reaction mixture was bubbled with nitrogen for 30 min. The mixture in the first flask that contained the nitronate anion of 8 was transferred via a cannula to the second flask. The resulting mixture was allowed to stir at room temperature under nitrogen. After 6 h, saturated aqueous NaHCO₃ (2.0 L) was added into the reaction mixture. The mixture was extracted with ethyl acetate, dried, concentrated and chromatographed over a short column [alumina, hexanes/ethyl acetate (3:1)] to afford a brown solid (1.185 g, 53 %, lit. 45 %). TLC analysis: hexanes/ethyl acetate (3:1) Rf = 0.86. ¹H NMR δ 1.21 (s, 6H), 2.41 (s, 3H), 2.64 (s, 2H), 3.48 (s, 6H), 5.06 (s, 1H), 6.13 (s, 1H), 6.31 (m, 1H), 6.90 (m, 1H), 7.24 (d, J=8.1 Hz, 2H), 7.36 (d, J=8.1 Hz, 2H), 10.87 (b, 1H).

**MeOBC (10).** [14] 9 (338g 1.00 mmol) and CH₃CN (50 mL) was added to a 250 mL round-bottomed-flask. A solution of BF₃O(Et)₂ (301 µL, 2.50 mmol) in CH₃CN (6 mL) was added slowly to the first flask. The reaction mixture was allowed to stir at room temperature for 12 h. The mixture was treated with triethylamine (1.00 mL, 7.17 mmol), concentrated, and chromatographed [silica, hexanes/DCM (1:1)] affording a dark green solid (148 mg, 50 %, lit. 46 %). TLC analysis: hexanes/DCM (1:1) Rf = 0.64. ¹H NMR δ -1.86 (b, 1H), -1.74 (b, 1H), 1.28 (s, 3H), 1.90 (d, J=4.9 Hz, 12H), 2.64 (s, 6H), 4.43 (s, 4H), 4.52 (s, 3H), 4.64 (b, 2H), 4.82 (s, 1H), 4.85 (s, 1H), 8.97 (d, J= 2.28 Hz, 1H).

**MeOBC-Br (11).** [18] A solution of 10 (210 mg, 0.326 mmol) in THF (182 mL) was treated with NBS (64.4 mg, 0.362 mmol) at room temperature for 15 min. Progression of reaction was monitored via TLC. Reaction mixture was dilute with DCM, washed with NaHCO₃, and dried (Na₂SO₄). Once concentrated the residue was chromatographed [silica, hexanes/DCM (1:1)] affording a dark green solid (188 mg, 79 %, lit. 85%). TLC analysis hexanes/DCM (1:1) Rf = 0.77. ¹H NMR δ -1.98 (b, 1H), -1.76 (b, 1H), 1.10 (d, J=4.9 Hz, 12H), 2.64 (s, 6H), 4.42 (b, 2H), 4.51 (s, 3H), 7.60 (m, 4H), 8.11 (m, 4H), 8.80 (s, 1H), 8.50 (s, 1H), 9.00 (d, J= 2.1 Hz, 1H), 9.07 (d, J= 2.1 Hz, 1H).

**Synthesis of 12.** [19] 11 (136.3 mg, 0.207 mmol), PdCl₂(PPh₃)₂ (29 mg, 0.0414 mmol), Cul (3.93 mg, 0.0207 mmol), and triisopropyl acetylene (188.6 mg, 1.03 mmol) were
Ryan D. Dolewski, Steve Kerbs, and Dr. Joshua V. Ruppel

added to a dry 25 mL Shlenk flask. Dry toluene and TEA (8.76 mL, 10:1) were added to the solution under nitrogen. The mixture was allowed to stir for 4 h at 50 °C. The solution was concentrated and chromatographed [silica, hexanes/DCM (2:1)] affording purple solid (134.7 mg, 86 %). TLC analysis hexanes/DCM (2:1) Rf = 0.29. 1H NMR δ -1.55 (br, 1H), -1.33 (br, 1H), 1.39-1.42 (m, 21 H), 1.93 (s, 12H), 2.63 (s, 3H), 2.64 (s, 3H), 4.37 (s, 2H), 4.50 (s, 3H), 4.55 (s, 2H), 7.60-7.63 (m, 4H), 8.11-8.14 (m, 4H), 8.79 (s, 1H), 8.80 (s, 1H), 8.91 (d, J=2.0 Hz, 1H), 9.13 (d, J=2.0 Hz, 1H).

Synthesis of 13. [18] A solution of 12 (314 mg, 0.439 mmol) in THF (43.9 mL) was treated with TBAF/THF (1.0 M, 129 mmol, 1.29 mL) in an ice bath for 15 min. The solution was concentrated and diluted with DCM, and washed with NaHCO₃. The reaction residue was concentrated and chromatographed [silica, hexanes/DCM (2:1)] affording a dark green solid (220 mg, 83 %, lit. 83%). TLC analysis hexanes/DCM (2:1) Rf = 0.29. 1H NMR δ -1.60 (br, 1H), -1.37 (br, 1H), 1.93 (s, 12H), 2.63 (s, 6H), 3.94 (s, 1H), 4.38 (s, 2H), 4.50 (s, 3H), 4.57 (s, 2H), 7.59-7.62 (m, 4H), 8.11-8.14 (m, 4H), 8.80 (s, 1H), 8.82 (s, 1H), 8.93-8.94 (d, J=2.0 Hz, 1H), 9.10-9.11 (d, J=2.0 Hz, 1H).

3. Results and Discussion

A synthetic protocol first reported by Lindsey and co-workers was used to access the bromo-bacteriochlorins of interest for our alkynylation studies (Scheme 1) [14]-[18]. The synthesis of the bacteriochlorin begins with the Wittig olefination of the 4-methyl benzaldehyde 1 to produce the corresponding alkene 2 in typically high yields. This is followed by pyrrole formation 3 and subsequent decarboxylation to produce 3-(p-toluyl)pyrrole 4. Formylation of the pyrrole ring to give 5 followed by condensation and reduction yields the desired Michael donor 6. Reaction of Michael acceptor 7 with 6 [20] in the presence of DBU gives 8. Subsequent formation of the pyrroline ring using the conditions established by McMurray and co-workers [21] gives compound 9. Finally, generation of the bacteriochlorin macrocycle is performed under acidic conditions established by Lindsey to give the bacteriochlorin 10.

Scheme 1. Bacteriochlorin synthesis

Alkynylation of bacteriochlorin 10 is illustrated in Scheme 2 with two competing strategies highlighted, Heck Alkynylation (Scheme 2A) and Sonogashira (Scheme 2B).
Brominated bacteriochlorin 11 (synthesized by brominating 10 under standard conditions) can be used to synthesize the “protected” alkynyl-bacteriochlorin 12 through either the Heck alkynylation or Sonogashira cross coupling reactions. The former (Heck alkynylation, Scheme 2A), previously reported by Lindsey and co-workers [18], resulted in a 59% yield. Our use of Sonogashira cross-coupling (Scheme 2B) to produce 12 resulted in an 89% yield (average of 86%, 3 trials). Finally, deprotection of the triisopropylsilyl group under standard conditions gives the desired alkynyl-bacteriochlorin 13.

Previous attempts to synthesize alkynylated bacteriochlorins avoided the Sonogashira reaction, a well know alkynylation reaction, due to the use of CuI as a co-catalyst. Under conditions used by most metal-catalyzed cross-coupling reactions, certain metals with relatively small atomic radii such as copper have the tendency to metalate or chelate with porphyrin (a close relative to bacteriochlorins), thus removing the catalyst from the system and reducing catalytic efficiency and yield. However, bacteriochlorins are not as susceptible to metalation under these conditions [22]. We have demonstrated that Sonogashira cross-coupling can be used effectively for alkynylation of bacteriochlorins and demonstrates an improvement over previously published strategies.

**Scheme 2.** Alkynyl-bacteriochlorin synthesis via Heck cross-coupling [18] (A) and Sonogashira cross-coupling [19] (B) methodologies.
4. Conclusion

Utilizing the Sonogashira reaction, we report an improved synthesis of alkynyl-bacteriochlorins that surpass the reported yields of the Heck alkynylation strategy [18]. Due to the 25-30% increase in yield of bacteriochlorin 12 utilizing the Sonogashira approach, we have improved the overall yield of this 14 step synthesis by ~0.5% (a noteworthy improvement considering the number of synthetic steps). We are currently investigating the use of alkynyl-bacteriochlorin in Cu(I)-catalyzed azide-alkyne 1,3-dipolar cycloaddition reactions with azido-carbohydrates to generate the desired CBCs. Determination of the pharmacokinetic and phototoxic properties of these CBCs is of future interest.

5. Acknowledgements

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6. References

An Improved Synthesis of an Alkynyl-Bacteriochlorin


Sewer Line Salamanders: Sewer Pipeline Impacts on Spotted Salamander (Ambystoma maculatum) Breeding Activity.

**ABSTRACT.** A current environmental challenge wildlife face is persistence in the face of extreme anthropogenic habitat alterations and destruction. A common type of habitat alteration in Spartanburg County is the use of creek floodplains as placement sites for county sewer pipelines. An artifact of maintaining sewer pipelines is development of tire track depressions along dirt roads running alongside the pipelines that fill with water during periods of heavy rain, which provide potential amphibian breeding habitat. The current study presents pilot data focused on evaluating (1) whether Spotted Salamanders (Ambystoma maculatum) use the puddles to breed, (2) if puddle size impacts salamander breeding activity, and (3) if anuran (i.e., frogs and toads) species also use the puddles to breed. We used visual surveys to count salamander and anuran egg masses in 22 puddles during the 2013 breeding season. We observed among puddle variation in the number of salamander egg masses present, as salamander egg mass counts varied from 0 to 109 egg masses per puddle. A paired t-test indicated that the number of salamander egg masses in sampled puddles significantly increased during the course of our study. In addition, linear regression analysis indicated that there was a significantly positive relationship between puddle area and the number of salamander egg masses in a puddle. While salamander egg masses far outnumbered anuran egg masses, we did find egg masses from three anuran species in our study puddles (i.e., American Toads: Anaxyrus americanus; Pickerel Frogs: Lithobates palustris; and Upland Chorus Frogs: Pseudacris feriarum).

**TANIYA MATHEW** was born in Kerala, India and moved to United States in 2008. She is a senior at USC Upstate pursuing a Bachelor of Science degree in Biology with a Premedical emphasis and minor in Spanish. She received the Freshman Chemistry Award in Spring 2011 and has worked as a tutor for introductory biology and general chemistry classes. Her research experiences started in the Spring of 2013 with the class project in Dr. Baumgarner's Comparative Animal Physiology course. This academic year, she is assisting Dr. Baumgarner with his cell physiology research on mice myotubes and AMPK protein expression. She competed for and was awarded a Magellan Scholar grant to continue the research with Dr. Baumgarner in the spring. In her spare time, Taniya enjoys listening to music and spending time with family and friends. Taniya starts medical school at the University of South Carolina’s School of Medicine in the fall of 2014 and someday hopes to work as a primary physician providing quality healthcare to medically underserved communities in South Carolina.

**SAMANTHA POARCH** graduated in December from the University of South Carolina Upstate with a Bachelor of Science degree in Biology. She started doing research with Doctor Pilgrim in Spring 2013 as a part of her Comparative Animal Physiology class. Finding that she enjoyed research, she competed for and was awarded a Magellan Scholar grant from USC Columbia. The Magellan Scholar grant supported her Summer
2013 research on small mammals in urban greenways under the supervision of Dr. Jonathan Storm. In addition to her coursework and research activities, Samantha was a supplemental instructor for Dr. Baumgarner’s Fall 2013 Human Physiology course and works at a local veterinary office. She was a member of USC Upstate’s softball team from 2011 to 2013. In her spare time, Samantha enjoys scuba diving. Samantha starts working towards her doctorate in August of 2014 at the University of Florida’s College of Veterinary Medicine.

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**DR. MELISSA PILGRIM** is Director of Research and an Associate Professor of Biology at USC Upstate. She joined the faculty at USC Upstate in the Fall of 2006. Her primary research focus involves an integrative approach to investigating how ecosystems respond to environmental change (natural and anthropogenic). Her research program integrates field ecology, biogeochemistry (e.g., stable isotopes), and ecophysiology. She earned her Ph.D. from the University of Arkansas in 2005 and transitioned to a post-doctoral research position at the University of Georgia’s Savannah River Ecology Laboratory (SREL). Many of her current research initiatives still involve collaborations with SREL faculty and students. In addition, she has an army of undergraduate students working with her in an undergraduate research group called Upstate Herpetology. Her publications range from book chapters in Herpetology volumes to scholarly articles in isotope, ecological, and herpetological journals. She currently serves on the Editorial Board for *Herpetologica*, as a Council Member of the South Carolina Academy of Science, and as the Upstate Regional Coordinator for the North American Amphibian Monitoring Program.
1. Introduction

A current environmental challenge wildlife face is persistence in the face of extreme anthropogenic habitat alterations and destruction [1]. As landscapes are altered there are several potential outcomes for wildlife. Four major outcomes for wildlife include complete loss of habitat [2], reduction in the quality of altered habitats [3], the integration of ecological traps into habitat mosaics [4], and the provisioning of supplemental habitat [5]. On a global scale, the negative outcomes associated with land alterations contribute to the current biodiversity crisis [6].

A common type of habitat alteration in Spartanburg County is the use of creek floodplains as placement sites for county sewer pipelines. County workers access the pipelines for maintenance using dirt roads running parallel to the pipelines. An artifact of maintaining the pipelines is development of tire track depressions along the dirt roads that fill with water during periods of heavy rain (Figure 1). The puddles along pipeline maintenance roads periodically dry up, which mimics the behavior of ephemeral wetlands (e.g., vernal pools) in forested habitats. Ephemeral wetlands are often used as breeding sites for amphibians, especially those species that prefer fishless wetlands [7]. Thus, there is potential that puddle formation along the sewer pipelines may provide breeding habitat for amphibians using the forested habitats around sewer pipelines. For example, Spotted Salamanders (*Ambystoma maculatum*) are typically abundant in the riparian bottomland and upland forest habitats surrounding many of the sewer pipelines in Spartanburg County and are a species that rely on ephemeral wetlands for breeding.

As part of our Comparative Animal Physiology class project we investigated the use of the sewer pipeline puddles by *A. maculatum*. Our long-term goals are to evaluate whether the puddles are beneficial (i.e., the puddles provide supplemental breeding habitat that augments current breeding activities of the species) or detrimental (i.e., the puddles serve as an ecological trap for the species) to *A. maculatum* populations inhabiting the floodplain of Lawson’s Fork Creek in Spartanburg County. As a starting point, the current study presents pilot data focused on evaluating (1) whether *A. maculatum* use the puddles to breed, (2) if puddle size impacts salamander breeding activity, and (3) if anuran (i.e., frogs and toads) species also use the puddles to breed.

2. Methods

**Study Organism**

*Ambystoma maculatum* (Spotted Salamander) is a widely distributed mole salamander species that reaches its northern range limit in Nova Scotia and its southern range limit in Texas. In South Carolina, the species is our state amphibian and can often be encountered in riparian bottomland and upland forests. The species requires ephemeral wetland habitats to breed (e.g., vernal pools). On wet spring nights male salamanders migrate to breeding ponds and deposit spermatophores that are picked up by females. Females deposit large gelatinous egg masses that typically contain 10 – 100 eggs per mass [8]. Spotted Salamander egg masses are often colonized by mutualistic, symbiotic algae (*Oophilia amblystomatis*; [9]–[11]). For the purposes of our study, the large size of Spotted Salamander egg masses made them easily visible to us during egg mass surveys (Figure 2).
Study Site

We used a stretch of the Spartanburg County sewer pipeline right of way adjacent to USC Upstate’s campus that stretches from 35.00568 latitude/-81.96327 longitude to 34.996813 latitude/-81.952838 longitude along the Lawson’s Fork Creek floodplain as our study site. The tire tracks along the sewer pipeline from county work trucks and low spots along the sewer pipeline filled with water during late winter and early spring rains, providing potential breeding habitat for Spotted Salamanders (Figure 1). Figure 3 shows the distribution of the puddles we surveyed during our study.

Data Collection

We divided the class into four groups assigned specific project tasks. The map crew was in charge of collecting GPS coordinates from each study puddle and determining the increase or decrease in puddle numbers as the study progressed (e.g., puddles drying). The map crew used a Garmin eTrex Vista HCx to obtain the GPS locations of puddles and build the map of our study site (Figure 3). The egg mass crew conducted egg mass surveys for each puddle, being careful to score puddle visibility, puddle shape, the number of Spotted Salamander egg masses, and all anuran egg masses (anuran egg masses were counted and identified to the species level). The depth crew provided estimates of pond size by recording puddle length and width dimensions along two transects. Specifically, the depth crew measured depth along the maximum length axis of each puddle at three evenly spaced points and along the maximum width axis of each puddle at three evenly spaced points. In addition, the depth crew measured depth at the center of each puddle. For this manuscript, we represent puddle size as puddle area (i.e., maximum length multiplied maximum width).

The zooplankton crew collected microorganisms by submerging a PVC pipe (30cm long with a diameter of 10cm) into the water until it sunk into the substrate and was anchored on the bottom of each puddle; the zooplankton crew consistently submerged the pipe within the first meter of the west end of each puddle. The zooplankton crew used a turkey baster to draw up all water captured within the PVC pipe and ran the water through a filtering mesh (mesh size of 60µm) to capture zooplankton suspended in the water; we set the mesh up over a 500mL beaker so that we would know the volume of water we sampled from each puddle. Once we ran all water from within the PVC pipe through the filtering mesh, we inverted the filtering mesh over a funnel linked to a sample storage container and rinsed it with 95% ethanol, which transferred captured zooplankton to the storage container. Finally, we sent the storage containers filled with zooplankton to Stetson University’s Limnology Class (under the instruction of Dr. Kirsten Work) for identification and among-puddle zooplankton density estimations. The current manuscript focuses on the data collected by the mapping, depth and egg mass survey crews, as the zooplankton samples are currently in Florida being analyzed by the Stetson students.

Data Summary and Analyses

We used Microsoft EXCEL 2010 for data management, summary, and analyses. For puddles that contained egg masses during at least one sampling event, we conducted a two-tailed paired t-test to determine if the number of egg masses in sampled puddles increased or decreased during our study. In addition, we used linear
regression analyses to evaluate the effect of puddle area on egg mass density. Throughout the document, we present means as ± one standard error.

3. Results

We mapped the initial distribution of puddles on January 31, 2013 and noted that no egg masses were yet present in any of the 22 identified puddles (Figure 3). All sample crews collected data on February 14, 2013 and March 28, 2013. During the first sampling event, 13 of the 22 puddles contained egg masses. For the thirteen puddles with egg masses, the number of egg masses per puddle ranged from one to thirty three and averaged 13.0 (± 3.07). By the second sampling event one of the 22 puddles dried. We found egg masses in 12 of the remaining 21 puddles. For the twelve puddles with egg masses during the second sampling event, the number of egg masses per puddle ranged from 3.5 to 109 and averaged 39.7 (± 12.22). A paired t-test indicated that the number of egg masses in sampled puddles significantly increased during our study (t = -2.579, df = 13, p = 0.022; Figure 4). The number of egg masses in a puddle increased with puddle area (Figure 3). Linear regression analysis indicated that there was a statistically significant positive relationship between puddle area and the number of egg masses in a puddle ($r^2 = 0.69$, $p < 0.001$; Figure 5). In addition to *A. maculatum* egg masses, we documented the presence of egg masses from three anuran species in our study puddles (i.e., American Toads: *Anaxyrus americanus*; Pickerel Frogs: *Lithobates palustris*; and Upland Chorus Frogs: *Pseudacris feriarium*).

4. Conclusions and Discussion

Our pilot data indicated that *A. maculatum* do indeed use the sewer pipeline puddles to breed. The increase of salamander egg masses from zero at the initial site mapping to a maximum of 109 at the last sampling event indicated that we did capture the progression of the spring 2013 *A. maculatum* breeding season. The positive association between puddle area and the number of egg masses in a puddle was not surprising, as other studies of pond breeding amphibians have shown a positive relationship between the number of egg masses deposited in a pond and the area of the pond [8]. The presence of anuran egg masses represents a potential food source for developing salamander larvae, as *A. maculatum* are known to consume invertebrates (e.g., zooplankton and insect larvae; [12]) and other vertebrates (e.g. tadpoles and other salamander larvae; [13]). As we integrate the findings of Dr. Work’s class regarding the zooplankton community composition and density into our data set, we will be able to further characterize the availability of food for larval salamanders developing in sewer pipeline puddles. The current work represents the start of what we hope to be a long-term study evaluating the degree that the sewer pipeline puddles impact the reproductive success of *A. maculatum* along Lawson’s Fork Creek. There is potential for the puddles to augment natural breeding habitat availability for the salamanders and serve as a source of individuals into the population. Conversely, the puddles may function as ecological traps for the salamanders by not providing resources necessary for developing larvae to survive and metamorphose from the puddles (e.g., puddle hydroperiod may be too short...
or puddles may lack enough food). Further complicating matters is the likely scenario that the two options presented above are not mutually exclusive outcomes, but may vary year to year. Regardless, our next steps include (1) comparing breeding activity in the puddles to breeding activity in natural wetlands along the creek floodplain, (2) evaluate reproductive success for salamanders using the puddles to breed relative to those using natural wetlands (i.e., how many metamorphs emerge from the puddles as compared to natural wetlands) and (3) evaluate among-year variation in salamander use of the puddles.

5. Acknowledgements

We would like to thank our 2013 Comparative Animal Physiology Class peers for assistance in the field (see Figure 6); in alphabetical order, our class peers included Gustavo Carmen, Amanda Covington, Zach Langston, Felicia Page, Yelena Prokhor, Bobby Salter and Nicole Smith. We also are grateful to Dr. J.D. Willson for use of his spotted salamander photograph.

6. References


7. Figures & Tables

Figure 1. Examples of sampled sewer pipeline puddles.
Figure 2. Spotted salamander (a) adult, (b) egg mass, and (c) individual egg with symbiotic algae inside (note the green coloration).
Figure 3: Map showing puddle (pond) locations along Lawson’s Fork Creek & the relationship between puddle area and egg mass count.
**Figure 4.** The average number of egg masses increased during the course of our study; n= the fourteen sampled puddles that had egg masses present during at least one of the two sampling events.

**Figure 5.** The effect of puddle area on the number of salamander egg masses.
Figure 6. The Spring 2013 Comparative Animal Physiology Class.
Survey Protocol and Interspecific Variation in Calling Activity Interact to Impact Anuran Detection in the Piedmont Region of South Carolina

**ABSTRACT.** The North American Amphibian Monitoring Program (NAAMP) is a large scale anuran (i.e., frog and toad) inventory and monitoring program developed in response to global amphibian decline. The NAAMP uses a standardized call survey protocol to evaluate the presence and persistence of anurans in a region. The goal of our study was to evaluate how the NAAMP’s protocol requirements of (1) conducting a minimum of one survey per sample window and (2) conducting call surveys along a route in sequential order impact anuran detection in the Piedmont of South Carolina. We used sound files recorded by automated recording systems (ARSs) during one NAAMP sampling window to assess the amount of sampling effort necessary to detect anurans in our region and to assess the effect of survey time on anuran detection probabilities. We detected the occurrence of seven anurans during our study and observed interspecific variation in detection probabilities, with 4 of the 7 species having detection probabilities under 0.5. In addition, survey time impacted the detectability of our species. Specifically, *Anaxyrus fowleri*, *Hyla chrysoscelis*, and *H. cinerea* tended to call closer to sunset, while *Acris crepitans*, *Lithobates catesbeianus*, and *L. clamitans* tended to call further from sunset. The influence of time on anuran detectability was most pronounced for *A. fowleri* and *H. cinerea*, where simply reversing the sequence of call survey completion through a night at least doubled the sampling effort necessary to detect the species.

**ADRIAN HAYES** graduated from USC Upstate with a B.S. in Biology in the fall of 2012. She is currently working at USC Upstate as a lab manager for Dr. Pilgrim. Before graduating, Adrian served as a Supplemental Instructor for Introductory Biology courses and was an active undergraduate researcher. Her research experiences started during the summer of 2011 in Dr. Turner’s Watershed Ecology Lab where she conducted water quality analyses evaluating the abundance of fecal coliforms in local water sources. In the spring of 2012, she received a research assistantship under the supervision of Dr. Pilgrim and served as the lead student volunteer for North American Amphibian Monitoring Program initiatives in the piedmont region of South Carolina. Adrian competed for and was awarded a Magellan Scholar grant to support her research investigating anuran bioacoustics during the summer of 2012. Adrian has presented her research at local, regional and international scientific meetings, as well to community members during outreach programs. The research presented in this volume highlights some of the work she completed with support from the Magellan Scholar program.

**ELIOTT GIBBS** is a senior biology major at USC Upstate. His undergraduate research experiences began with work studying urban predator ecology under the supervision of Dr. Jon Storm; in fact, his poster presentation of the urban predator project award at the 9th Annual SC Upstate Research
Symposium. Elliott is also interested in amphibian biology and became an official volunteer for the North American Amphibian Monitoring Program under the supervision of Dr. Melissa Pilgrim. He received a Magellan Scholar grant to study anuran bioacoustics during the summer of 2012; a portion of this research is the focus of the current journal article. In addition to his research activities, Elliott was an active member of the USC Upstate Chemistry Club and a Supplemental Instructor for Introductory Biology courses. Recently, Elliott was hired as a Production Chemist with New Life Chemical & Equipment, Inc.

**DR. MELISSA PILGRIM** is Director of Research and an Associate Professor of Biology at USC Upstate. She joined the faculty at USC Upstate in the Fall of 2006. Her primary research focus involves an integrative approach to investigating how ecosystems respond to environmental change (natural and anthropogenic). Her research program integrates field ecology, biogeochemistry (e.g., stable isotopes), and ecophysiology. She earned her Ph.D. from the University of Arkansas in 2005 and transitioned to a post-doctoral research position at the University of Georgia’s Savannah River Ecology Laboratory (SREL). Many of her current research initiatives still involve collaborations with SREL faculty and students. In addition, she has an army of undergraduate students working with her in an undergraduate research group called Upstate Herpetology. Her publications range from book chapters in Herpetology volumes to scholarly articles in isotope, ecological, and herpetological journals. She currently serves on the Editorial Board for Herpetologica, as a Council Member of the South Carolina Academy of Science, and as the Upstate Regional Coordinator for the North American Amphibian Monitoring Program.

### 1. Introduction

Anthropomorphic changes to the planet (e.g., habitat fragmentation, pollution, and climate change) have resulted in the current biodiversity crisis [1]. Amphibians are central to the biodiversity crisis, as they are the most threatened vertebrate class [2]. In addition, the decline of amphibians has drawn considerable attention because they are often viewed as bioindicators of environmental quality due to their sensitivity to environmental contaminants (e.g., heavy metals, phenols, pesticides and inorganics; [3]). Thus, as amphibians continue to disappear, conservationists worry that their loss may be warning us of overall ecosystem decline [1], [3].

The North American Amphibian Monitoring Program (NAAMP) is a large scale anuran (i.e., frog and toad) inventory and monitoring program developed in response to global amphibian decline. The NAAMP is managed by the United States Geological Survey (USGS) and capitalizes on the breeding behavior of anurans. Male anurans form leks or breeding choruses where they emit vocalizations in order to attract females for reproductive purposes [4]-[6]. Anuran vocalizations are species-specific, making species identification during breeding seasons easy, trainable, and testable [6]. Therefore, the NAAMP uses a standardized call survey protocol whereby the presence
of anurans in a region can be assessed and monitored [6]-[7].

The NAAMP protocol specifies when a volunteer can complete a survey, where call surveys are to be completed in a region, and what data will be collected during a call survey. There are three sampling windows for our region, which run from January to June. Surveys must be completed once during each of three sampling windows. Within these sampling windows, surveys must be completed between 30 minutes after sunset and 01:00. The USGS assigns each NAAMP participant a route along which call surveys are to be completed; each route is an approximately 15 mile stretch of highway with 10 stops separated by at least 0.5 miles. The stops along a route are numbered one through ten, and must be completed in sequential order. Thus, the survey protocol introduces a potential temporal bias into data collection.

While the NAAMP program offers several benefits to the scientific community, including the ability to (1) track the presence or absence of anuran species in a region through time [8]-[9], (2) evaluate climate change impacts on species [10], (3) monitor populations through time and (4) better understand landscape ecology through evaluations of anuran habitat preference [11], the protocol has received some criticism. Most previous research evaluating biases associated with NAAMP protocol have focused on variation in inter-observer abilities [12], the temporal scale of a sampling window [8], [13]-[14], and what biases may arise from NAAMP’s strictly nocturnal surveys [8]-[9], [15]. The goal of our study was to expand this research by evaluating how the NAAMP’s requirements of (1) conducting a minimum of one survey per sample window and (2) conducting call surveys along a route in sequential order impact anuran detection in the piedmont of South Carolina. Our hypothesis was that the minimum requirement of one survey per sample window and the requirement to conduct call-surveys along a route in sequential order would negatively impact our ability to detect anurans in the piedmont region of South Carolina.

2. Materials & Methods

We programmed four automated recording systems (ARSs; Song Meter SM2+ Platforms) to record five minutes at the 30 minute mark of every hour of each day. Once programmed, we installed the ARSs at four wetlands in Spartanburg County, South Carolina (Figure 1). To test our hypothesis we used the ARS recordings to generate a data set comparable to our NAAMP data set. Specifically, we completed call surveys by listening to the ARS sound files recorded at the 21:30, 22:30, 23:30 and 0:30 time periods from May 13th to June 17th, 2012. As we listened to each sound file, we scored all anuran species calling as present.

To determine the probability of detecting \( P_d \) each species in our data set, we used the following equation: \( P_d = \frac{ns}{t} \) (number of surveys a species was detected) / \( t \) (total number of surveys). To determine the number of surveys \( n \) that would be required to have a 95% probability of detecting a species once during our sampling period we used the following equation: \( 0.95 = 1 - (1- P_d)^n \).

To evaluate the effect of survey time on anuran detection probabilities we calculated the overall detection probability for each species during each time period at each wetland. In addition, we used the ARS files to build two artificial routes where each of our four wetlands represented a stop along the route. For artificial route 1, we used
the probability of detecting each species at each wetland at a specific time from West to East, which resulted in determining detection probabilities for Scotsgrove at 21:30, Patterson at 22:30, Ludwick at 23:30 and Cleveland at 00:30 (see Figure 1 for visual reference). For artificial route 2, we simply reversed the pattern and determined detection probabilities for each species in a pattern from East to West (see Figure 1 for visual reference).

3. Results

In total we completed 560 5-minute call surveys (46.67 hours of listening to sound files). We detected seven anuran species calling at our wetlands; however, we observed among-wetland variation in anuran breeding assemblages and calling activity (Table 1). Anuran detection probabilities ranged from 0.0125 to 0.7357 (Figure 2). We determined that one call survey was an inadequate sampling effort to have a 95% probability of detection for any of the seven species (Figure 3). In addition, we found that survey time impacted species detection probabilities (Figure 4); some species were more likely to call early in the evenings, while others were more likely to call later in the evenings. Specifically, we observed a minor increase in calling activity of Acris crepitans, Lithobates catesbeianus, and L. clamitans from sunset to 1 AM, but a marked decrease in the calling activity of Anaxyrus fowleri, Hyla chrysoscelis, and H. cinerea from sunset to 1 AM. The interspecific variation in calling activity through a night caused the detectability of species along the artificial routes to vary depending on the temporal sequence of call survey completion (Figure 5). The increase in the number of call surveys required to detect species resulted in an increase in the number of routes needed to detect 3 species and the increase in sampling effort was particularly strong for A. fowleri and H. cinerea, as sampling effort to be 95% confident of detecting the two species in our wetlands more than doubled if route order was reversed (Figure 6).

4. Discussion

Data we collected supported our hypothesis; the NAAMP protocol’s minimum survey requirement did impact anuran detectability in the piedmont region of South Carolina. One survey did not represent adequate sampling effort for any of our detected species. In addition, survey time and route sequence did impact anuran detectability in the piedmont region of South Carolina. Specifically, A. fowleri, H. chrysoscelis, and H. cinerea tended to call closer to sunset, while A. crepitans, L. catesbeianus, and L. clamitans tended to call further from sunset. The influence of time on anuran detectability was most pronounced for A. fowleri and H. cinerea, where simply reversing the sequence of a route at least doubled the sampling effort necessary to detect the species.

Our results are not surprising, as many abiotic factors, including time, have been shown to impact anuran calling activity (Table 2) and the matter is further complicated as not all factors impact each anuran species in the same way. The interspecific variation in the effect of time on calling activity for our detected species paralleled the results of previous research; similar temporal changes in calling activity were found in other studies of A. fowleri [8]; gray treefrogs (H. chrysoscelis/versicolor) [9],[15]; H.
cinerea [15]; L. catesbeianus and L. calmitans [8]-[9],[15]; and [15] found a similar pattern in calling activity for A. gryllus (a congener of A. crepitans). Interestingly, all of the species mentioned above have broad geographic ranges that encompass the piedmont of South Carolina, but extend well beyond the region. Thus, the similarities between our work and the published literature suggest that temporal patterns in anuran calling activities we report are species-specific and not simply regionally-specific.

In closing, our study revealed biases associated with the NAAMP protocol that could impact its effectiveness as an anuran inventory and monitoring program. We caution researchers that documenting the occurrence of species with low detection probabilities may require completion of more than one survey per route during NAAMP sampling windows. In addition, the sampling effort required to detect the occurrence of a species will vary depending on the effect of time on its calling activity. In the future, we plan to expand our work to include occupancy modeling as an approach to assessing how the number of sampled breeding sites impacts the detection of anurans in the Piedmont and how annual variation in interspecific calling activity impacts the detection of anurans in the Piedmont.

5. Acknowledgements

We would like to thank Jennifer Holleman and Peter Lembcke, for assistance in the field and Dr. Ben Montgomery for statistical advice. We greatly appreciate the Spartanburg Area Land Conservancy and the Conservancy’s landowner partners for granting us land use. We are grateful for financial support received from the Magellan Scholars Program, USC Upstate’s Office of Sponsored Awards and Research Support, and the Division of Natural Sciences and Engineering.

6. References


7. Figures and Tables

Figure 1. Four study wetlands in the Piedmont of South Carolina.

Table 1. Anurans detected calling in ARS sound files during our 35 night study window. Numbers represent the number of nights each species was detected in each wetland during the study period and nd = a species was not detected.

<table>
<thead>
<tr>
<th>Species</th>
<th>Wetland</th>
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<tr>
<td></td>
<td>Cleveland</td>
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<tr>
<td>A. crepitans</td>
<td>35</td>
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<td>A. fowleri</td>
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<td>H. chryscoscelis</td>
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<td>H. cinerea</td>
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<td>L. catesbeianus</td>
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<td>L. clamitans</td>
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<td>P. crucifer</td>
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Figure 2. Interspecific variation in anuran detection probabilities during our study.

Figure 3. Interspecific variation in sampling effort required to have a 95% probability of detection for anurans during our study. The numbers on each bar represent the number of call surveys required to detect the species during our study.
Figure 4. The effect of time on anuran detection probabilities during our study.

Figure 5. The effect of time on the number of call surveys required to have a 95% probability of detection for seven anuran-species during our study.
Figure 6. The effect of route sequence on the number of routes required to have a 95% probability of detecting anurans in our study. S→C is an artificial route starting at Scotsgrove at 21:30 and ending at Cleveland at 0:30. C→S is an artificial route starting at Cleveland at 21:30 and ending at Scotsgrove at 0:30.

Table 2. Abiotic factors that have been found to impact anuran calling.

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<td>Time of Year</td>
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<td>Time of Day</td>
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Urban Greenways Support Communities of Native Small Mammals

**ABSTRACT.** Loss of species diversity is greatly influenced by the loss of natural habitat, including habitat loss resulting from the spread of urban development. Some urban areas attempt to conserve biodiversity by preserving urban greenways, linear parklands maintained in a more natural state than a typical urban park. In this study we sought to determine if urban greenways in Spartanburg, South Carolina provide suitable habitat for native small mammals. In addition, we hypothesized that there would be a positive relationship between vegetation density and the abundance of white-footed mice (Peromyscus leucopus). We compared the small mammal communities within three urban greenways to that of three rural forest sites. We capture-mark-recaptured small mammals during May and August of 2012. All of the small mammals we captured were native species. The diversity of the small mammal community within urban greenways was similar to that of rural forests. At all sites, the white-footed mouse was the most abundant species, representing 91.3% of all captures at urban greenways and 70.2% of captures at rural forests. The golden mouse (Ochrotomys nuttalii) was the second most abundant species at rural sites, but nearly all individuals were captured at a single site (Pacolet North). Contrary to prior studies, we did not find a significant relationship between vegetation density and the abundance of white-footed mice. Our results suggest that urban greenways provide effective habitat for native small mammals.

**Derek Kunda** came to USC Upstate as a member of the Scholar’s Academy in 2008. After remaining in the program for three years, he graduated from Boiling Springs High School and remained at USC Upstate to pursue a degree in Biology (Pre-Medical) with a minor in Chemistry. He plans to attend medical school beginning Fall of 2015 and to become a forensic pathologist. Derek is a member of the USC Upstate Honors Program and he enjoys playing soccer in his spare time.

**JOEY MORRISSEY** entered USC Upstate as a member of the Scholar’s Academy in 2008. After three years in the program, he graduated from Broome High School in Spartanburg, and entered USC Upstate as a Biology major with a Chemistry minor. He is now on a Pre-Veterinary track and hopes to enter Veterinary school in the Fall of 2015. He began conducting small mammal demography research with Dr. Storm during the summer of 2011 and has stayed active in this research since then.

**DR. JON STORM** is an Assistant Professor of Biology at USC Upstate. He earned his Ph.D. from Indiana State University and has published in journals such as the American Naturalist, Journal of Comparative Physiology, Journal of Experimental Biology, Canadian Journal of Zoology, Functional Ecology, and the Journal of Wildlife Management. His research interests include the urban ecology of small mammals and anti-predator behavior. His research on white-
1. Introduction

Due to the spread of urban development, wildlife habitat in many parts of the world has turned into small pockets of natural land surrounded by a human-dominated landscape [1]. For example, in the Upstate region of South Carolina, developed land increased from 90,142 ha in 1990 to 233,234 ha in 2000. The amount of developed land in Upstate South Carolina is expected to increase to 616,606 ha by 2030 [2]. Due to urban sprawl in South Carolina and elsewhere, some biologists have suggested that the most effective way to protect wildlife is to design urban areas that co-function as wildlife reserves [3]. One example of this philosophy is an urban greenway, an area of parkland maintained in a more natural condition than a typical urban park. Urban greenways are commonly retained along urban streams and rivers and often contain trails for recreation [4]. During urban planning, greenway retention plans often include wildlife conservation goals; however, the actual contribution of urban greenways to wildlife conservation remains unclear [5].

Most research on wildlife in urban greenways has focused on birds. For example, bird species that are well-adapted to urban environments are common in greenways less than 50 m wide, but forest-interior species (i.e. those not well adapted to an urban environment) need greenways that are 300 m or wider for effective habitat [6]. By surveying parklands and urban habitat within and around Buenos Aires, Argentina, [7] found that native small mammals were common in natural reserves, but species diversity declined and introduced species such as the European house mouse (Mus musculus) became common in urban parklands and other urban habitats. Only one prior study has examined small mammal diversity in urban greenways of North America [8]. However, most of their study sites were typical urban parks, and only one site was an urban greenway. They found that urban parks supported a small mammal community similar to that of rural forests; however, this was a short study (only 4 days of sampling per site during a single year) and they did not examine demographic parameters such as abundance and density.

In this study we sought to i) determine whether urban greenways in Spartanburg, South Carolina provide effective habitat for native small mammals and ii) whether white-footed mice density was positively correlated with vegetation density.

2. Materials and Methods

We capture-mark-recaptured small mammals at three urban greenways (Chinquapin, Cottonwood, and Palmetto Trails) within the city of Spartanburg, and three riparian forests (Peter’s Creek Heritage Preserve and two sites at the Pacolet River Heritage Preserve) in rural Spartanburg County, SC. Each site was trapped for 7 continuous days during May and August, 2012. At each site we set out a 5 x 25 grid of H. B. Sherman live traps baited with a mixture of oatmeal, sunflower seeds, and bacon.
bits. Traps were checked each morning before 0900. Captured individuals were given a unique metal ear tag (National Band and Tag Company) and immediately released at their site of capture. We also recorded the gender, mass, reproductive status (male: scrotal or non-scrotal; female: lactating, pregnant, or non-reproductive), and age class (adult or juvenile) for each captured individual. Southeastern shrews (Blarina carolinensis) and pine voles (Microtus pinetorum) were not ear tagged due to the inability to effectively ear tag these species.

We estimated the abundance of white-footed mice (Peromyscus leucopus) using a Schnabel index, a standard capture-mark-recapture technique for estimating the number of individuals in a population (N). The Schnabel index compares the ratio of marked to unmarked individuals captured on a given trapping day using the equation below:

$$N = \frac{M \times S}{R}$$

N = population size
M = number of marked individuals in the population
S = sample size of captured individuals on a given day
R = number of marked individuals recaptured on a given day

We used the Schnabel estimate of population size to calculate the density of white-footed mice at each field site (individuals/ha). To calculate density, we first calculated the mean maximum distance moved (MMDM) for each white-footed mouse captured at least twice during a 7-day trapping period following the method of [9]. We calculated the MMDM in order to determine the effective trapping area given that the home range of some white-footed mice was likely on the edge of our trapping grid and would bias the density estimate. We added the MMDM distance to each side of our trapping grid to calculate the effective trapping grid area. We then calculated density by dividing the Schnabel index of abundance by the effective trapping grid area.

The density of vegetative ground cover was assessed at each study site during July, 2011 (see [10] for a complete description). Briefly, vegetative horizontal cover was assessed at 20 randomly selected locations at each site using a 2 m black and white profile board. The proportion of the profile board that was visible from a distance of 15 m was visually estimated and scored such that: 1 = 0-19% visual obstruction, 2 = 20-39% obstruction, 3 = 40-59% obstruction, 4 = 60-79% obstruction, and 5 = 80-100%. We used horizontal cover data from 2 vertical dimensions: 0-0.5 m and 0.5-1.0 m above the forest floor. We performed a linear regression in Microsoft Excel to determine whether vegetation density has a positive effect on white-footed mouse density. All procedures were approved by the University of South Carolina Animal Care and Use Committee.

3. Results and Discussion

The species richness of the small mammal community within urban greenways was similar to that of rural forests (Table 1). In both urban greenways and rural forests, the white-footed mouse was the most common species, representing 91.3% of all captures at urban greenways and 70.2% of individuals captured at rural forests. White-footed mouse density was higher at urban greenways than within rural forests (Table 2).
Our results match previous work which has found that, relative to rural forests, white-footed mice are most dense in woodlands surrounded by urban habitat [1] or within small forest patches containing dense vegetation [11]. White-footed mice are abundant throughout the Eastern United States [12] and they are habitat generalists, commonly occurring in small and large forest patches, urban habitats, and along roadsides [13]. In addition, white-footed mice are often abundant within forest fragments, particularly within edge habitat [1].

The golden mouse (Ochrotomys nuttalli) was the second most abundant species at rural forests; however, nearly all of the golden mice were captured at one site, Pacolet North. The golden mouse is often syntopic with white-footed mice and they are not strong resource competitors [14]. Golden mice have a patchy dispersion, being common in some areas and absent from other areas of seemingly suitable forest habitat [15].

Species diversity of small mammals was low across all sites [Table 1], but there was a tendency for rural forests to have slightly higher diversity, largely due to the presence of golden mice. The low diversity we found is similar to that of other field studies in South Carolina. For example, [16] found a Shannon diversity of 1.49 for the small mammal community at the Savannah River Site. Loblolly pine (Pinus taeda) plantations in the Lower Coastal Plain also have a low species diversity, ranging from a Shannon diversity of 0.0 – 0.57 [17].

Contrary to our previous work [10], we found no relationship between vegetation density and the density of white-footed mice (r = 0.326, df = 10, p = 0.301, Figure 1). There was a tendency for urban greenways to have a higher mean horizontal cover score that rural forests, but Pacolet River, one of our rural forest sites, also had dense vegetation (Table 3). The greater vegetation density within urban greenways is likely a result of the linear, fragmented nature of urban greenways fostering increased light penetration and the growth of ground cover [18]. The density of white-footed mice was greatest at the Chinquapin site, likely due to the dense ground cover of green brier (Smilax spp.) at this site. The high vegetation density at Pacolet River also explains the presence of golden mice at this site. Golden mice are semiarboreal and prefer habitat containing dense vegetation [8].

4. Conclusions

In this study we sought to determine whether urban greenways in Spartanburg provide suitable habitat for native small mammals. Our research suggests that the small mammal species composition of urban greenways is similar to that of rural forests. This suggests that urban greenways are an effective wildlife management practice for the retention of native small mammals within urban areas of the southeastern United States. We suspect that house mice are abundant in urban areas such as Spartanburg; however, house mice stay near buildings and do not establish populations within urban greenways. In general, the density of white-footed mice was higher within urban greenways than rural forests, likely due to the higher vegetation density at urban greenways. Similarly to other studies of the small mammal community in South Carolina, we found species diversity to be low, but slightly high at rural forest sites than within urban greenways.
5. Acknowledgements

We thank the USC Upstate Center for Research and Scholarship Support for providing a mini-grant to D. Kunda, J. Morrissey, and J. Storm to fund this research. We also thank the USC Upstate for a Teaching and Productive Scholarship grant to J. Storm. We thank the SPACE and South Carolina DNR for the usage of land.

6. References


7. Figures & Tables

Table 1. Number of individuals captured at each study site during May and August, 2012 in Spartanburg County, South Carolina.

<table>
<thead>
<tr>
<th>Species</th>
<th>Urban Greenways</th>
<th>Rural Forests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chinquapin</td>
<td>Palmetto</td>
</tr>
<tr>
<td>Southern Shrew; Blarina carolinensis</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>White-footed Mouse; Peromyscus leucopus</td>
<td>51</td>
<td>36</td>
</tr>
<tr>
<td>Golden Mouse; Ochrotomys nuttali</td>
<td>_ _</td>
<td>_ _</td>
</tr>
<tr>
<td>Pine Vole; Microtus pinetorum</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Shannon Diversity</td>
<td>0.187</td>
<td>0.57</td>
</tr>
</tbody>
</table>
Table 2. Density of white-footed mice (*Peromyscus leucopus*) at each study site during May or August, 2012 in Spartanburg County, South Carolina. Density was calculated at the estimated abundance from the Schnabel index divided by the effective trapping grid size determined by the mean maximum distance moved.

<table>
<thead>
<tr>
<th></th>
<th>Urban Greenway</th>
<th>Rural Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chinquapin</td>
<td>Cottonwood</td>
</tr>
<tr>
<td>May 2012</td>
<td>18.7</td>
<td>11.4</td>
</tr>
<tr>
<td>August 2012</td>
<td>6.0</td>
<td>4.7</td>
</tr>
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</table>

Table 3. Mean horizontal cover of vegetation at 3 urban greenways and 3 rural forests in Spartanburg County, South Carolina. Each site was sampled at 20 random locations using a vertical profile board.

<table>
<thead>
<tr>
<th></th>
<th>Site</th>
<th>Mean Horizontal Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenway</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chinquapin</td>
<td>3.775</td>
</tr>
<tr>
<td></td>
<td>Cottonwood</td>
<td>4.375</td>
</tr>
<tr>
<td></td>
<td>Upstate</td>
<td>3.2</td>
</tr>
<tr>
<td>Rural Forest</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pacolet Blue</td>
<td>2.175</td>
</tr>
<tr>
<td></td>
<td>Pacolet River</td>
<td>3.45</td>
</tr>
<tr>
<td></td>
<td>Peter's Creek</td>
<td>2.55</td>
</tr>
</tbody>
</table>
Figure 1. There was no relationship between mean horizontal cover and the density of white-footed mice (*Peromyscus leucopus*) at each site during May and August, 2011.
Factors that Lead to the Successful Completion of a College Degree by Individuals with Disabilities

**ABSTRACT.** As the number of students with disabilities continues to increase, it is essential that postsecondary institutions provide services that will support them in completing their degrees. The current study explored the skills, services, and accommodations that are assisting students with disabilities successfully earn a college degree. Almost all of the study participants reported that they had accessed services through an office of disability at their institution. They also identified extended time on exams, priority registration, distraction-free testing environments, notetaking assistance, textbooks in accessible formats, and taping of lectures as helpful accommodations.

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**DR. TINA HERZBERG** is an Associate Professor and Director of Graduate Programs for the School of Education at the University of South Carolina Upstate. Dr. Herzberg has a bachelor’s degree in Mathematics with Secondary Teaching Education from Angelo State University, a master’s degree in Visual Impairment from Texas Tech University, and a Ph.D. in Special Education and Interagency Collaboration from Texas A&M University. Her research interests include braille literacy, transcription of print into braille, tactile graphics, and postsecondary education of students with disabilities. Current research projects include: 1) interviewing youth with visual impairment regarding their experiences with braille and tactile graphics; 2) developing and evaluating online modules designed to increase the accuracy and quality of mathematics materials prepared for braille readers in grades K-12; and 3) examining university faculty attitudes and intentions toward providing academic accommodations for postsecondary students with disabilities.
1. Introduction

The number of students with disabilities in post-secondary programs has significantly increased over the last two decades. In 1995-96, only 6% of students enrolled in post-secondary institutions identified themselves as having a disability [1]. In contrast, approximately 11% of students enrolled in post-secondary institutions identified themselves as students with disabilities in 2007-2008 [2]. Gender and ethnicity of students with disabilities mirrored the general student population [2]. On the other hand, college students with disabilities tended to be older, and students with disabilities were less likely to be considered full-time students in comparison to their nondisabled peers [2].

Despite an enrollment increase, many college students with disabilities have not successfully completed their education [3]-[6]. Students with disabilities that have dropped out often report a gap in the support and services available to them in post-secondary education programs in comparison to P-12 education programs [4]. The role of students with disabilities in post-secondary education settings changes dramatically from passivity and participation to active responsibility. The students with disabilities must disclose their disability and actively seek out available services when they enroll in post-secondary education programs, whereas in high school, students with disabilities are supported by multidisciplinary teams that monitor the effectiveness of accommodations and ensure the student is successful in their education [7]. Some students with disabilities navigate the transition from a passive role to an active role more successfully than other students. Additional barriers to success include: lack of understanding and knowledge by university personnel, students seeking services too late, and reluctance of students to disclose information about their disability [4].

These barriers were also noted in the 2012 study by [8]. Fifty-nine students and six disability coordinators from five community colleges and three universities participated in nine focus group sessions. Many of the students shared that low expectations of others and a lack of understanding by postsecondary faculty posed a barrier to their success in school. They felt that some faculty members did not understand their needs or rights for accommodations. This coupled with the students’ general lack of information about postsecondary setting and their own needs seemed to lessen opportunities for positive outcomes. Students and the disability coordinators also believed that a lack of academic preparedness in writing, mathematics, and study skills posed as a barrier, especially in the first year.

However, little research has explored the factors and skills that have assisted individuals with disabilities in successfully completing their postsecondary education [9]; [3]. Last year, a research report published by John J. Heldrich Center for Workforce Development and the Kessler Foundation overviewed the experience of twenty college completers with disabilities from New Jersey [3]. All twenty had accessed services from an office of disability or special services. The completers reported that the most important factor associated with success was a personal relationship with a faculty member or a staff member from an office of disability or special services. The completers also believed that understanding their disability gave them the confidence to disclose their disability and advocate for their needs.
The purpose of this project was to investigate the factors, skills, and services that contribute to the successful completion of a post-secondary education program by individuals with disabilities across the United States. The data collected may be useful in assisting public K-12 schools to adequately prepare students with disabilities for higher education. Additionally, this data may expand the existing knowledge base and assist postsecondary institutions in reviewing and/or expanding services and training opportunities for students with disabilities.

2. Method

An online survey was developed using Survey Monkey™. The survey instrument developed by Barber to interview college completers was used as a guide for some of the questions. Refer to Appendix 1 for a complete listing of the survey questions. The survey began with a brief description of the purpose of the study and consent information; this was followed by 37 items divided into four sections. In addition to demographic information, participants were asked to share information about their level of perceived preparedness when they began college, satisfaction with their overall academic experience in college, services and accommodations that have contributed to their success, and why they think they have been successful in college.

Approval to conduct the research was obtained from the Institutional Review Board at the University of South Carolina Upstate. The study was open to individuals with disabilities currently enrolled at a community college, vocational school, technical school, business school, or a 4-year college/university throughout the United States who had successfully completed at least one-half of their program of study and were scheduled to graduate on or before May 2014. Potential participants were recruited via an email distributed over several Listservs for higher education professionals involved in the delivery of services to students with disabilities. Listserv members were asked to forward the information about the study to academically successful students with disabilities. The participants were self-selected through voluntary response to the recruitment email.

The use of an electronic survey instrument allowed the researchers to recruit participants nationally and anonymously in a user-friendly format. Survey Monkey™ is accessible for individuals who use screen readers and other assistive technology. It also electronically provides data in different formats that can be used with SSPS™ and other advanced statistical analysis software. Conversely, the use of an electronic survey did not permit the researchers to probe responses with additional questions or ask for clarification.

3. Results and Discussion

Ninety-nine (99) individuals with disabilities began the online survey; however, only 90 individuals from 20 different states completed the online survey. Seventy (80.4%) elected to complete the demographic portion of the survey. Of the individuals who provided demographic information, 50 (71.4%) of the survey completers were female, and 20 (28.6%) were male. Of the 67 individuals who responded to the question, six (8.96%) attended a two-year institution or community college, and 61
(91.04%) attended a four-year college or university. Sixty-eight participants reported a wide range of disabilities. The three most commonly reported disabilities were learning disabilities (n = 34), attention deficit disorder/attention deficit hyperactivity disorder (n = 21) and physical disabilities (n = 13). Other reported disabilities included: psychiatric disorder (n = 8), health impairment (n = 7), auditory processing disorder (n = 7), speech impairment (n = 6), traumatic brain injury (n = 5), other (n = 5), deafness or hard of hearing (n = 4), blindness or visual impairment (n = 2), autism (n = 2), and prefer not to answer (n = 1). In addition, seven participants reported that they had multiple disabilities. All but seven participants shared that they had disclosed information about their disability with their school.

Participants were asked if they felt adequately prepared when they first entered college. Thirty (35.3%) felt prepared, 12 (14.1%) did not feel prepared, and 43 (50.6%) felt somewhat prepared. Participants who reported that they did not feel adequately prepared were asked what skills or information they were lacking. The most commonly reported missing skills or information were: time management (n = 30; 46.2%) and study skills (n = 28; 43.1%). Figure 1 provides a complete listing of commonly identified missing skills or information.

![Figure 1](image_url)

**Figure 1.** If you did not feel adequately prepared, what skills or information were you missing?

Students were then asked what services and skills contributed to their success in their education. Seventy participants (76.9%) stated that they had sought accommodations or accessed services from an office of disability during their course of study. The participants reported that they had learned about resources and services available at their school/institution for students with disabilities through a variety of sources, including parents, friends, doctors, high school teachers, college websites, college professors, and guidance counselors. Figure 2 below highlights the other services and skills that were perceived by the participants as helpful.
Figure 2. Do any of the following contribute to your success at college or the university?

Students were then asked which accommodation, if any, was the most helpful. The most common response was extended time on exams (n = 20). Other accommodations reported as the most helpful were distraction-free testing environment (n = 8), taping lectures (n = 6), priority or early registration (n = 6), and note-taking assistance (n = 6). Participants also identified additional accommodations that were helpful; the five most commonly identified were extended time for exams (n = 30), priority or early registration (n = 23), distraction-free testing environment (n = 18), note-taking assistance (n = 15), and textbooks in accessible formats (n = 13).

The vast majority of participants (n=73, 90.1%) reported adequate access to technology. Seven (8.6%) participants reported that they had somewhat adequate access to technology, and only one (1.2%) reported inadequate access to technology. Fifty-six participants (65.1%) felt that their course of study was preparing them for employment while 24 (27.9%) participants felt that their coursework was somewhat preparing them. On the other hand, six participants (7%) felt that they were not being prepared for employment.

More than half of the participants indicated that they had experienced obstacles since beginning their postsecondary education. Obstacles included professors unwilling to accommodate (n=25), inaccessible classroom materials (n=17), not knowing who to contact when experiencing problems (n = 14), inaccessible online materials (n=13), and lack of awareness regarding available services (n=11).

Lastly, participants were requested to share advice with high school students with disabilities planning to attend college. Several themes emerged across the open-ended responses. Many of the participants encouraged the high school students to research their options, including different resources and degree programs available on university campuses. For example, one participant commented, “Take your time and find the best school that fits your needs.” The participants also stressed the importance of advocating for yourself, managing your time, and seeking help when needed. Several participants also suggested that the future college students get involved and make
friends on campus. Most importantly, they offered encouragement. As one participant suggested, “DO IT!!! It’s an experience that you cannot duplicate or replicate anywhere else. You get out of it what you put into it. It won’t always be easy but it will be worth it if you finish. It sets you apart from most of the rest.”

4. Conclusion

This study supported the findings of the 2012 [8] study. Only 35% of the 90 participants in this study felt that they were completely prepared for the rigors of postsecondary education. Similar to [8], the participants in this study specifically identified writing, mathematics, and study skills as areas of concern. In addition, almost 30% of the participants reported that they had experienced professors who were unwilling to make accommodations. Moreover, the participants identified the ability to self-advocate their needs, asking questions when they do not understand, communicating regularly with their professors, and self-discipline as factors that contributed to their success.

As suggested by [3], the findings of this project indicate that services and accommodations often provided by an office of disability play an important role in the success of students in postsecondary settings. Frequently utilized accommodations such as extended time on examinations and priority registration were identified as very helpful by the participants. In addition to ensuring that students with disabilities have adequate skills in core subjects such as mathematics and writing, P-12 schools, colleges, and universities can support student success in postsecondary education settings by teaching key compensatory skills required to access all areas of the core curriculum such as time management, study skills, and notetaking skills. Moreover, high school students planning to continue their education in postsecondary settings must be prepared to initiate contact with an office of disability, disclose information about their disability, and effectively communicate how their disability affects their academic performance.

5. Limitations

The study had several limitations. First, the use of a survey did not offer opportunities to probe or ask for clarification when needed. Second, there was no triangulation of data. The study would have been strengthened by in-person interviews or focus groups, interviews with disability coordinators, and/or access to student school records. Third, the individuals that participated in the study were volunteers and may or may not be representative of all individuals with disabilities enrolled in postsecondary programs.

6. Future Studies

Future research should focus on the perceptions, skills, and knowledge of faculty members in teaching postsecondary students and providing accommodations. Additional research is also needed to establish an evidence-based model that can be used by universities and colleges in supporting students with disabilities. The model
should clearly delineate the skills, services and accommodations that lead to success in postsecondary settings and offer specific recommendations for training of faculty, staff, and students.

7. Acknowledgements

The work on this project has been funded by the USC Upstate Office of Sponsored Awards and Research Support.

8. References


9. Appendix One

Listing of Survey Questions:

1. What year did you enter college for the first time?
2. When you first entered college, did you feel adequately prepared?
3. If you did not feel adequately prepared, what skills or information were you missing?
4. When you first entered college, did you understand what your professors expected of you academically?
5. Where did you live when you first attended college?
6. Please rate your satisfaction with your overall academic experience in college.
7. Do any of the following contribute to your success at college or the university?
   - Tutoring
   - Accessing services/supports through disability services
   - Ability to self-advocate my needs
   - Found the right program or major
   - Seek encouragement from an influential person in my life
   - Ability to make others feel comfortable, including professors
   - Learned to read a textbook effectively
   - Learned to take organized, helpful notes
   - Ask questions when I don't understand
   - Use good listening skills
   - Seek tools and resources I need
   - Self-discipline
   - Self-confidence
   - Communicate regularly with your professors
   - Communicate regularly with your rehabilitation counselor
   - Joined a social fraternity or sorority
   - Participation in a student club/group
   - Seek personal counseling
   - Health services
   - Took a first year seminar or class designed to help first year students adjust to college
8. Do you believe that your course of study for your degree is preparing you adequately for employment?
9. Approximately how much time do you spend each week studying or completing homework?
10. How do you learn best?
11. Have you disclosed information about your disability to your school?
12. Have you sought accommodations or accessed services from an office of disability during your course of study?
13. How did you learn about resources and services available at your school/institution for students with disabilities?
14. If you accessed services or requested accommodations, please rate your overall satisfaction with the services.
15. Which accommodation was most helpful?
16. What other accommodations were helpful?
17. How were your accommodations selected?
18. Why do you think you have been successful in college?
19. What additional skills, accommodations or services do you think would have improved your success in college?
20. Do you have access to adequate technology in college?
21. What obstacles (if any) have you experienced in college?

22. Do you routinely interact with the following people (by phone, email, or in person)?
   - Faculty during office hours
   - Faculty outside of office hours
   - Academic advisors
   - Counselors at the college/university
   - Disability service providers
   - Rehabilitation counselors
   - Close friends attending the same college/university
   - Close friends not attending the same college/university
   - Your family
   - Graduate students/teaching assistants
   - Previous teachers
   - Other individuals who have disabilities

23. Did you ever seriously consider dropping out of college?

24. If you ever seriously considered dropping out, what prevented you from dropping out?

25. What advice would you offer to high school students planning to attend college?

26. What is your major or primary course of study?

27. What is your age?

28. What is your gender?

29. What is your race?

30. What kind of postsecondary institution do you attend?

31. Please check all that apply:
   - Attention deficit disorder/Attention deficit hyperactivity disorder
   - Speech/language impairment
   - Health impairment
   - Behavioral impairment/disorder
   - Psychiatric disorder
   - Learning disability
   - Deaf or hard of hearing
   - Blind or visual impairment
   - Auditory processing disorder
   - Traumatic brain injury
   - Mental retardation
   - Physical disability
   - Autism
   - Multiple disabilities
   - Deaf-blindness
   - Prefer not to answer
   - Other (please specify)

33. What is the highest level of school you have completed or the highest degree you have received?

34. What degree are you currently seeking?

35. In what state or U.S. territory do you live?

36. Is English your native language?

37. What is your preferred literacy medium?
   - audio
   - print
   - large print
   - braille
Creating Images with Sound:
Phonosymbolic Representations in A Clockwork Orange

**ABSTRACT.** Anthony Burgess invented an argot for his protagonist, Alex, in his famous novel A Clockwork Orange. This paper examines this invented language in “phonosymbolic” terms as a set of sound symbols with subconscious implicatures that go beyond the surface and reinforce the tone of the novel. The method is based on the research of procedure Cynthia Whissell who systematically assigned a numerical value of relative pleasantness, activation, cheeriness, and nastiness for 28 of the sounds that construct English words. A random selection of Nadsat words are analyzed based on Whissell’s four predetermined phonemic criteria. Our results demonstrate weak tendencies toward phonosymbolism indicating negative values for pleasantness, activation, and cheerfulness and a positive value for nastiness. Applications of the research extend beyond A Clockwork Orange to other pieces of literature, the process of creative writing, brand name creation in marketing, and exploration into the core of human communication across cultures.

Frederick Wood’s interest with words began with his love affair with creative writing. The arrangement of words to convey thoughts of beauty and excitement has been his passion for as long as he can remember. Frederick (who goes by FB) credits Dr. Marlow with having focused that desire by expressing his love for the spoken word and how it has come to shape civilization. His observations on dialect and language origins opened for FB an entirely new avenue through which words could be viewed. Dr. Marlow challenged FB to find a new way to present these phenomena and to see emotions quantified in the words we speak. It was an undertaking of a magnitude likes of which FB had never seen. The result translated seamlessly into his writing. His characters have begun to come to life. Their voices have become edger when the need arises as well as softer when times are more comforting. FB has brought these principles into his blogging as well. With over 500 readers he has to maintain a constant flow of ideas that appeal to multiple audiences. Being able to adjust his word usage to reflect his tone has been a tool that he has come to rely upon heavily. If you would like to read any of these works you can find his writings at [http://inthewoodspublishings.com](http://inthewoodspublishings.com). FB would like to thank Dr. Marlow for his ceaseless efforts, countless interviews, and precious time invested in completing this project.

**Dr. David W. Marlow** is Associate Professor of English, ESOL, and Linguistics at the University of South Carolina Upstate. A PhD is in Linguistics, an MS in Information Science, and an MA in TESOL round out his degrees and he has taught ESOL in Japan, China, and the US. His primary research interests center on linguistic difference and diversity and strategies for leading students into deep connections with course concepts. Dave is founder of the South Carolina Language and Life Project (SCLLP) which seeks to enhance understanding of dialect diversity and promote linguistic
tolerance in South Carolina though education, community outreach, and academic research. On the international level, Dave is involved in ongoing teacher training and research in Palacagüina, Nicaragua. Exploring Phonosymbology is a new endeavor for Dave, driven by FB’s interest in the subject, but this too aids in understanding human communication and interaction. At the core of all his endeavors, Dave seeks to make a meaningful difference in people’s lives.

1. Introduction

“Philosophers and Anthropologists have made it increasingly clear that language, rather than reflecting reality, can create its own reality” [1]. Anthony Burgess manipulates this linguistic tool in his novel, A Clockwork Orange, where he creates a fictitious language called Nadsat for his protagonist, Alex. The origins of Nadsat can be traced back mostly to Russian, intermixed with some completely invented words, and a few repurposed English words. As early as 1971 literary critics noted the sound symbolism in Nadsat with Robert Evans saying “the Slavic words connote communist dictatorship.” Literary critic, [2], notes that Nadsat “seems to be a variation on …‘lexical onomatopoeia’ which rely on established ‘semantic properties’ but also foreground ‘phonetic properties’ to a much greater extent, in order to create a ‘heightened meaning’”. Through Nadsat, then, the “medium becomes the message in A Clockwork Orange” [2]. The meanings expressed by Alex are largely thought to be representative of him and his views of his future dystopia. [2] reinforces this point by citing another researcher, “M. Keith Baker argues that the teen language, “Nadsat”, spoken by the narrator Alex, represents various forms of entrapment and conditioning: it may reflect the subtle influence of “Russian propaganda” as well as having an alienating effect on its teen speaker, since it cannot be understood by mainstream society.” This paper explores these issues through a linguistic lens by examining sound-meaning connections known as phonosymbology.

2. Phonosymbology

Literary critics have argued whether Nadsat has had an effect in reinforcing the tone of its novel [2] or is just a confusing gimmick to promote readership [3]. Linguistic analysis suggests sounds carry meaning beyond the lexical value of a word; Nadsat words, therefore, have the potential to reinforce or detract from the author’s intended tone. Any spoken word can be broken into phonemes: the smallest independently recognized sounds of a language. Research to establish the emotional content of phonemes began as early as 1933 with [4] and his paper “Further Experiments in Sound Symbolism.” He categorized phonemes in terms of big vs. small and dark vs. light. Others such as [5] and [6] have reinforced this idea that the sounds we make when speaking are naturally expressive. Still others like [7] and Saussure [8] have contended that sounds are arbitrary symbols.

Cynthia Whissell of Laurentian University took this idea a step further concluding that phonemes in Newman’s categories were overly simplified. In her paper “Phonosymbolism and the Emotional Nature of Sounds”, [9] concluded that certain phonemes held qualities reflected along four criteria that she defined as Pleasantness,
Activation, Cheeriness, and Nastiness. After an extensive analysis of song lyrics, advertisements, fiction, and nonfiction, [9] quantified 28 of the 40+ English phonemes on a scale of -0.09 to 0.09, assigning a criteria value on one or more of the four categories. Her findings demonstrated that “there is a weak tendency for the phonemes /v/, /th/, /dh/, /iy/, /uh/, and /ay/ to be present more often in pleasant words, and similarly a weak tendency for the phonemes /b/, /d/, /r/, /s/, /t/, /w/, /ng/, and /ih/ to be present more often in unpleasant words. There is a weak tendency for the phonemes /f/, /h/, /j/, /r/, /ng/, /ch/, /uw/, and /oy/ to occur more often in active words, and a weak tendency for the phonemes /bl/, /dl/, /lr/, /sl/, /tl/, /wl/, /ngl/, and /ih/ to occur more often in passive words [9]. [The authors note that Whissell’s symbols do not follow the currently preferred International Phonetic Alphabet (IPA) and use Whissell’s symbols in honor of her original choice].

Based on the phonosymbolic values deduced by Whissell, we show that Nadsat’s words reflect negative values for pleasantness, activation, and cheerfulness, and a positive value for nasty, just as Burgess intends.

3. Results and Discussion

The methodology for this experiment can be laid out in six steps. First, we randomly selected 20 words for the study from each of three categories: Russian borrowings, English re-purposings, and new inventions. Second, each of the selected words was transcribed into their phonemic components. Third, each phoneme was assigned a phonosymbolic value based on Whissell’s scales (-0.09) – (0.09) for pleasantness, activation, cheeriness, and nastiness. Next, totals for each word were established by adding and subtracting the individual phonemic values assigned to each phoneme in each category. Finally, the average of each set of words in each category was then determined as was the over-all average for the Nadsat words selected for this study. An excerpt of Whissell’s chart is as followed: /r/ is -0.04 Pleasantness, 0.08 Activation, 0 Cheeriness, and 0.09 Nastiness.

If a phoneme was not quantified on Whissell’s chart it was represented by 0 in all categories. For example, the word skrik is phonemically transcribed [ s k r ay k ]. The values for each phoneme and for the word as a whole are provided in Table 1 below.

<table>
<thead>
<tr>
<th>Table 1. Phonosymbolic Values for “skrik”:</th>
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</thead>
<tbody>
<tr>
<td>Pleasantness</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>/s/</td>
</tr>
<tr>
<td>/k/</td>
</tr>
<tr>
<td>/r/</td>
</tr>
<tr>
<td>/ay/</td>
</tr>
<tr>
<td>/k/</td>
</tr>
<tr>
<td>skrik</td>
</tr>
</tbody>
</table>

From these findings we see that in terms of phonosymbology, skrik is highly unpleasant, inactive, neutral for cheeriness and slightly nasty.
4. Results

Burgess’s main concern when writing A Clockwork Orange was the individual’s lived experience with in the novel’s given scenario [2]. The individuals referred to in this statement are not Alex, but the reader as they experience the world right in tandem with Alex. The language of Nadsat then becomes the metaphor for the entire world presented. Once a language is created the possibility of a person under a specific mood can reinforce the mood, ongoing, by choosing from any number of words whether consciously or unconsciously. [9] was able to demonstrate that Chomsky and Saussure were incorrect in their assumptions of the arbitrary nature of phonemes. She stated that “phonemes do not have the power to induce full blown emotional responses of the lock-and-key type under any and all condition, but they do have some of this power some of the time” [9]. Therefore, Nadsat like any other language has the potential to either reinforce or detract from the established tone of a novel. The following table (Table 2) shows the final numerical results for the averages in each of the three categories, plus an overall average for the Nadsat language.

<table>
<thead>
<tr>
<th></th>
<th>Pleasantness</th>
<th>Activation</th>
<th>Cheeriness</th>
<th>Nastiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian</td>
<td>-0.05</td>
<td>-0.06</td>
<td>-0.07</td>
<td>0</td>
</tr>
<tr>
<td>English</td>
<td>-0.09</td>
<td>-0.03</td>
<td>-0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>Invented</td>
<td>-0.03</td>
<td>-0.05</td>
<td>-0.03</td>
<td>-0.01</td>
</tr>
<tr>
<td>Average</td>
<td>-0.056</td>
<td>-0.043</td>
<td>-0.056</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Pleasantness averaged -0.056 on a scale of 0.09 to -0.09. This is only 0.032 from the lowest potential value on Whissell’s chart. This overtly unpleasant feel is felt again and again in the novel. The youth entertain themselves by stealing cars, breaking and entering, and fighting in the park. The elderly are accosted on the street. This rather large tendency toward phonosymbolic unpleasantness reinforces Burgess’ apparent intention. Cheeriness also averaged -0.056. Alex kills two people, maims both enemies and friends, and is conditioned - through the rehabilitation - to have a violent reaction whenever anything unpleasant arises. Burgess shows no cheer in anyone but Alex, and even this main character loses his cheery nature both during his rehabilitation and when reintroduced into society. With regard to activation, there are moments of activity in the novel, but the average phonemic value of Activation was -0.043. This falls right in line with the amount of down time Alex spent in the milk bar, prison, and watching movies for his rehabilitation. Nastiness was the only positive phonemic value. Alex reveled in his misdeeds as did other characters. Dim, for example, began to sneer when he became a policeman. The phonosymbolic value for Nastiness average 0.02. This is not a large positive value and is just the other side of non-committal. However, any positive number in the category of nasty does reinforce the negative tone of Nadsat. Taken together the average values for phonosymbolism in Nadsat reinforce the dark dystopic tone of the novel. Had Burgess known about the phonemic weight words could hold he may have made his world still darker by using fewer “non-nasty” sounds like /k/ and more “nasty” sounds like /r/.
5. Discussion

While our focus here has been on phonosymbolic representation in one specific novel, the implications of this study reach much further. One noteworthy implication of the findings is that while there is no indication that Burgess intentionally manipulated phonosymbolic principles—in fact, it seems quite unlikely he had been exposed to the linguistic literature in this relatively obscure domain of linguistics—the figures resulting from the above analysis demonstrate that the phonology of his word choice reinforces his clearly intended dark and unpleasant tone nonetheless. While phonosymbology may not be an overt consideration for authors, the concept of listening to the words of a text to see if they “sound right” appears regularly in the reflections of creative writers (e.g. [10]). Further, there is evidence that some authors, for example Tolkien, have overtly considered sound-symbol connections in their creative endeavors [11]. One further application of the methodology applied in this paper would be to analyze other invented languages and their effect upon the reader. The sounds of Tolkien’s Dwarfish, and Elvish languages could be explored, for example, as could Star Trek’s Klingon, to determine if the phonosymbology of these languages reflect the literary tone the authors are trying to produce. Further, a study could be completed on the effectiveness of teaching phonosymbolic principles to Creative Writing students.

Expanding beyond Literature, the concept of phonosymbology, has also been applied cross-linguistically with the somewhat controversial suggestion that the connection between certain sounds and the associations people make have at least some similarities in such disparate languages as English, German, Japanese, and Korean [12], English, Gaelic, Greek, and Yoruba [13]. And at a very practical level, phonosymbolism has been rechristened to the less linguistically intimidating: “sound symbolism,” and has become increasingly important to Marketing professionals in the choosing of brand names [14] and has even been extended to the question of the sound connection between product names and the given names of spokespersons for those products [15] as well as to the relative masculinity or femininity of a given product and the resultant effect on marketing [16].

6. Conclusion

Phonosymbology presents a valuable tool for anyone wishing to explore a linguistic facet of subliminal messaging. As the sound-symbol connections are tendencies and not absolutes, the effects are real, but not binding, creating an ethical approach to affecting people’s perception in either Creative Writing or Marketing. Further, the cross-linguistic application should appeal not only to writers and business people, but also to students of human communication—which connects to the root of humanity itself.
7. References