

Utah State University

From the Selected Works of Sarah E. Null

2016

Affordable Method of Thermal Infrared Remote Sensing of Wadeable Rivers using a Weather Balloon

Sarah Null

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A Letter from the Editor on Chief

JUR Press is proud to present Volume VII of the Journal of Undergraduate Research and Scholarly Excellence with published works across a wide range of disciplines by undergraduates from around the world.

We are a journal for undergraduates and by undergraduates. Our slogan – linking the global undergraduate community – captures our mission to serve the interests of worldwide undergraduate thinkers, tinkers, experimenters, writers, and artists. While JUR does provide a platform for students to publish and showcase their work, we also give students the opportunity to learn about the publication process from start to finish through internships as editors, operations associates, and referees. Our undergraduate network has grown to include not only international authors, but also affiliate and satellite editors from around the world! We are truly committed to enhancing the undergraduate experience, and we continually seek to engage as many undergraduate students in our organization as possible.

This year has been a blessing as I have settled into the role of editor in chief with support from those around me. I am honored to have such a strong foundation built from all staff members and the entire JUR network. As seniors graduate and pursue their future and new members join to engage in the publication process, I am reminded of the hard work, determination, and dedication every present and past JUR member has done to better the organization and themselves. I have seen each member this year grow and truly embrace the meaning of “interdisciplinary” as they manage academics, internships, sports, volunteer positions, and take time out of their day to make someone else's. I am incredibly thankful for the laughs and smiles that each unique personality brought throughout the year to complete this edition.

For all that we have accomplished this year, I want to say congratulations to each member and how incredibly thankful I am for their efforts. You are exceptional individuals with a wide range of talents. I look forward to what the future has to offer for those graduating, and what the year holds for new and returning members.

To our published authors, I congratulate each of you on your accomplishment and we are thankful to have been part of your undergraduate academic experience.

Yours truly and truly yours,



Anna Chopp
Editor in Chief
Journal of Undergraduate Research and Scholarly Excellence
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This publication would not have been possible without Colorado State University and the contributions of numerous advocates and benefactors.

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Congratulations to our graduating seniors: Andréa Anthony, Laney Collins, Ben Fisk, Juliette Granger, Michaela Koretko, Jamie Manz, Carl Meyer, Abbey Pizel, Jordan Vileger, Katie Watts, and Lindsey Whittington

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Empathy Factory: How Louisiana Can Treat Mental Illness

BY ALEXANDRA LENCZYCKI AND LEEANN DERDEYN, PH.D.
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Throughout human history, illnesses and the way they alter individuals have been treated in two parts, with the healing of both the body and the mind. While these treatments may be more tailored for physically presenting illnesses, the remedy of mental ailments with few concrete symptoms and even fewer concrete treatments can pose a more complex quandary for physicians and the public as recipients of medical advice. This begs the question: If using the same duality and two-step prescription to heal the ailing body part and the mind, is it possible to treat the mind twice?

In Rebecca Solnit's "The Separating Sickness" the history of leprosy and its effects on patients is examined, with an emphasis on the disease as having two separate impacts—the physical symptoms, and the social ramifications that linger even after the antibiotic course is completed.¹ Solnit analyzes the treatment process of leprosy patients carried out by doctors of the National Hansen's Disease Programs in Louisiana, and develops a treatment model consisting of a physical cure based in biology and medicine and an overwhelming dose of emotional support. When comparing this practice to other physically altering diseases in modern medicine, any illness with the potential to be life-altering is almost always treated with medicine as well as clinical compassion that follows a similar model. Despite the growing volume and momentum of conversations on mental illness in the modern world, this two-part treatment of biological and social understanding is prescribed tentatively at best—if at all to those suffering from it due to setbacks on both fronts. This lack of social healing is rooted in the pervasive stigma on mental illness that persists in societies today, which both inhibits the seeking of initial help and reforming social relationships even after treatment is sought. Furthermore, the biological treatment of mental illness is restricted through not only the restriction of research on these illnesses and ways to cure them, but also by the lack of access to treatment that some may experience due to social or economic disparity. These factors culminate in a treatment system for mental illness that lacks in biological remedy, as well as social compassion. It is a system

that would become far more effective if it became more contingent with the powerful treatment of drugs and empathy that is described in Solnit's leprosy clinic.

Despite the simplicity of treating physical illnesses with physical cures, often times there is more to treat than solely the body. Solnit surmises this best in her discussion of leprosy when she states that it is "really two diseases: the physical effects and the social response to them."¹ Her entire essay details both the physical debilitation of the disease and the steps taken to treat patients, and the emotional support given to them by their caretakers as a more holistic course of treatment even after the patients had been medically cured of their leprosy. Often times, there were lingering symptoms that necessitated treatment of a different kind, often laden with emotional support and education. Solnit underlines this claim with the declaration that "[t]oday, most leprosy research focuses not on the bacterium but on patient care."¹ While the treatment of leprosy consists of an "effective multiple-drug solution" followed by routine patient care, in other instances of chronic illness or lingering side-effects of acute illness, the physical effects of the illness are treated alongside the psychological ones.¹ Trisha Greenhalgh describes this method of treatment in her article "Chronic Illness: Beyond the Expert Patient," which functions as a sociological record for patients' adaptation to chronic illness during their course of physical treatment. In her examination of a patient with diabetes, she reported that "both patient and clinician had to work hard to achieve the goal of getting on with life . . . health care should be seen not as a series of decisions made by the patient or clinician at particular times (as in shared decision making) but as never ending, full of surprises, and having continuously to adapt."² Despite this seemingly effective model of patient and clinical expertise, Greenhalgh warns that in order for this model to work, there must also be effective change within society that accommodates these changes on a larger scale. Moreover, there needs to be challenges to the current model of patient care, where the focus is placed solely upon medical improvement. While helpful to the patient, Greenhalgh

asserts that "it is time to move beyond [these methods] and embrace richer, more holistic models which consider a person's family, social, and political context. . . . We need more whole systems programmes [sic] of change, especially where social determinants of health inequalities loom large."² While in recent years there has been an increase in advocacy regarding the social empowerment of those struggling with disability or chronic illness, there has been less discussion of this model in relation to mental health. The care and treatment of those suffering from mental illness has improved dramatically in the last fifty years with the increased exposure it has gained from activism of all sorts, and many effective treatments for mental illness today consist of proper medication and consistent psychological services that parallel the management systems discussed by Solnit and Greenhalgh. However, as Greenhalgh and Solnit also implied, there is a necessity for change that would allow complete acceptance of individuals that are currently marginalized by the broader common public. This is especially true of those affected by mental health problems, as the rampant stigma against these individuals is still prominent in many societies today, despite more intensive efforts to mitigate these harmful social issues.

The stigma associated with mental illness poses a troubling paradox—in spite of its more widespread acknowledgment and validation on the global health stage, it still persists as an elusive and underreported issue due to the threat of alienation from the common public culture. Peggy Thotis addresses these subjects in her article, "Resisting the Stigma of Mental Illness," citing the idea that "[t]he mentally ill" are believed to be unpredictable, irrational, dangerous, bizarre, incompetent, and unkempt," and when these stereotypes were tested "[i]n laboratory studies, desire for social distance is evident in awkward interactions and negative ratings of persons believed to have had mental health problems."³ The negative association of those with atypical neurological behaviors has been a pervasive cultural theme that only seems to solidify as societies continue to marginalize those requiring mental care. As societies continue to pressure individuals toward growth and

advancement, those deemed outside the “normal” curve are believed to be a hindrance, and are ejected from classes of productivity for being unable to keep up in the midst of their own mental and emotional quagmires. Solnit considers this in her own thoughts on suffering, where she muses that “[u]p close, aggressive measures are required to be impervious to suffering; you have to convince yourself that . . . their suffering has nothing to do with you.”³¹ This offers some insight into the stigmatization of others perceived to be outside the normal functioning whole, expressing an idea possibly shared by larger societies that one’s struggles are uniquely their own, and should not be brought to the social or vocational table. Angela Thachuk validates these claims with her own research, offering that “[mental illness] undermines [patients’] consideration as eligible candidates for employment, threatens job security, and limits possibilities for professional advancement,” with her own references to Otto Wahl’s book, *Telling is Risky Business*.⁴ These facts of disparity are rooted in the earlier research of Thotis, creating a debilitating set of stereotypes that prevent many from speaking up about their illness and advocating for the help they require due to the fear of being labeled “mentally ill.”

However, even after asking for help despite these social pressures, patients may also be discriminated against in the medical sphere. Thachuk surmises this by stating: “the legitimate concerns of those patients already labeled mentally ill are often viewed through the lens of their diagnosis. When histories of psychiatric treatment are disclosed, individual complaints are often not taken seriously, and care is compromised.”⁴ This sort of treatment from any medical professional can have debilitating impacts on patients who may already be compromised due to mental problems. When a history of mental illness is uncovered, Thachuk argues, a patient ceases being a patient and instead becomes a statistic or laundry list of intimidating symptoms, stripping the individual of their identity and instead offering alienation instead of treatment. Solnit describes something similar with her studies in the leprosy clinic in Baton Rouge, where she notes that when one of the patients enduring a rare, modern case of the disease sought treatment in a general hospital, “the medical staff at the hospital regarded [him] with puzzlement and dread, asking his parents to put on gloves, masks, and gowns when visiting him.”³¹ His experiences in the hospital had followed his visit to another doctor about skin rashes, to which the doctor prescribed topical treatments that were of no use. Only after he was in a situation of extreme stress involving

loss of consciousness was he ushered to the hospital, and even still was regarded warily by medical professionals. In both cases, patients experienced alienation from the public and hesitancy from physicians, making it incredibly difficult to guarantee proper treatment or even acknowledgment from the wider, more “normal” societal whole. In addition to these social hardships, in both situations the lingering effects of a diagnosis of mental illness or leprosy left a larger impact on their lives, and continues to leave the same type of impacts on patients with mental illness today.

Studies have displayed a correlation between the prominence of mental illness and socioeconomic disparity. In a study conducted by Ann Bartel and Paul Taubman, individuals diagnosed with mental illness were separated and categorized by severity according to the type of illness, and comparisons were made with earnings made by the individual over a period of years. Following their findings, they conclude “no elaborate economic theory is needed to believe that mental illness affects success at work. Thus it is not surprising that Bartel and Taubman found that those suffering from any mental illness had lower earnings and worked fewer hours.”³⁵ In spite of this rather broad conclusion, Bartel and Taubman did discover that there was “a reduction of 15% in earnings on diseases first diagnosed 15 or more years earlier.”³⁵ This is further emphasized by Thachuk’s argument addressed earlier, where those labeled as mentally ill find themselves at a significant disadvantage while job-hunting beneath stigmatizing employers. As a result of these factors, the reduction in wages serves as a detriment to an individual’s standard of living overall, limiting the ability to access healthcare, housing, and higher-paying jobs.⁴

Access to mental health treatment also experiences disparity based upon race, as outlined in an article published by Julian Chun-Chung Chow, Kim Jaffee, and Lonnie Snowden titled, “Racial/Ethnic Disparities in the Use of Mental Health Services in Poverty Areas.” In their report, Chow, Jaffee, and Snowden state that “poor areas with a high proportion of minority residents generally lack the resources needed to maintain community services at a minimum level. This dearth of services decreases access to mental health treatment and exacerbates mental health problems for minority and other residents in those communities.”³⁶ The lack of economic promise based on race and status may create a barrier to healthcare for some, as those with lower economic status are less likely to have the access to the insurance or finances needed for mental health treatment. This lack of access contrasts directly with

the level of access granted to those in need of treatment for leprosy, with the National Hansen’s Disease Clinical Center (NHDCC) offering free physician consultations for doctors treating patients across the country, pathological reviews of biopsies, and treatment antibiotics available at no cost to patients.⁷ While these services are available exclusively to physicians treating patients, the abundance of resources made available for individuals at little to no cost across the country—despite the NHDCC’s sole location in Baton Rouge—allows patients to benefit directly from these services. In contrast, the difficulty of accessing mental health care is far greater with the consideration of social alienation as well as racial and economic status as well. These added stigmas and restrictions of care place a vast amount of pressure upon individuals already struggling with mental illness. With these factors combined, they may also act as a buffer against re-assimilating with the rest of “normalized” society. For some that remain trapped in a system of privilege and animosity toward those beyond the center of the productive neurotypical bell-curve, the pressures wrought by the toxic blend of socioeconomic disparity and personal health needs can create a debilitating issue that requires more than medicine to fix.

In addition to the difficulty of access to healthcare for some, throughout history it has also not been uncommon for research and treatment options in mental healthcare to lose funding as budgets constrain healthcare providers and drug companies. In her article, “No New Meds,” Laura Sanders discusses the current idea plaguing the playing field for many mental health care professionals. She posits that many doctors and researchers are bemoaning the fact that “drug development for complex psychiatric illnesses is misguided . . . faulty assumptions, animal models that don’t look anything like human diseases, hazy diagnoses and a lack of knowledge about how the brain works have all thwarted the search for better drugs.”³⁸ The press for funding cuts against a wider, marginalized public in desperate need of treatment mirrors other situations of historical significance, as seen in the need for leprosy treatments discussed in Solnit’s article. Her discussion of the history of the Carville treatment center is precluded by the notion that they could only offer palliative care to patients in the early years, instead of offering viable treatment options, due to the restricted availability of drugs that actually worked. This mirrors the discussion proposed in Sanders’ article, with her assertion that the drugs that are currently on the market do little to actually treat the mental illnesses of trial patients; rather they offer some semblance of treatment for the

symptoms at the cost of results and an assured future for the psychiatric drug market. Some drugs are even purported to cause the chemical imbalances they are attempting to fix, as discussed in Robert Whitaker's "Bitter Pills." Whitaker discusses the rise of the "chemical imbalance" theory of mental illness in the 1960s, when scientists were first testing antipsychotic medications and they appeared to be working in mentally ill patients. As a result, "this led them to hypothesise [sic] that schizophrenia was caused by too much dopamine activity," and they continued to prescribe medications that blocked dopamine receptors as a viable source of treatment.⁹ After a while, however, scientists began to theorize that these medications were actually the ones causing the imbalances due to the brain's adaptation to the chemical levels. Whitaker supports this theory by explaining that "the brain is trying to nullify the effects of the drug . . . [and] is functioning in a manner that is 'qualitatively, as well as quantitatively, different from the normal state.'" The release and continued prescription of these drugs for over fifty years now, despite the side effects and research on them, is alarming. However, with Sanders' analysis of the drying psychiatric pharmaceutical pipeline, there may be few other viable options to treat patients which only adds to the necessity of different, more comprehensive treatment models for those needing mental health care.

The reasons behind the difficulties to find viable treatment options for these diseases may be rooted in problems with pathology research itself. Solnit cites that research and development for more effective treatment of leprosy is slowed by the difficulty to pin down the cause of the disease itself, a trait that is also shared in the realm of research on psychological ailments. She writes that "the bacterium is delicate and slow. . . . Unlike almost all other bacteria, *M. leprae* cannot be grown in the laboratory, putting ordinary research methods out of reach. . . . Today, most leprosy research focuses not on the bacterium but on patient care."¹ This idea, while not necessarily the exact same as the manifestation of mental illness in patients, proves true with both parties. Testing for mental illnesses and how they respond to tests and treatment is an immensely delicate process, one that must be tailored to an individual and results in a rather large amount of resources for effective research and development. In addition, research and treatment courses for specific illnesses may not always be applicable to every case of illness, with variance being a large factor from patient to patient. It is through these reasons that both leprosy and mental illness treatments are slow to be realized, and there

exists a threatening possibility that effective treatments for these ailments may not be realized in the short-term, if at all. Solnit's case illustrates why it is vital in spite of these barriers to do the best that clinicians are able to mitigate the symptoms of their patients and treat them with compassion. With this model in mind, in spite of its slow research and limited treatment viability, the validation and empathy that is offered to patients suffering from mental illness can behave as a vital step on the road to improvement.

The prevalence of mental illness on a global stage is growing at a rapid pace, while the global record of leprosy cases continues to dwindle. In spite of these differences, the establishment of parallels and differences in care access, treatment, and the potentials of both sets of patients are paramount in assessing how to better treat patients in both categories. Overall, however, one of the most vital pieces of treatment that cannot be overlooked is the way each patient in both categories must be treated with respect, validation and compassion. The existence of empathy on the prescription or treatment schedule for any patient is vital, regardless of physical or mental illness. This continued remedy has been bustling around Carville and Baton Rouge for years, as Solnit notes, and the practices of the so-named "empathy factory" ought to be exported to all other patients as a side treatment for whatever they struggle with.

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A Literature Review of Pain Research: Theories, Mysteries, and Future Directions

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Abstract

Pain is widely considered to be a universal human experience. No matter where you are in the world or what language you speak, cutting your hand on a sharp object should hurt. But what exactly does it mean to “hurt”? Where does pain come from?

The current understanding of pain comes from a combination of research findings from many areas. Instead of looking at pain as purely biological, psychological, or philosophical, a combination of these different vantage points forms a more comprehensive idea. It is important to note that the following is a review of secular, Western scientific theories of pain. The cultural theories of what pain is, where it comes from, and how to treat it are vast in number and rich in content. These theories are also a combination of biological, psychological, and philosophical ideas; however, they deserve the dedication of an entirely separate essay.

This paper is a literature review of pain research through a secular, Western lens, and will discuss and analyze theories of pain and different treatment approaches. Certain phenomena, such as phantom limb pain, which complicate our understanding of pain and sensation are explored. Also explored is the important role of language in the conceptualization of pain, especially in healthcare environments. Inequalities have been found in healthcare quality and health outcomes along axes of race and class, due in part to inaccessibility and implicit biases of healthcare professionals. This paper argues for a biopsychosocial model of pain for scientists and healthcare professionals, given these understandings of language, culture, and the psychological aspect of pain experience.

Theories of Pain

Biological basis of pain

It is important to make a distinction between *nociception* and *pain*. Nociception is the objective, biological processes of nerves sending warning signals to the brain of potential damage somewhere in the body. Pain is the subjective experience that results from “the transduction, transmission, and modulation of sensory information”.¹ In everyday usage, “pain” is often conflated with nociceptive processes.

Bell and Magendie made significant contributions to our understanding of pain today;² specifically, their findings explored nociceptive mechanisms. Although their theories were not supported by later experiments, their conceptualization of the body’s sensory nerves served as the basis for the current understanding of the function of motion, the spinal cord, and pain. Magendie and Bell both provided rudimentary evidence of a separation between dorsal and ventral nerve systems in the spinal cord.² Expanding on this discovery, Bell hypothesized that sensory nerves, motor nerves, and vital nerves are distinct from each other, but seem to all come together at certain points in the body. Because the technology that exists today was not available, scientists were not able to fully test various physiological mechanisms. Despite this, Bell was able to reach an incredibly accurate conclusion; he believed that somehow color, taste, motion,

and other external stimuli were able to be sensed by the body and transmitted through these nerve networks.² We now have detailed insight into the physiological mechanisms of the nervous system that expands upon Bell and Magendie’s earliest conclusions.

Psychosocial basis of pain

In addition to these physiological aspects of pain, there is a psychosocial component that is equally as important. Early ideas in psychology treated the mind and body as distinct entities working independently of each other. Although later research has not supported this conceptualization, there is still conflict within literature as to the exact relationship between the mind, brain, and body. Engel called for a more holistic approach to pain, especially for sufferers of chronic pain. He stated that psychosocial factors such as emotional stress could affect reporting of symptoms and response to treatment; this newer biopsychosocial model focuses on *disease* and *illness*, with illness defined as “the complex interaction of biological, psychological, and social factors”.¹ Disease is the objective, biological event that causes a disruption within the body, whereas illness is the subjective experience stemming from the presence of disease.

Pain can be separated into two categories: *physiological pain* and *pathological pain*. Researcher C.J. Woolf argued that the colloquial use of the word pain obscures the complex

mechanisms behind it; using one word to describe a range of sensations incorrectly implies one mechanism driving it.³ Woolf defined physiological pain as the range of intermittent sensations experienced due to various stimuli that almost achieve threshold intensity to cause damage or injury; however, there is no significant inflammatory response or damage to the nervous system. Pathological pain describes the sensations experienced from actual significant inflammatory response due to tissue injury or damage to the nervous system.³ In other words, physiological pain is relatively harmless, while pathological pain is an indicator of significant trauma. The kind of pain one is experiencing would greatly affect how it is treated. For instance, someone could have low grade chronic joint pain, which can be classified as physiological pain, and be given an exercise regimen as treatment. Someone with more severe chronic joint pain such as that arising from advanced rheumatoid arthritis can be classified as pathological pain and therefore treated with more rigorous methods such as medication.

This biopsychosocial model highlights the importance of viewing the individual as a whole. Science, especially medical science, has a tendency to be overly objective; when studying human beings, complete objectivity is impossible. If one solely looked at objective, biological data, they would not have a full understanding of the mechanisms arising

ing from those biological events. Even the ways in which biological events affect the subjective, human experience varies from person to person. For example, getting a tattoo could feel disastrously painful for one person, but could hardly be felt by another, even though the underlying nociception is the same. Different factors mediate this response: in addition to biological factors, a person's emotional sensitivity to trauma, the cultural significance of getting a tattoo, and their mental preparedness for the possible pain associated with getting a tattoo are important.

Successful Treatments

Cognitive behavioral treatment approaches

Cognitive behavioral therapy for pain is based upon the psychosocial aspect of pain and has three main components: educating patients on the psychosocial aspects of pain and increasing their sense of self-efficacy (confidence in one's autonomy, especially behavior), the teaching of coping skills including cognitive restructuring, and giving patients the opportunity to apply and maintain skills learned in treatment.⁶ Cognitive therapy can come in many forms, and is a common treatment for a range of physical and psychological ailments. Self-efficacy has been found to be an effective treatment for pain tolerance.^{4,5} In various cognitive studies, when participants' perceived control over the situation (receiving pain) was manipulated, there was a positive correlation between perceived control and pain tolerance.^{4,5,6} In other words, participants reported reduced levels of pain experience when they believed they had more control over the situation.

Multidisciplinary treatments

A combined treatment approach has been found to be most efficacious for people experiencing chronic pain. Combining psychological treatments with pharmacotherapy would have a greater benefit for patients dealing with chronic pain than acute pain. Studies have shown that multidisciplinary treatment centers yield more successful outcomes for patients than receiving no treatment, pharmacotherapy alone, and other single-treatment options.⁷ Effects were seen in improvements of mood, pain experience, and readiness to return to work. It is possible that a lower dose of medication could be used if a patient is also receiving cognitive therapy. Because sustained use of drugs can have detrimental effects to physical health (especially the kidneys for certain medications) multidisciplinary treatment approaches offer the benefit of delaying these negative effects.

People dealing with chronic pain tend to avoid certain situations that make pain

worse; for instance, those with arthritis are likely to avoid physical activity, although sustained exercise actually helps with arthritic pain. *In vivo* treatments have cognitive and behavioral components; this is a form of multidisciplinary treatment that has been shown to be more effective than any single-modality treatment.⁸ In various treatment conditions, patients were either placed on a waitlist and received no treatment, received education about pain as their treatment, did exercise, or received a combination of education and exercise therapy. Results showed that the combination was most effective, and the other three conditions were comparatively not significantly effective.

Language and pain

Pain is a difficult sensation to accurately verbalize; it is not uncommon for people to use phrases such as "the pain I'm feeling is like when you smash your finger in a door" or "it feels like pins and needles." These phrases are attempts to relay one's pain experience to another via a shared experience. These examples themselves can be culturally or geographically relative depending on the type of pain experienced. For instance, someone living in a rural area might use the example of "my finger feels like it was bitten by a snake"; someone living in a city is less likely to use that example as snakes are less common in urban areas, thus making it unlikely that someone living in a city has been bitten by one. How someone verbally communicates their pain experience affects how the listener understands it, which affects their attitude toward treatment (if they are a healthcare provider).⁹

Because of the difficulty in accurately communicating pain, healthcare providers often use a numeric rating scale to assess patient pain levels. Patients are asked to rate the intensity of their pain on a scale of 0-10⁹ with a rating of 0 indicating no pain and a rating of 10 indicating excruciating pain. Studies suggest modest accuracy for these studies, highlighting a potential gap in understanding between healthcare providers and patients.¹⁰ This miscommunication can potentially be exacerbated by other obstacles to communication, such as language barriers and cultural differences.

One's expectation of how painful an experience will be affects their actual experience of it, as explained in the tattoo example above.^{11,12,13} Treating pain as a purely objective, physiological phenomenon (which is actually just the nociception component) downplays a patient's experience of pain. Pain can still exist, even without evidence from test results indicating a problem, and should be treated. When dispensing treatment, providers can help patients by be-

ing conscious of their language (verbal and body) that they are using in order to validate their patients' experiences and make patients more confident in the treatment options.

The Mystery of Phantom Limb Pain

Phantom limb pain results after the loss of a limb of the body, with patients reporting experiencing pain in the limb that is no longer there.¹⁴ How can sensory information from the hallux ("big toe") of an amputated leg be transmitting sensory information to one's brain? The phenomenon of phantom limb pain complicates our understanding of pain. Although the biopsychosocial model is widely accepted, phantom limb pain may offer insight into which part—biological or psychosocial—is more of a factor in the experience of pain in certain situations. In this case, the psychological aspect of pain seems to be more of a mediator than the biological, although some evidence points to a possible physical source of pain at severed nerve endings; therefore, a psychologically-based treatment (e.g. mirror treatment) would be beneficial. Although phantom limb pain often radially decreases, such that pain becomes limited to the site of amputation, it is still an affliction that deserves treatment.¹⁵

Mirror treatment involves putting a mirror in between the patient's remaining limb and the missing one. For example, someone with an amputated arm would have a mirror against the shoulder of that arm, so that they can only see their remaining arm and its reflection. By performing various behavioral tasks (such as waving the arm or grasping an object), patients are able to "gain control" of their missing limb (self-efficacy), decreasing pain experienced.¹⁶ Although an effective treatment has been identified, the phenomenon may be an indicator that the popular understanding of pain is too rigid and does not accommodate physical pain arising from mental anguish.

Conclusion and Future Directions of Research

There are many areas that warrant further study, but a few are presented here. There have been several studies whose results have indicated ethnic disparities in the experience of pain.^{17,18,19} Despite this, there has been a lack of research into possible explanations; there are mainly notes at the ends of research articles which state that future studies should look into this issue further.

There also exists ethnic disparities in quality of medical care for pain (and overall medical care), controlled for many possible confounding variables.^{17,20,4,21} Compensatory solutions to remedy this issue warrant further research. Unequal medical treatment for pain on the basis of race and class negatively

impacts not only physical health, but mental health as well.

Studies have shown that black patients receive inadequate treatment when compared to white counterparts, white people show an absence of empathy toward black people, and that there is a widely held stereotypical view that black people do not experience (or experience very little) physical or mental pain.^{22,23} Surprisingly, even when healthcare professionals were sampled, researchers obtained similar findings. It has also been shown that racism (interpersonal and systemic) has extremely detrimental effects on mental health—in some studies of African Americans, racial discrimination (in multiple forms) was cited as the number one psychological stressor in their daily lives for almost every participant.^{24,25,26,27} As healthcare providers and researchers are in positions of power relative to the general population, their biases have a direct negative impact on patients' experiences in the healthcare system.

Possible solution

What might a successful solution look like? The most important element is feasibility—of course, eliminating systemic racism would be the most effective solution, but it is not practical. One major challenge is that solutions cannot effectively eliminate bias. Biases and stereotypes form at an early age, and it has been found that implicit biases are nearly impossible to change.²⁸ With this in mind, individual healthcare providers may not hold explicit discriminatory thoughts, but the implicit biases they hold can affect their assessment of patients.

One solution would be a system that allows for a double blind evaluation of the patient. Upon arrival for appointments, patients could fill out a short computer survey, rating their pain across numerous measures. A different healthcare provider that does not know the ethnicity of the patient could then evaluate this survey, possibly as part of an oversight committee. The assessment of the patient by their assigned provider and the oversight provider could then be compared, with discrepancies being noted and analyzed. It is important for the survey to be evaluated by someone other than the patient's physician so that the physician does not recognize the patient's verbal answers from their written ones.

Limitations

Adding an extra evaluative step would take up time that many healthcare organizations do not have, making this implementation unfeasible. However, many healthcare organizations already have some sort of assessment of competency for physicians, so

this would not be much of a burden to many. Of these existing systems, doctors are evaluated on an individual and team-based level; often patients are assigned a healthcare team that works together.²⁹ It is widely agreed upon that physicians' performance should be periodically assessed throughout their careers. However, a major conflict concerning evaluations is about the specific measures; how will providers be assessed, and who will do the assessment?²⁹ If a computer does the oversight, it would be harder for the software to pick up on nuances of qualitative assessments. In addition, the cost of these extra steps in the process is surely a huge barrier in implementation. How would it be decided which patients to screen? If history of severe pain issues is the requirement, then a large segment of the population would be left out. Because these biases are seen in the evaluation of physical and emotional pain, a more thorough assessment with a wider range of types of healthcare organizations participating would be necessary.

There are different ways to address provider-side biases, and differential modifications would be necessary in order to account for multiple variables; the type of healthcare organization and patient population demographics relative to the demographics of the physicians are just some examples of factors that could affect the structure of this intervention. Although generating and implementing solutions is difficult, it is still important to view pain within context of world—the biopsychosocial model would be incomplete without recognizing the impact of societal racism on health, which includes experience of pain. In order for the biopsychosocial model to be adequate in conceptualizing pain, it must take into account the various social structures that harm marginalized people; focusing on just the biological and psychological aspects ignores how a social environment affects health. Although it has been found nearly impossible to completely eliminate implicit biases, putting measures in place and enforcing them is a step in the right direction.

Pain is surprisingly very multifaceted. It is far more complex than the average person would believe – a commonly held view is that there is a direct relationship between the infliction of pain and the experience of pain. It was previously thought that pain shouldn't be affected by any factors that were not biological. As pain research progresses, a more comprehensive, biopsychosocial approach is changing the way pain is understood and treated.

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Transcendentalist Literature and the Question of Slavery: An Examination of Transcendentalist Critiques Before and After the Fugitive Slave Act of 1850

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1850 stands to this day as a seminal year in the history of American society and democracy. Henry Clay and Stephen Douglas, working under the auspices of a fracturing Union, drafted and passed into law the Compromise of 1850. This piece of legislation, a centerpiece in studies of American history, was one that attempted to unite the nation while simultaneously creating a divide that led to the Civil War. Beginning with the Missouri Compromise of 1820, which divided the nation into “free” and “slave” states, America debated the abolition of slavery. However, with the newest compromise of 1850, a new law was created – the Fugitive Slave Act of 1851. Under this legislation, citizens and officials in even the most ardently abolitionist states were required to transfer escaped slaves over to the proper authorities. The ideals of freedom and liberty began to crumble. It was at this point that Americans began to devolve into factions, divided along the lines of freedom and slavery. As is often the case in moments of extreme social strife and radical change, it was the role of the writer to emerge in cross-examination of the very nature of American law. The nation’s foundations of philosophy were largely confined to the realms of religion. However, branching off of their Unitarian beliefs, the Transcendentalists emerged as the first of our American philosophers. Early texts such as Ralph Waldo Emerson’s “Self-Reliance” and Henry David Thoreau’s magnum opus, *Walden*, spoke to themes of removal and self-enlightenment. The Transcendentalist goal was not to explicitly spur mass social change, but instead to advocate the independence and supremacy of the individual mind; they sought the mystical “One” and the greater truth, actively attempting to remove themselves from overt political debate. Even in Thoreau’s “Civil Disobedience” a text that explicitly tackled the dichotomy between a government and a subject, there is a certain reluctance displayed towards all democratic participation. Thoreau, discussing the act of voting, stated that, “even voting for the right is doing nothing for it. It is only expressing to men feebly your desire that it should prevail”.¹ This oft-cited text,

while certainly inflammatory at the time and inspirational in future Civil Rights struggles, was initially designed as a treatise in favor of personal liberty. However, Thoreau and his fellow Transcendentalists, by 1851, began their slow awakening from dormancy into a position of social activism. Liberty and justice, key aspects of their philosophy, were endangered. For thinkers such as Thoreau, Emerson, and Margaret Fuller, a necessity arose to speak and distance themselves from pragmatic stances of removal from society. In this awakening, they transitioned from thinkers to activists with distinct beliefs regarding not just democracy, but the role of the individual in such a state. Describing John Brown, convicted of treason for his raid on Harper’s Ferry, Thoreau stated that he was “a transcendentalist above all, a man of ideas and principles”.¹ The Transcendentalists were once a force of philosophy and education. After 1850, the tides turned and the Transcendentalists assumed their most valuable role: a voice of reason and tolerance.

To fully understand the change in the role of the Transcendentalists in socio-political discourse, it is necessary to progress through a historical timeline of their essays and addresses. In doing so, not only is the progression elucidated, but the writers themselves emerge less as philosophers and more as citizens. At the center of this progression and debate are the giants of this literary movement: Ralph Waldo Emerson, Henry David Thoreau, and Margaret Fuller. At the center of the argument are a series of addresses and essays, ranging from Emerson’s “Self-Reliance” in 1841 and “Emancipation in the West Indies” in 1844, to Thoreau’s 1854 essay “Slavery in Massachusetts”. While the seeds of changing discourse can be seen most clearly in Margaret Fuller’s review of *The Narrative of Frederick Douglass* in 1845, it is important to track this progression from its roots to a blossoming voice of political activism. As such, any examination must begin with a focus on Emerson’s “Self-Reliance” and its relationship with Fuller’s writings on Frederick Douglass.

In 1845, five years before the Compro-

mise of 1850, Margaret Fuller’s review of *The Narrative of Frederick Douglass* emerged as one of the first pieces of Transcendentalist commentary on the plight of the American slave. Prefacing an excerpt from the piece, literary critic Lawrence Buell explains that, “Fuller carefully distances herself here from abolitionist zealotry, almost as much as Emerson did in ‘Self-Reliance,’ and she carefully distinguishes her detestation for the institution of slavery from her attitude toward slaveholders”.² Buell’s commentary is directed at early Transcendentalist rhetoric, before the more pragmatic turn over the following fifteen years towards overt socio-political commentary. Emerson sought to point to ideas of individuality and the necessity of individual removal from the dictums of a too-quickly evolving society. As Emerson stated in “Self-Reliance”:

This is the ultimate fact which we so quickly reach...the resolution of all into the ever-blessed ONE. Self-existence is the attribute of the Supreme Cause, and it constitutes the measure of good by the degree in which it enters into all lower forms.³

Emerson’s stance in “Self-Reliance” emphasizes the self over society; this specific excerpt does not encompass the range of Emerson’s ideas, but it does illuminate his early views towards society and the self. Instead of involvement in what Emerson believed to be the trivial happenings of society, he advocated a search for Truth and the “One.” This truth, only to be found through self-exploration, was out of reach for those who overly involved themselves in political debate and social commentary. To find “the ONE,” it was necessary to remain vigilant in a stance of removal.

In 1844, Emerson’s rhetoric begins to change, albeit slightly. Ten years after the decision for the British Empire to emancipate all slaves in their colonies, Emerson delivered an address to the people of Concord. Today, this text is titled: “Emancipation in the British West Indies”. Emerson began his speech by directly addressing his peers in Concord:

Friends and fellow citizens: We are met to exchange congratulations on the anniversary of an event singular in the history of civilization; a day of reason; of the clear light; of that which makes us better than a flock of birds and beasts; a day which gave the immense fortification of a fact, of gross history, to ethical abstractions.⁴

Using direct language, Emerson celebrates that for ten years, the British Empire has declared slavery illegal in its colonies. This decision was one that has gone down in history as the beginning of the emancipation of African slaves across the world. Emerson does not speak of slaves or slavery; instead, he states that the event was momentous because of the “reason” that served as its backbone.

These first lines would seem to be an assault on slavery as an institution in America. Despite this, Emerson clings to his previous rhetorical stances—tempering his words and at times backpedaling to state that slave owners do not possess the entirety of the blame and are, to an extent, victims that must not be persecuted:

When we consider what remains to be done for this interest in this country, the dictates of humanity make us tender of such as are not yet persuaded. The hardest selfishness is to be borne with. Let us withhold every reproachful, and, if we can, every indignant remark. In this cause, we must renounce our temper, and the risings of pride.⁴

With this remark, the slaver is to some extent pardoned for his actions. The ownership of slaves becomes not the crime of the individual, but a crime of society itself. In positioning his argument to eschew blame from those who already possess slaves, Emerson distances himself from rabid abolitionists. While he may state that “The blood is moral: the blood is anti-slavery: it runs cold in the veins: the stomach rises with disgust, and curses slavery,” he refuses to lay blame on those who perpetuate a system of violence and forced servitude.⁴ Furthermore, he states that: “Many planters have said, since the emancipation, that, before that day, they were the greatest slaves on the estates. Slavery is no scholar, no improver”.⁴

But Emerson was not content to simply condemn the violence of slavery in the colonies. Instead, he declared that the anniversary of the British proclamation was a “moral revolution”.⁴ To close, he stated:

The genius of the Saxon race, friendly to liberty; the enterprise, the very muscular vigor of this nation, are inconsistent with slavery. The Intellect, with blazing eye, looking through history from the beginning onward, gazes on this blot and it disappears. The sentiment of Right, once very low and indistinct, but ever more articulate, because it is the voice of the universe, pronounces Freedom. The Power that built this fabric of things affirms it in the heart; and in the history of the First of August, has made a sign to the ages, of his will.⁴

With his final words, Emerson recedes once again. This element of advancement and retraction is common throughout the early works of Emerson and his fellow Transcendentalists. They sought to promote a greater good and a pursuit for truth and reason, but did not wish to take a role in the forefront of social commentary. In 1844, their rhetoric was still focused inwards, on the self and how it interacted with nature. They sought a perfection of the intellect and freedom from oppression. By condemning the treatment of African slaves in British colonies, Emerson positions his argument abroad. Any condemnations of slavery are indirect and seek to prevent the enslavement of free Massachusetts citizens who journey into southern slave states. Moving back and forth from moderation to condemnation was their great tool; by critiquing only up to the point of mild controversy, the Transcendentalists eschewed the negative opinion of the general public and were allowed to remain free to focus on their own intellectual pursuits.

By the next year, this theoretical stance began to decay as the eclectic philosophy of Transcendentalism evolved. Margaret Fuller, a member of the movement and one of the first American feminists, was often one of the most outspoken writers of her peers—whether in consideration of American or foreign affairs. Her commentary on the existence of slavery in America and abroad proved to be one of her more radical stances, especially considering the state of the Union in 1845. During that year, Fuller reviewed Frederick Douglass’s autobiography and described the former slave turned writer as “an excellent speaker” who, in “exposing himself to obvious danger,” sets “the seal on his deep convictions as to the religious need of speaking the whole truth”.⁵ Using a strategy similar to that used by Emerson a year before, she moved from moderation to a more outspoken strategy of persuasion and editorial opinion. By describing Douglass as such, she seeks to elevate him from the posi-

tion of a former slave to that of a talented man of rhetoric, unafraid of the dangers that he may be exposed to because of his writing. Tying Douglass to the merits of mixed race and widely read authors like Dumas and Soulie, Fuller wrote of African descent not as a curse or an impediment, but simply as a facet of a man.

The apex of the piece lies in her description of the slaveholder and those in favor of the continuation of slavery:

...blindness is but one form of that prevalent fallacy which substitutes a creed for a faith, a ritual for a life. We have seen too much of this system of atonement not to know that those who adopt it often begin with good intentions, and are, at any rate, in their mistakes worthy of the deepest pity. But that is no reason why the truth should not be uttered, trumpet-tongued, about the thing.⁵

It is central to the examination of this excerpt that the temperance of rhetoric is acknowledged. Fuller is careful to refrain from any clear denunciation of slaveholders or defenders of slavery. The key to her view is her utilization of “good intentions” and “the truth.” Much as Emerson hesitated to denounce slaveholders, Fuller uses blindness as a substitute for consideration. Instead of outright persecution of slaveholders, she advocates for a view of them as ignorant of a greater truth; perhaps the same truth that Transcendentalists so often pursued. However, beneath the tempered rhetoric, there is a clear criticism. According to Fuller, slaveholders were blind to the fallacies of their stance, and blind to the fact that those of African descent are equal in ability and intellect. Instead of denouncing the blind, Fuller advocates re-education. Echoing earlier thinkers such as Bronson Alcott, Fuller believed that the solution to the problem was not outright judgment, but the endeavor to correct ignorance.

By the end of the 1840s, the Transcendentalist movement changed its strategies towards dealing with the problem of slavery. Instead of advocating understanding of ignorance, they began to directly denounce slavery and slaveholders, pointing out the fact that the African and the slave was no further removed from truth and reason than the white man or the slaveholder. Thoreau’s 1849 essay “Civil Disobedience” was among the first to shed a negative light on slavery and is canonized as a signal of a changing mindset among Thoreau’s peers and Americans as a whole. Though he wrote “Civil Disobedience” in 1849, several years after Fuller’s initial words on slavery, Thoreau was

the first to explicitly address the problem of slavery. In this seminal text, admired by Civil Rights leaders since its publication, Thoreau states that:

In other words, when a sixth of the population of a nation which has undertaken to be the refuge of liberty are slaves, and a whole country is unjustly overrun and conquered by a foreign army, and subjected to military law, I think that it is not too soon for honest men to rebel and revolutionize.¹

Witnessing the effects of slavery in a “free” state such as Massachusetts, Thoreau was pulled from his seclusion in the woods surrounding Concord and became one of America’s most outspoken activists for civil liberty. Massachusetts being a member of the Union, it was bound to the laws of the Constitution. The great problem for both Thoreau and, as he saw it, America as a whole, was that the same document that created democratic liberty was also used to uphold the atrocities of slavery. With this in mind, Thoreau distanced himself from the timid inaction of his fellow Transcendentalists and demanded change. In his essay, he references what he perceives as the injustices of the Mexican-American War and ties this same mentality to America’s role as a slaveholding nation. He speaks of rebellion and revolution, but neither of these terms was meant to encourage violence. Instead, Thoreau’s rebellion and revolution was one of mindfulness, in which he encouraged the American populace to stand for American ideals and refuse to acquiesce to a government that supported slavery.

Impactful as the essay may have been—both in contemporaneous discourse and 20th century movements towards civil rights—it was also inspired by a stint in jail after refusing to participate in public elections or pay his taxes. Conversely, Emerson remained aloof, waiting to display public judgment until another address in Concord on May 3, 1851. Today, this address is referred to as “The Fugitive Slave Law”, taking its name from the law that outraged Emerson. In this essay, he illuminates an evolved mindset towards American slavery, stating: “I do not often speak to public questions – they are odious and hurtful, and it seems like meddling or leaving your work...My own habitual view is to the well-being of students or scholars”.⁶ Referencing his seminal works such as “Self-Reliance” and “The American Scholar,” these remarks may be seen as excuses for inaction; however, it is more likely that Emerson saw these words as an explanation for time he used to fully form a previ-

ously uncertain stance.

Speaking once more to an audience of his neighbors and peers, Emerson said, “The one thing not to be forgiven to intellectual persons is, not to know their own task, or to take their ideas from others”.⁶ He believed that his previous public removal from the debate surrounding American slavery and abolition was justified by his lack of personal knowledge about these institutions. By 1851, Emerson saw the effects of slavery and the necessity for freedom, as Concord was often a place of passage for escaped slaves. Speaking from a sense of horror upon seeing the extensive reach of the new law, Emerson remarked that,

I have lived all my life without suffering any known inconvenience from American Slavery. I never saw it; I never heard the whip; I never felt the check on my free speech and action, until, the other day, when Mr. Webster, by his personal influence, brought the Fugitive Slave Law on the country.⁶

Emerson is loyal to previous addresses such as “Emancipation in the West Indies”, explaining that his lack of knowledge had halted any direct action against American slavery as a whole. Finally, he refuses to remain inactive and describes the atrocities of slavery in America. Witnessing firsthand the effects of the Fugitive Slave Law, Emerson quite literally saw the chains of slavery rattling past his window. These images served as a catalyst, inserting Emerson directly into the debate surrounding abolition. Describing his internal struggle, Emerson asked the following of his peers:

Are you for man and for the good of man; or are you for the hurt and harm of man? It was the question whether man shall be treated as leather? Whether the negro shall be, as the Indians were in Spanish America, a piece of money? Whether this system, which is a kind of mill or factory for converting men into monkeys, shall be upheld and enlarged?⁶

Emerson positioned liberty at the heart of his argument, capitalizing on foundational American rhetoric. The imagery of abuse is reinforced through comparisons to the Spanish Empire and natives. Most importantly, the slave is described as a man and not a beast. By making such a statement, Emerson finally stood in clear opposition to slavery. Speaking to the nobility of liberty, Emerson compared it to “the Crusade of all brave and conscientious men, the Epic Poet-

ry, the new religion, the chivalry of all gentlemen,” and indeed it was for both Emerson and his peers.⁶ Ultimately, it was the liberty and the injustice, finally brought to clear light on their doorsteps, that pulled these thinkers from their self-imposed exile into the forefront of the abolitionist debate.

By 1854, Thoreau’s rhetoric had moved even closer towards a clear stance in favor of abolition. The key difference between Thoreau and Emerson was the same vitriol used in “Civil Disobedience.” In what is now known as “Slavery in Massachusetts,” Thoreau spoke directly to those who remained indifferent to the debate, stating that, “there is not one slave in Nebraska; there are perhaps a million slaves in Massachusetts”.⁷ Thoreau posits that slavery is not simply confined to the plight of those in chains, but also to those who are chained to ignorance. He believed that the citizens of a state that deemed itself “free” did not hold a moral advantage over those in a “slave” state. Instead, Thoreau saw citizens who remained passive as being guilty of all crimes of slavery. Further, the ignorance that led to indifference towards or support for American slavery was a form of slavery itself. This harkened back to years of writing on individuality and truth. With these claims, he aimed to both antagonize and show his fellow citizens that their indifference and ignorance left them as slaves to the government. For Thoreau, the only way to escape these chains was to take action and a firm stance against slavery as an accepted institution. Any reluctance to act was blindness towards the irony that America, land of the free, was simultaneously the land of slavery and bloodshed. To spur feelings of patriotism, he offered a comparison of citizens of Concord in 1775 and 1851, exclaiming, “as if those three millions had fought for the right to be free themselves, but to hold in slavery three million others”.⁷ This statement emphasized the difference between the ideas that gave birth to democracy and the ideas that sought to maintain it in Massachusetts. Thoreau saw compliance with the Fugitive Slave Act as hypocrisy – citizens of Concord were pleased to glorify their past but refused to see the crimes of their own time. He builds upon this idea by demanding that Concord “let the State dissolve her union with the slave-holder...she can find no respectable law or precedent which sanctions the continuance of such a union for an instant. Let each inhabitant of the State dissolve his union with her, as long as she delays to do her duty”.⁷ Echoing the ideas of the first American patriots, Thoreau explicitly dared those in his audience to remain blind to the injustice of American democracy. Stirring multi-generational passion, he asked them to live up to their reputations

as the descendants of revolutionaries.

Thoreau's long analogy of the water-lily was meant to remind Americans of the beauty of democracy and the supremacy of the individual. He believed that, "It suggests what kind of laws have prevailed longest and widest, and still prevail, and that the time may come when man's deeds will smell as sweet".⁷ It is nature that Thoreau uses to remind Americans of the promise of the first democracy. Unsurprisingly, he believed that nature displayed the purity of heart through which democracy could be born. Laws written on paper are not those that have lived the longest; instead, the laws of morality, liberty, and freedom prevail as eternal. The water-lily is beautiful because it is born beautiful. These qualities are akin to the ideas of liberty and freedom – eternal and forever just. He continues with the allegory by stating that, "it reminds me that Nature has been partner to no Missouri Compromise. I scent no compromise in the fragrance of the water-lily".⁷ The Missouri Compromise and the Fugitive Slave Act, both spearheaded by a coalition of representatives who sought to find a middle ground, proved to be the most egregious of insults to Thoreau's idea of the Union. A Union, for Thoreau, was not to be an entity that chose the least controversial actions; instead, it was to be an entity in which the greater good was upheld, no matter the problems that would seemingly interfere in the short-term.

"Slavery in Massachusetts" ends with a proclamation that, "Slavery and servility have produced no sweet-scented flower annually, to charm the senses of men, for they have real life: they are merely a decaying and a death, offensive to all healthy nostrils. We do not complain that they live, but that they do not get *buried*. Let the living bury them; even they are good for manure."⁷

Thoreau positions slavery and servility (whether they are manifested in the form of physical chains or the herd mentality of an indifferent populace) as decay and rot. These disturbing facets of society obscure the truth of America, hiding the reality of the life of a slave, as well as the fact that the nation could survive without slavery. The water-lily grows wild, without the assistance of mankind in a garden. Simply by its own biology, the flower is self-sufficient. Thoreau considered slavery and servility to be blockades before a free mind and, thus, a free man. Thoreau was just as aware that slavery had always been a facet of civilization, but he also believed that it could be eradicated. The abolition of American slavery was just as much a possibility as

the abolition of English rule in America. Democracy, much like the flower, was able to flourish once it was not lost in the foul scent of a dictatorship. And with the abolition of slavery, so could America flourish once more.

The unfortunate nature of this allegory is that the foul scent continued, obscuring the smell of the water-lily. No matter the efforts of abolitionists, slavery would not end without war. But the Transcendentalists, writing between the years of 1845 and 1854, sought a reclaimed America, one that was not buried beneath the filth of slavery. The importance of this decade was paramount for the legacy of the Transcendentalists. Their first statements regarding slavery had been tempered and refused to take a stand against Americans. Emerson first tackled the subject in a criticism of slaveholders in the West Indies, Fuller discussed slaves as men instead of objects, and Thoreau used slavery as a term for the ignorance of mankind. But with the passing of the Fugitive Slave Act, their rhetoric changed and our original American philosophy became one of social activism. Much as they wanted to remain lost in their thoughts about nature and truth, they were forced into action once slavery presented itself on their doorsteps. Emerson himself, though long an advocate for the importance of self-existence over society, stated that, "it is the genius and temper of the man which decides whether he will stand for right or for might".⁶ Speaking against the Fugitive Slave Law, he spoke against his own long-held philosophies, admitting that he had to take a stand. Fuller and Thoreau, though often lost in the shadow of Emerson, came to define the activist themes of American literature, changing fiction, history, and philosophy. Their eclecticism would carry on in their influence. Examining their works as historical documents, the impression of a massive change emerges; as America moved towards Civil War, so did Transcendentalist philosophy shift to pragmatism and fiery rhetoric. Though it would be years before the Civil War commenced, the first shots had already been fired. By shifting from abstract concepts to an analysis of their own world, the Transcendentalists evinced a new patriotism that would be mirrored in the gradual progress of America during the Reconstruction era and afterwards.

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⁴Emerson, R.W. "Emancipation in the British West Indies." *The Essential Writings of Ralph Waldo Emerson*. Ed. Brooks Atkinson. New York: Random House, 2000. Print. Pg. 753, 753-754, 755, 765, 770, 776.

⁵Fuller, M. (2000) "On the Narrative of Frederick Douglass." *The American Transcendentalists: Essential Writings*. Ed. Lawrence Buell. New York: Random House. Print. Pg. 355, 356.

⁶Emerson, R.W. (2000) "The Fugitive Slave Law." *The Essential Writings of Ralph Waldo Emerson*. Ed. Brooks Atkinson. New York: Random House. Print. Pg. 779, 780, 783-784, 792.

⁷Thoreau, H.D. (2000) "Slavery in Massachusetts." *Walden and Other Writings*. Ed. Brooks Atkinson. New York: Random House. 695-714. Print. Pg. 697, 701, 709, 713, 714.

Luna Moth

BY ANGELA NATRASEVSCHI

COLORADO STATE UNIVERSITY, COLORADO

solitary spinner of silk

paled— hatching

hidden

through interwoven— stacked in translucent layers

of what rambling shadows had drawn

on an intermittent body

*rooted from the earth— tendrils wrapped in deficits of color— I would know the emptiness this left—
if I had bloomed*

counterpart— the other duplicate

erratic faceless animal

host of deciduous

birch— persimmon— hickory

Luna Agate

BY ANGELA NATRASEVSCHI
COLORADO STATE UNIVERSITY

Accompanying artwork on adjacent page

ice tooth

solid ground and

cratered backbone—

the insides of the mountains

rimmed in rust

internal curves of formation—

the banded grain of

your peachy cheek—

the glacial divide of chalcedony

layered in ancient parallels—

your probable waters

woven into the mouth of the canyon

Snowdrop

BY ANGELA NATRASEVSCHI

COLORADO STATE UNIVERSITY, COLORADO



A. Natrasevski, *Snowdrop*, 2016
Oil on Board; 3' x 4'

To paraphrase the poet David Baker, as writers and artists we recycle language and ideas, like scavenger animals we take something that has died and give new life to it. Much of my work is concerned with transformation of existing narratives in poetry or myth. My work investigates these concepts most often through themes of natural imagery, decay, and resurgence. This is done by reflecting on the essential experience I have with a narrative or poem. I address this through inventing a visual world for these transformations. This work is meaningful to me because I find solace in the worlds of narratives I am transforming, and the practice of enacting variations of these narratives has become very meditative and reflective for me. There is a quietness to the internal aspect of making this work that I value. This work allows me to communicate my internal experience of these existing narratives, but also opens my work to interpretations outside of the context of the narrative.

Transient

BY ANGELA NATRASEVSCHI
COLORADO STATE UNIVERSITY, COLORADO

faint / moment
borrowed / north
framed in chalk—
quiet / ignorant body

sediment / solids / settling

*I would know the dirt on my soles like I know your hands by the table, wood grains
in furrowed skin. I would know the touch left on the wall— and charcoal faults— in
your cotton shirt.*

filaments— bare

of ounces and quantified in
skinned knee / fragility
loose clover / rug burn blush

hospital socks

*

*I would know the ringed moon like I know the night-roamer— in translucent skin—
the gap between your silent ribs and marble mouth.*

covered / shadow
fading

empty

/

dissipate

Sandpaper Soles

BY LINDSEY WHITTINGTON

COLORADO STATE UNIVERSITY, COLORADO

Collette decided to run away.

Like most Iowan summers, the air was thick. The moisture pulled at her brow, making her sweat. Clouds drifted over the embankment, dutifully blocking the sun and keeping its rays at bay. The suffocating humidity was all that was left. It sat in the air like a clenching fist around a chicken's ropery throat. Just one flick of the wrist, and it would snap.

Collette, little as she was, noticed the change in the air. She was small for her age, not even reaching four foot, five inches at ten years old. Her thin legs swiveled beneath her torso, as flat and shapeless as her face. She had a small nose and large, round eyes that peeked out from under her eyelids like half-lit moons. Her hair was clipped into a tight bob, like a bowl balanced atop her head, wiry and tough like uncooked spaghetti noodles.

She was a child of little maintenance, one left to her own devices. Trying to dress herself and attempting to comb her own hair with her twiggy, weak arms was difficult. The brush always seemed to miss the ends, which became clumps of dirt and matted hair. She was an unkempt child, one between the age of childhood and puberty, left without guidance. She was untouched by age, but not untouched by the feeling of indifference.

Collette took her stuffed dinosaur and nothing else. She left her shoes behind after they filled with water, and the repetitive sloshing made the bottom of her feet itch. Her socks were stuffed into the mouths of her shoes. The stones squished between her toes, oozing upward like tiny fish eggs. The shore was a patchwork of mud and rocks. The nearer to the tree line, the muddier the bank was. As Collette grew closer to the edge of the river, big stones just became smaller stones. A landfill of grey and green, moss and quartz. Some stones were smooth—years of wear rubbed down by the water's rough hands. Others stuck upward like child's teeth, serrated and bony. It was nearly impossible to walk along the banks barefoot. She remembered being seven years old and crying as she tried to retrieve her stuffed dinosaur from its jagged embrace. Her cousin had thrown him out toward the edge of the river, stolen her shoes, and hidden until Collette came back up the bank with scrapes and blood speckling her feet.

"How many times do I have to tell you?" Her mother cried. Her eyes were pits of opal.

"But Joshua—"

"I'm not talkin' to Joshua. I'm talkin' to you, Lettie. How many times?"

"But mama—"

"Don't you mama me. Get inside and ask your grandma to help clean you up."

Collette was tough now, like sandpaper: rough and ragged. Her skin was rubbed raw and then made fresh again; each layer hardening until her small toes were lined with skin as hard as the rocks she walked upon.

Collette pushed her dirty hair behind her ear and kept walking down the riverbank.

The river wound its way through the thick trees, and cabins speckled the embankment on either side. They lined the farthest reaches along the bank, pushed back atop a small incline to avoid flooding during wet summers. Her mother's cabin sat amongst them, nearly indistinguishable from the rest of the other tin-roofed, red-painted homes. There was no running water in any of the cabins. But there was a community pump, and Collette's mother had to carry a big basin clasped between her thick hands and thighs when she wanted to wash any dishes or give Collette a bath. She would heat the water to a lukewarm atop the cast iron stove and then plop Collette right down into it. Then she would shiver and convulse as her mother scrubbed her dirty back and worn feet until she was raw again.

She kept her dinosaur tucked in the crook of her arm as she walked along the river's edge. It had been a gift from her father, years before he left to live in Des Moines with someone named Jackie, miles away from her and her bitter mother. One of the last times she saw him, he sat her down right on his knobby knee and pushed her wiry hair out of her face.

"You seem bigger than I remember," her father had said, bouncing her on his knee. He always wore a baseball cap over his balding head. He was just as skinny as Collette, thin and wispy like a fishing rod. He was such a contrast to her mother now, who had grown fat and round in her years of resentment. But on this particular day, her mother was smiling nearly as wide as her father. Her mother had a birthday bag clasped in her hands.

"I think it's a special day," her mother had said back, ignoring him, holding the bag up closer to Collette. "I think someone got you

somethin' special too, Lettie."

"It's my birthday! It's my birthday!" Collette cried. She clapped her hands together and giggled. "What did you get me?"

"You'll have to wait and see!" her mother had laughed, standing up from her place on the rugged floor of their family's cabin. "Your cousins are comin' over soon. Auntie Wendy said they'd be here in a few."

Collette couldn't remember the last time she'd gotten something new, all her own. She salivated at the thought, a hunger she had never felt before blooming under her ribs, squeezing and gurgling. She kept her hands clutched together, even when her family arrived, even while she sat in front of a little chocolate cake decorated with purple and blue icing. Her fingers were even wound together beneath the little wooden picnic table as she blew out the candles. She hadn't wished for much. She only wished to hold the bag in her hands.

After her entire family had finished up their cake, the single present from her father sat alone in the middle of the table. It was too far out of reach from Collette, so she sat there, staring at the bag, her big eyes growing larger and larger. The bag was striped with blues and purples that matched the devoured cake. There was fluffy tissue paper stuffed atop, fluttering and twisting absently in the breeze. Collette squeezed her hands even tighter beneath the table.

"It's time!" her mother had cried, standing from her place at the wooden table. Collette's tiny cousins came running up the bank, her aunts and uncles pouring out from the cabin, crawling out of the recesses they had escaped to during the lull of the party. They all stood around the single present, staring expectantly at Collette. Her father stood as well, grabbing the little striped bag and carrying it over to her. He set it gently in front of her, kneeling down so he was at eye level. She unclasped her anxious hands. The blood rushed back into her tiny fingers, making them tingle.

"Happy birthday, kiddo," he had said, kissing the top of her head. Her eyes filled with tears, but they never fell. Her eyes were so large the tears were sucked right back up into the curves of her lids.

She reached her hands out and grabbed the little present, carefully removing the tissue paper with her small fingers. There was no card, but inside was the stuffed dinosaur. It was purple: Collette's favorite color. She tucked it tightly under her chin, closing her

giant eyes. Her father rubbed the top of her head while her mother clapped her hands. Everyone was smiling, their cheeks wide and teeth clenched, but Collette didn't see them. All she felt was her father's hand in her hair, and all she heard was her mother's high laughter. It was to be the last time for both.

Collette placed her dinosaur down on a large, dry rock. On the rock's side were thousands of green and gold specks—colonies of lichens reaching up the length of the jagged stone. The dinosaur tipped slightly to the left, his glassy eyes staring straight ahead.

"What are you thinking, Robbie?" Collette said. She sat crossed legged in front of her dinosaur. She rubbed the bottoms of her feet from habit and tipped her head slightly to the side to match his gaze. Robbie was her father's name. Before her dinosaur's name was Robbie, Collette had named him Leopold. Leopold had been her aunt's cat's name before he died. Before he was Leopold, his name was Spike. Before Spike, his name was Iowa. And before that, his name was Purp. Short for purple. That was her dinosaur's original name, the one her father helped her pick out.

Collette picked up a twig and tossed it into the running water beside her. She watched it float away, the current tossing it to and fro, fleeing from her sight. She turned back to Robbie.

"I think it's going to rain." Collette looked up into the cloudy sky, the change in the wind bringing goose bumps to her flesh. Her mother always seemed to be saying that. It's going to rain. It's going to rain.

"I think we need a new plan, Robbie," Collette said. She picked up another stick and tapped it into the stones beneath her, attempting to dig a small hole.

"I'm tired. And Mama's gonna be mad when she finds out we ran off." The wind tipped Robbie onto his side. Collette's dirty hair fluttered into her face. It smelled like fish.

"But I don't want to go back, Robbie. Maybe I could dig a hole to..." Where? She trailed off. Robbie stared ahead.

"Mama can get pretty scary." She tried to smile. She remembered her mother's opal pitted eyes. Robbie continued to stare.

"I wish I had my shoes."

Collette balanced her chin in her small hands, her elbows resting on the tops of her knees. The bottoms of her feet were red, but no marks had appeared. The calluses had taken care of that. She contemplated her decision. Robbie waited patiently.

"If she doesn't even notice I'm gone... Maybe this was a dumb idea."

Collette searched her comrade's face. Robbie seemed to agree. Collette sighed.

"I wonder where Papa is."

She rubbed her eyes with the backs of her hands and stood up from her place on the shore of the river. The Cedar River. A small outgrowth from the Mississippi, the American Nile. That's what her teacher always said. But the Cedar was small, twisting. It meandered about eastern Iowa, running along the outskirts of her cabin village, outside West Liberty, another speck of a tiny town scattered across fields of corn and soy beans. West Liberty had a grocery store and the burger place her mother's new boyfriend took her to after school on Thursdays when he was off from the auto shop. Made-Rite, it was called. There was an old movie theatre called The Strand which sat across the street from an old depot where trains used to stop and you could buy tickets to take you anywhere west. Her teacher told her that, too. They hadn't in years, though. The small town didn't have much else.

Collette waded into the water. It felt nice and cool on her sore feet. She rolled up the bottom of her pant legs to avoid getting them wet. She splashed out a little bit farther. She needed smooth stones. Her cousin Joshua always told her so. She always watched him flick his thin wrist, the stone flying out of his hand and skipping ten or twelve times across the surface of the river. She had been practicing for a while to show him she could do it, too. She dipped her hands in and felt around beneath the murky surface. Her fingers brushed a large rock, so she pulled it out and threw it as hard as she could, just like Joshua. It made a big splash a few yards away. Again, she dug around, finding a flatter rock. She tried again, really flicking her wrist this time, but it just plunked right into the water, spraying her pants. Frustrated, Collette pushed out a little bit further, running her hands along the riverbed for another flat stone.

She turned back to shout at Robbie, so he'd understand what she was up to. "I'll be out in a minute. I just want to try—"

But then she was falling. The ground fell out from under her right foot, the riverbed beneath dropping down a few feet unexpectedly. Collette put her hands out, as if to break her fall, but the dank river water smashed into her face, filling her mouth. Her head went under, and her arms flailed upward in attempt to grasp onto anything solid around her. She fluttered upward, kicking her legs hard to reach the surface.

Her head broke out, water spewing from her mouth, coughing. Her body was caught in a quick current, and she could barely keep

her head above the water. She tried to swim back toward the shore, pushing quick and hard with her skinny little arms and legs. But her clothes seemed to weigh her down, pulling her under. She could see Robbie sitting on the same rock she had left him on. She paddled, but seemed to go nowhere and everywhere at the same time. She was rolling away without direction, Robbie becoming a smaller and smaller purple blot in the distance.

Again, her head went below the surface. She opened her eyes in panic, but in a strange sort of way the water was comfortably silent. She could hear nothing but the turn and curl of the currents as they broke in between rocks and pushed along the riverbed. She was spinning in directionless circles, and everything was green and brown. A fish brushed along her leg and, surprised, she opened her mouth. Water rushed inside again but this time, it felt as if it was filling up her head. She was becoming heavy, and Collette feared this was all she would ever be.

Her body, upright, struck against a boulder that broke up the stream before her like a giant thumb. The water burst from her mouth, and she clawed her way out of the water's girth. Her head broke free, and air filled her blubbing lungs. She took great heaves of it, letting it burn her throat. She was crying. At least, she thought she was. Perhaps, it was just the water leaking from her nose.

"Help!" she bellowed. "Help!"

But her voice was drowned out by the rushing water and the brushing of branches in the wind. There was no one in sight. The red cabins were blanketed in deep shadows, and they seemed to be a part of a different world, one outside the ravaging current. Collette pushed herself up, trying to climb atop the large rock in her wake. But, instead, the current caught her again, and she was swept to the side in a dizzying hook around the rock.

Collette pushed and pushed with all her strength, freeing her head from the depths of the river. She was closer to the bank now. She could make out the stones that speckled its edge. She could even feel rocks beneath her as her toes brushed against them.

An overhanging branch plunged into the water a few yards ahead of her. Collette kicked and kicked, and she reached her tiny arms up high to grasp onto the tree branch. The rest of her body was pulled forward with the current, her feet breaking the surface of the water, her pants filling up, creating small eddies of their own around her toes. Collette

tugged her way along the tree branch, falling under the water a few times, before the bank was shallow enough to stand in. The currents were lulling, their power plucked away by the giant rocks and trees cutting out of its depths.

Collette stood, soaking wet, surrounded by old, soggy trees hanging limp in the breeze. She stumbled around, tripping here and there on hidden rocks beneath, until she collapsed on the beach. She sputtered and coughed up water, her body resting against the faces of the stones. Collette closed her eyes before rolling over on her back. She opened them, only to be met with water droplets plopping down onto her face. It was raining.

After a few minutes, a steady beat of raindrops were trickling from the sky. The clouds rumbled in reply, the thunder pounding against the ground and the hills and the trees. Collette felt it rumbling her chest as she laid exhausted beside the Cedar River.

She reached her hands up above her, spreading her fingers as wide as she could make them. She wanted to feel the slick beads speckle the skin of her palms. She reached up and up so far her shoulders began to ache.

"I can't do this anymore," she said, in a whisper, just like her father had said. She mimicked those words, let them flutter between her teeth almost like a song. "I can't do this, can't do this, can't do this no more."

She had watched him and her mother from around the corner of the doorway that led into her tiny room.

"I can't pretend that I love you. I can't pretend that I'm happy here. Just take care of Lettie. And take care of yourself, Tessa."

Her mother had screamed after him as he shut the screen door behind him. "You're just givin' up? Leavin' me with what? Just this shit cabin in this shit town with your shit family? You think I got somethin' you don't?"

She had ripped the door back open and followed after him, her voice like angry chirps from fat partridges. Collette had tip-toed after them and stood in the doorway of their cabin, the screen door the only separation between her and her parents. Her mother's cries filled the air, resonating with the geese that dotted the river, their loud honks echoing over the trees. Her mother's fists slammed against the door of his old, blue pickup before it reversed and peeled out of the driveway. She always wondered what might have happened if her mother's hands had been able to catch him.

"Collette!" Her name had perforated the stillness of the air. It was her father's voice,

calling back from the open window as he drove away. She just saw the brim of his hat poking out.

"Collette, I—"

But his voice was carried away. Collette hadn't been able to hear him from her place in the doorway. And she couldn't hear him now. All she heard was the gentle pitter patter of the rain as it covered her.

She closed her eyes again and placed her arms gently across her stomach. She could feel her heart beating. She could feel her stomach gurgling. She could feel her intestines pushing to and fro like the leaves atop the tallest oak. She could feel the warmth of her own skin, no matter how cold she seemed to grow.

The rain eventually stopped. Collette stood from her place on the riverbank, her feet slipping on the wet stones. She turned around and headed south, back toward Robbie. He was waiting for her on his little rock throne. She wanted to tell him she was sorry. Sorry for leaving him behind. She wanted to hold him close.

THOMAS BLOOMBERG

FRONT RANGE COMMUNITY COLLEGE, COLORADO

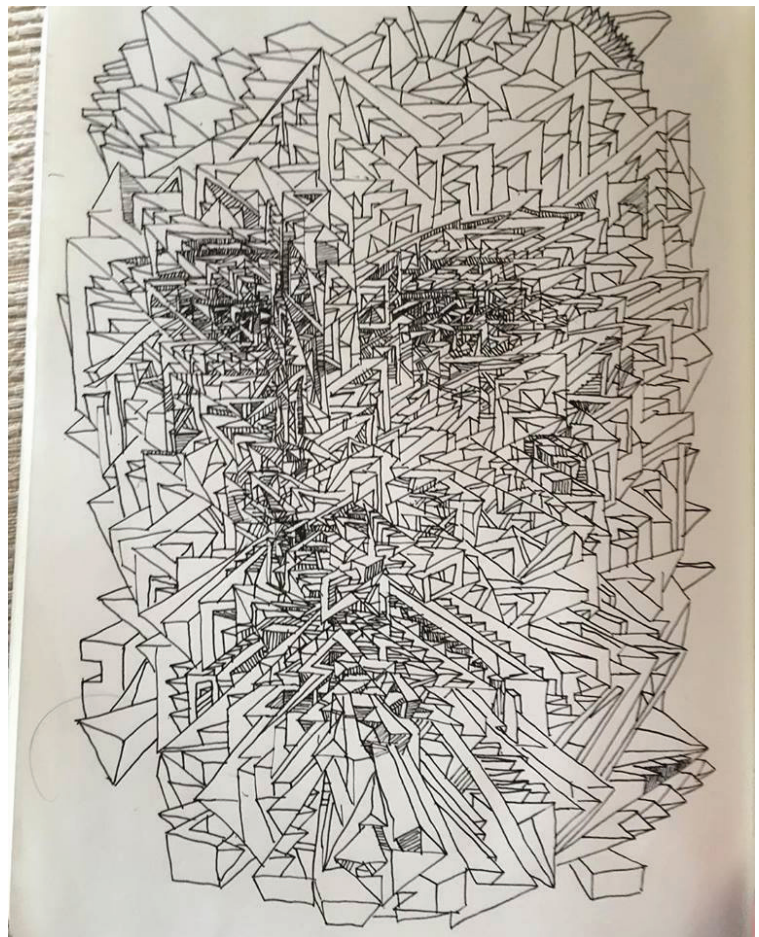
Creating art is the outlet for meditation and personal growth that has always existed within me on a fundamentally human level. Self-expression is a natural reaction to the world one finds themselves in, and an invaluable aspect to achieving some sense of purposefulness amongst the stagnancy of daily living. For my personal endeavors I attempt to convey the surreal and abstract

components of the chaotic state of nature we find ourselves in the thick of; via painting and drawing. Seeking the realism that can only manifest at times in the most unlikely renderings is a crux in my process, because to me turbulence offers the greatest respite and thus the most powerful imagery. The duality of calmness and calamity is not a consideration I take lightly in my work, in

fact my intentions often are to demonstrate both coinciding, whether by peaceful or violent means. Ultimately being a visual artist has offered me a vessel for impregnable interpretation of the world I have found myself dealt into, and it is an opportunity not to be squandered. I create art because there is no other form of existence known.



T. Bloomberg, *Forsaken Conscience*, 2015
Pen and Ink on Bristol; 12' x 18'



T. Bloomberg, *Humanism and Nonsensical Mathematics*, 2016,
Pen and Ink; 7' x 9'

KENDALL ROSE KIPPLEY

COLORADO STATE UNIVERSITY, COLORADO

As you approach my paintings you become immersed in a world of vibrant phenomena. Fractals guide you in and thread your gaze in and out of the work, allowing your eyes to move around in rhythm. I interpret the flow of matter and energies that drive our natural world through my paintings. My work relates the art making processes to the forces that produce natural phenomena

on earth through a range of methods, materials, and intuition. The imagery becomes spontaneous and uncertain, but also intentional and carefully constructed. The rhythmic line work and energetic use of color that I have become obsessed with has captivated my spirit and expressed it outwards. I have become endlessly absorbed by the movement of energy in the universe,

which reflects in the scenes I chose to paint. Inspiration for this work comes from the interest I have in exploring my own tension with the universe and my awe of the natural world. The paintings become a visual record of energy, resulting in a new way to perceive phenomena within nature through materials on a surface.



K. Kippley, *Flux*, 2015
Oil, Acrylic, Mixed Media on Canvas; 48" x 60"



K. Kippley, *High Viscosity*, 2015
Oil on Panel; 48" x 48"



K. Kippley, *Interfering Circumstance*, 2015
Oil on Panel; 48" x 70"



K. Kippley, *Impossible Storm*, 2015
Oil on Canvas; 48" x 60"

ALEXANDRA LAKE

COLORADO STATE UNIVERSITY, COLORADO

The process of printmaking allows me to explore my interests through repetition and layers. Without personally understanding their motivations, I work with images through different compositions and additions of printed layers until I believe that they are represented authentically. Through the intentional use of different printmaking techniques, I maintain some control over the appearance of my forms. However, I enjoy exploiting the unpredictable nature of some techniques as well as the 'black box' nature of the press to allow the forms to emerge with a life of their own.

I am inspired by natural forms that possess an indefinable attraction. I only pursue the exploration of a structure if I cannot pin down exactly what is appealing about it and, therefore, feel obligated to give it a sense of autonomy in my production of it. My general sense of isolation and vulnerability both for myself and the existence of other living things also influence what figures I am drawn towards. I treat my work as an investigation into the false sense of security that comes from our biological existence. I find that the contradiction of nests is a great platform to explore this fragility. While

proposing safety and comfort, nests are themselves delicate structures that provide no assured protection. Lately, I have been extending this metaphor to bodies. In my work, life forms become nested 'selves', perpetuating their existence by relying on their biological structures to let them continue. These forms embody the anxious empathy I find when realizing that our greatest bond to our surroundings is our shared quality of impermanence.



A. Lake, *Nested Selves*, 2015
Collagraph and Litho Ink; 23.5" x 38"



A. Lake, *Selves*, 2015
Collagraph, Lithograph, and Litho Ink; 16.5" x 23"



A. Lake, *Untitled*, 2015
Collagraph and Conte Crayon; 32.5" x 45"

COURTNEY WELLS

COLORADO STATE UNIVERSITY, COLORADO

Personality is the base of human interaction. My paintings are inspired by these unique interactions that emerge when in contact with conflicting or paired personality types. I focus on the Big 5 Trait theory incorporating personality types such as extraversion, consciousness, neuroticism, openness, and agreeableness. It's intriguing to me how people can vary on a scale of each trait, but how we all possess them. I play with the push and pull of these traits based on the situations and interactions people are confronted with, while also romanticizing interactions between people that could occur because of past experiences.



C. Wells, *Untitled*, 2016
Oil on Canvas; 24" x 36"

RACHEL WOLF

COLORADO STATE UNIVERSITY, COLORADO

Photography gives me the ability to communicate to the world who I am through the silence of an image. Learning to capture a message through an artistic moment has influenced me to be more courageous in pursuing my passion and discovering the world around me. Through the lens, I have the opportunity to express original ideas and offer a different perspective, often missed in our daily lives. Photography opens a door

to the world unseen by our eyes alone; where it captures intricate details, depth beyond our perception, and texture that can only be felt through the lens. Inspired by the world I have experienced; my work represents the wonders and natural beauty of a still moment in time, where the emotions and places are never posed. While the world continues to change, these images will forever hold the beauty of these moments.



R. Wolf, *Journey*, 2014
Black and White Photography, 20" x 24"



R. Wolf, *Zion*, 2015
Color Photography, 20" x 24"

An Affordable Method of Thermal Infrared Remote Sensing of Wadeable Rivers using a Weather Balloon

BY TIM BEACH, SARAH NULL, PHD, AND CURTIS GRAY, MS
UTAH STATE UNIVERSITY, UTAH

Abstract

Stream temperatures influence instream habitat and the health and function of aquatic organisms by affecting metabolic rates, life histories, and productivity. Affordable and repeatable methods to monitor stream temperatures with appropriate temporal and spatial resolution are needed to detect thermal refugia for species of interest or identify thermal pollution. This study describes an approach to measure high resolution water temperatures in relatively short (~1-3 km), wadeable river reaches using a weather balloon-mounted thermal infrared camera. We tested this approach in November of 2014 at a confluence mixing zone of the Logan River and Blacksmith Fork in northern Utah, USA. Overall, thermal infrared imagery captured directly overhead reduced reflectance, which occurs at oblique angles (e.g., taken from stream banks).

Also, radiant surface stream temperatures were representative of kinetic stream temperatures measured at depth in the water column. Our method provided high spatial resolution of a confluence mixing zone that is poorly described using conventional stream temperature measurements, such as temperature loggers or higher altitude fixed-wing aircraft remote sensing, which may represent lateral stream surface temperatures with few pixels. Finally, our approach costs less than \$400 per flight (not including a thermal infrared camera) and is not constrained by battery-life, so can be easily repeated to monitor spatio-temporal stream temperature change.

Introduction

Stream temperatures are instrumental to the health and function of aquatic ecosystems, influencing dissolved oxygen, nutrient cycling, and chemical properties of rivers and in turn, affecting metabolic rate, life history, and productivity of aquatic organisms.^{1,2} Stream temperatures are known to limit biota in some systems, particularly cold-water fish species such as salmon and trout.^{3,4} For these reasons, developing inexpensive and repeatable monitoring approaches to easily collect high-resolution stream temperature data is needed.^{5,6}

Methods for measuring stream temperatures include temperature loggers, distributed temperature sensing (DTS), and thermal infrared (TIR) remote sensing.^{7,8,9} Temperature loggers and DTS measure kinetic (internal) temperature at discrete locations in the water column.¹⁰ Temperature loggers are cheap and relatively easy to use, but are often sparsely deployed in rivers and are susceptible to damage and loss.¹¹ DTS has high spatial (~ 5 min) and temporal (~ 5 min) resolution over the length of a fiber optic cable, although deploying DTS systems require considerable expertise and time.¹² TIR imaging provides a spatially continuous representation of radiant river surface temperature, and kinetic temperatures are calculated from radiant TIR observations using Planck's Law.¹¹ TIR cameras measure and store stream temperatures as individual

pixels in a digital image. Forward Looking Infrared (FLIR) cameras have previously been used to capture TIR imagery from stream banks and aircraft.^{13,14} For a thorough comparison of strengths and weaknesses of each temperature monitoring approach, see Briggs et al. and Handcock et al.^{12,11}

TIR remote sensing measures emitted TIR radiation (8-14 micrometer [μm] wavelengths) from the water surface.^{9,16} Water emits radiation as a function of temperature and emissivity, which is typically 0.95-0.97.^{16,17} TIR remote sensing measures water surface temperatures at the top 0.1 mm of the water column.⁹ Although water temperature at the surface of a river may vary from temperature deeper in the water column in slow-moving water, surface temperature is typically assumed to represent the entire water column in flowing rivers (i.e., dominated by advection).¹⁸

Remotely sensed TIR radiation has inherent error. Radiation can be partially absorbed by the atmosphere from humidity, air temperature, and distance between the TIR sensor and surface of the water.¹⁶ Atmospheric absorption is minimized by reducing the distance between sensors and streams and collecting data during low humidity conditions. Distortion at image borders is another problem, but can be partially corrected by removing outer pixels when mosaicking multiple images together. Oblique angles greater than approximately

60° increase reflectance and overestimate water temperatures.¹⁷ Heterogeneity of water surface and radiation from other objects like stream banks or riparian vegetation also increase error.^{9,15,17}

There are numerous techniques for acquiring TIR imagery, including: satellites, fixed-wing aircraft, low-flying helicopters, unmanned aerial vehicles (UAVs) or drones, bankside collection, and weather balloons or blimps.^{19,21,16} Study scale, repeatability, budget, and river access may influence which collection method is most appropriate. Satellite TIR imagery is generally not used for small rivers and creeks because spatial and temporal resolution is coarse.¹⁹ Fixed-wing aircraft and low-flying helicopters commonly collect TIR data at the watershed-scale.^{9,20} Aircraft allow for variable spatial resolution, creating opportunities to collect data that meets specific research needs. Flights may capture 50 river kilometers per day; however, they are expensive.¹⁵ Because of the expense, data collection is repeated less frequently, producing poor temporal resolution. UAVs and drones are increasingly used to collect TIR data; however, drones must have a sufficient payload to support thermal cameras. Our camera weighs 0.9 kilograms (kg). This requires multicopter-type drones (which cost approximately \$20,000 - \$40,000) rather than less expensive hobby drones. Larger drones are limited by battery-life, uncertain Federal Aviation

Administration rules and status, and are prohibited from locations such as National Parks.^{24,25} Bankside TIR photography is inexpensive, detecting temperature change over time when multiple images are captured. This method is appropriate only for very small spatial areas with bankside access, so it may be used for reconnaissance to locate hyporheic flows, springs, and seeps.

Weather balloons have collected TIR imagery of surface water pollution in large, non-wadeable rivers or confluences of rivers with the ocean in a handful of instances. Lega and Napoli used an ultralight fixed-wing plane, tethered balloon, unmanned blimp, and Lighter than Air UAV to monitor surface water pollution.²⁶ They found TIR remote sensing was successful to detect pollution, but did not include a thorough analysis of alternative aerial platforms. Horner-Devine et al. pulled a balloon-mounted TIR camera with a boat to describe river plume shape and turbulence as the plume front moved seaward.²³ Doneker et al. used a blimp-mounted TIR camera pulled by a boat to monitor pollution mixing temperatures in a large, unwadeable river.²² No previous papers have described weather balloon platforms to monitor stream temperatures of small streams, analyzed the accuracy and spatial resolution of weather balloon platforms compared to temperature loggers, or presented costs of weather balloon platforms.

Handcock et al. showed that when at least three pixels of remotely sensed images span the width of streams, measured stream temperature error averages approximately 2% of actual stream temperature.²⁷ Error increases to 13% when fewer than three pixels represent river width, as occurs when TIR imagery is captured from high-flying fixed-wing aircraft at altitudes above 1 km, or satellites. They conclude that TIR imaging should be limited to large rivers.²⁷ We challenge that finding, and provide an alternative method for collecting high resolution TIR imagery over relatively short (~1-3 km) reaches in wadeable rivers using a weather balloon-mounted TIR camera. Weather balloons have previously been recommended to collect TIR imagery of stream temperatures where bridges are not present on rivers for overhead sampling.²⁸ We present a method for collecting stream temperature data in wadeable rivers.

Study site

Our study site is the confluence of the Logan and Blacksmith Fork rivers in Logan, Utah, USA (41.7062, -111.8521) (Figure 1). Elevation is 1,382 meters above sea level. Blacksmith Fork is a smaller tributary to the Logan River. The study region is

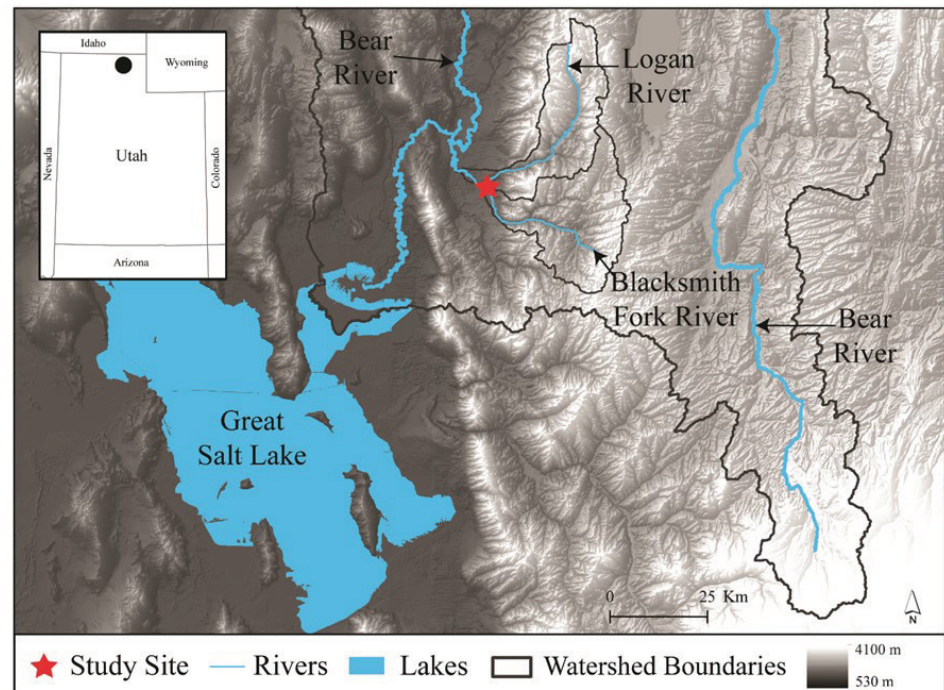


Figure 1. Confluence of the Logan and Blacksmith Fork Rivers study site.

characterized by cold, snowy winters and hot, dry summers (mean January and July maximum air temperatures are 0°C and 31°C, respectively). The Logan and Blacksmith Fork rivers drain the west slope of the Bear River Range in northern Utah. Downstream the Logan River flows into the Bear River, which drains into the Great Salt Lake. These rivers are dominated by snowmelt runoff in spring, although groundwater maintains baseflow through summer and fall. These rivers supply water for agricultural and urban use, accommodate recreation, and provide habitat for waterfowl, shorebirds, and cold water fish, and contribute freshwater to the Great Salt Lake. The confluence of the Logan and Blacksmith Fork Rivers has tall riparian trees (> 30 m), lending itself to tethered weather balloons that can be maneuvered to image stream temperatures below the dense riparian canopy (Figure 2). Riparian canopies block the line of sight for aircraft that fly above the canopy.

The headwaters of the Logan River provide critical habitat for the bonnevillie cutthroat trout (*Oncorhynchus carkii utah*), a 'species of special concern' currently protected under a multi-agency conservation agreement intended to preclude listing under the federal Endangered Species Act.³⁰ Other fish species present in the Logan River and Blacksmith Fork include non-native brown trout (*Salmo trutta*), stocked and wild rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*), native mountain



Figure 2. Google Earth aerial imagery showing riparian vegetation in October 2014 with stream banks and sandbars superimposed.²⁹ Arrow shows flow direction.

whitefish (*Prosopium williamsoni*), and sculpin (*Cottus spp.*).³¹ Generally, native trout species are restricted to upstream reaches while non-natives like brown trout are present in the lower elevations of the system. Trout species, such as bonnevillie cutthroat trout, are sensitive to stream temperature changes from habitat degradation and climate change, so affordable and easily repeatable stream temperature monitoring is desirable.³² Adult cutthroat trout (all subspecies) require stream temperatures less

than 22 °C, although optimal temperatures for embryos are 10 °C, juveniles require temperatures of 11 – 21 °C, and spawning adults prefer temperatures of 6 – 17 °C.³³

Methods

Thermal camera and temperature loggers

We used a FLIR T450sc compact infrared camera to capture both visible light and TIR imagery in the 7.5 to 13 μ m spectral range.³⁴ TIR images represent radiant stream temperatures. Our camera had an 18 mm lens for thermal imaging with a 19° to 25° field of view. TIR camera resolution is 320 x 240 pixels and operating temperature ranges from -15 to 50 °C. Visible image resolution is 2048 x 1536 pixels. The accuracy of the TIR camera is +/- 1 °C or +/- 1% (limited range) of the reading. Our temperature range during sampling was 11 °C (including air temperatures that are not presented). The camera weighs 0.9 kg, which is one of the lightest FLIR science and research TIR cameras.

To validate the measurements of the FLIR TIR camera, we placed twelve Thermochron 1921G iButton temperature loggers (Maxim Integrated) in the water column approximately six inches above the streambed. One iButton was installed on land to measure air temperature. The iButton temperature loggers were programmed to collect stream temperatures every ten minutes, placed in waterproof capsules, and deployed in a rough grid above the bed of both rivers to validate TIR temperatures. Our placement of data loggers was based on the spatial plume of water from the Blacksmith Fork tributary, a known tributary mixing zone. Temperatures of both tributaries were taken with a handheld probe prior to our flight, although the exact spatial dimensions of the mixing zone were unknown. Both rivers have riffle morphology and are advection-dominated so assumed both rivers are vertically well-mixed outside of the confluence mixing zone. Typically shallow rivers may stratify in deep pool geomorphic units, but not in riffles.³⁵ Data loggers are accurate to +/- 1 °C in the -30 to +70 °C range. Future research could verify the accuracy of iButtons near 0 °C using a more accurate thermometer.

Weather balloon

The weather balloon had a suspended case to house the FLIR camera and three ground tethers to guide and control the balloon (Figure 3). We used a 600 gram professional weather balloon, which was filled with helium to approximately 1.8 m in diameter. The case containing the camera was attached to the neck of the balloon via a Picavet system, allowing for self-equalization



Figure 3. The TIR balloon platform comprises three main parts: the balloon, camera case, and tether system.

and a nadir view angle.³⁶ Our Picavet system is anchored to the four corners on top of the case and is created by a continuous, two meter long, 0.3 cm diameter mason line. The neck of the balloon was outfitted with a small, 3.8 cm diameter PVC pipe to support the 0.9 kg camera.

Stream temperatures were measured by temperature loggers and TIR imagery from approximately 13:00–13:30 on November 18, 2014. Air temperature reached a maximum of 1.1 °C. Stream discharge was 2.8 cubic meters per second (cms) (99 cubic feet per second [cfs]) and 1.6 cms (55 cfs) in the Logan and Blacksmith Fork Rivers, respectively (USGS site numbers 10109000 and 10113500). One hundred and twenty TIR and 120 visible light images were captured from the weather balloon that was flown at an altitude of approximately 20 meters. The camera was programmed to simultaneously capture both visible and infrared images automatically every 15 seconds.

We planned the flight to coincide with high pressure (actual air temp was 1.1 °C, cloud cover was approximately 15%, maximum wind speed was less than 10 km per hour, and there was no precipitation). We also preselected our flight location based on a known river mixing zone at the confluence of two tributaries. Our flight path began by moving downstream in the Logan River, then subsequently moving up river along the confluence and finally upstream in the Blacksmith Fork River (Figure 4A). Three field technicians moved the balloon

by simultaneously walking upstream or downstream, where each person controlled one of the balloon's tethers. Tall trees are plentiful in the area, requiring the field crew to utilize all three tethers as well as someone on the bank with a good view of potential hazards to guide field crew. Occasionally, one person holding a tether would step around obstacles on the bank or in the river, which was achievable as the remaining two people steadied the balloon. A few branches extended over the channel, which is typical of riparian corridors, and careful cooperation was needed between all four field technicians to fly the weather balloon.

Data processing

We processed and mosaicked approximately 40 visible images using known reference points with Adobe Photoshop CS5 software. Then, we substituted corresponding TIR imagery using the mosaicked configuration identified with the visible light images. We removed pixels that extended beyond the stream or that had fractions of stream banks, and interpolated radiant stream temperatures along banks using nearby pixels within each stream. We used ArcGIS to geo-reference the resulting TIR image using known reference points. FLIR Systems, Inc. provides Researcher IR software to automatically estimate kinetic stream temperatures from radiant stream temperatures using emissivity estimates of water; however, we compare radiant TIR imagery captured directly overhead with kinetic temperatures measured by iButtons as a conservative estimate in this proof-of-concept study, to understand the accuracy of our method if water emissivity estimates are uncertain.

We linearly regressed 13 iButtons in the mixing zone with TIR measurements at the same locations to quantify the difference between surface (TIR) and water column (iButton) temperatures using the statistical program R (Figure 6).³⁷ The regression relationship between FLIR measured surface temperatures and iButton measured water column temperatures were calculated using a general linear model (simple regression) on the values of the iButton verses the pixel values of the FLIR at the corresponding location. While this inherently includes error between radiant TIR and kinetic iButton measurements, it differentiates between surface and water column stream temperatures.

Results

The iButton data recorded during the balloon flight were averaged through time to show stream temperatures of the two rivers (standard deviation of sites through time was

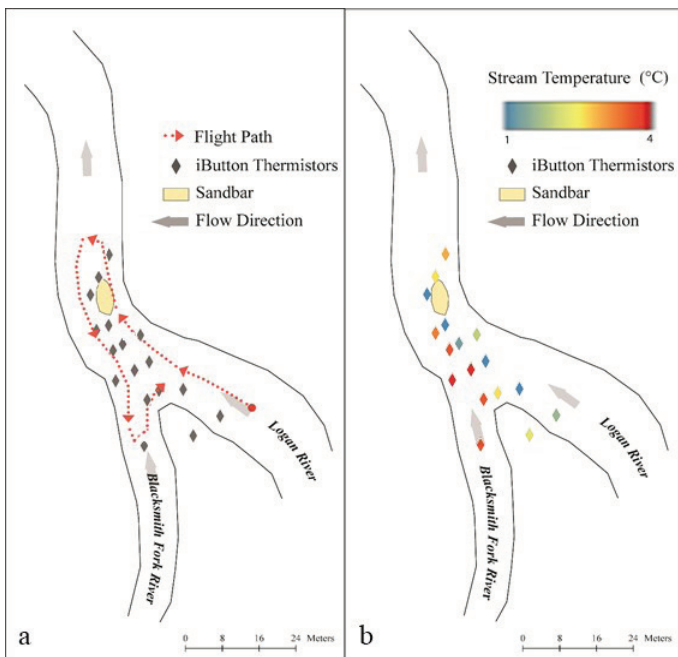


Figure 4. Stream survey data from the weather balloon platform and iButton temperature loggers on November 18th, 2014. (a) Flightpath of weather balloon in relation to temperature loggers, focusing on mixing zone of the Logan and Blacksmith Fork Rivers; (b) Measured iButton stream temperatures

0.09 °C) (Figure 4B). Stream temperatures ranged from approximately 1 to 4 °C, with warmer temperatures in the Blacksmith Fork River and cooler temperatures in the Logan River. We deduced that the two rivers mixed near the confluence, but iButtons were insufficient to measure the spatial extent and detail of the mixing zone (Figure 4B).

Logan River stream temperatures were measured at approximately 1 °C and 1.5 °C with TIR and iButtons, respectively, and Blacksmith Fork stream temperatures were measured at approximately 4 °C for both TIR and iButtons (Figure 4B and 5). TIR surface temperatures were thus representative of the water column and reflectance did not confound data collection when imagery was collected with the weather balloon. This suggests radiant stream temperatures measured directly above streams using a weather balloon-mounted FLIR camera are within 1 °C of kinetic temperatures collected by temperature loggers. This corroborates prior research showing remotely sensed radiant temperatures were within 0.5 °C of measured kinetic temperatures.¹⁴

The mosaicked TIR imagery clearly delineates and quantifies the mixing zone between the Logan River and Blacksmith Fork (Figure 5). The number of pixels representing the lateral stream extent varied by stream width, but was approximately 580 pixels just upstream of the sandbar (Figure 5). Thus, pixel size was approximately 3 cm.

Linear regression significantly predicted water column temperature ($p < 0.001$), however an unexplained variability remained ($R^2 = 0.823$) (Figure 6). Potential factors that explain variability include air temperature, the amount of solar radiation, shading from canopy cover, and differences between surface and water column temperatures. The TIR camera underestimated stream temperatures near 0 °C. Our method delineates the mixing zone on the surface and gives a reasonable predictor of the temperatures in the water column, proving the utility of image-based temperature measurements.

Discussion

Discussion of costs

The tethered weather balloon method for collecting TIR imagery is inexpensive, costing less than \$400 per flight (not including a TIR camera purchase or rental). The TIR camera we used cost \$15,000 in 2013 and could be rented for \$1150 for one week.³⁸ Table 1 itemizes non-camera costs. Helium is the most costly expense and in late 2014 was about \$39/cubic meter. One tank of helium enabled two flights and most weather balloons can be used five to six times. More importantly, because this method is inexpensive, it can be easily repeated for short reaches to: improve understanding of daily, seasonal, or inter-annual stream temperature change; monitor stream temperatures prior

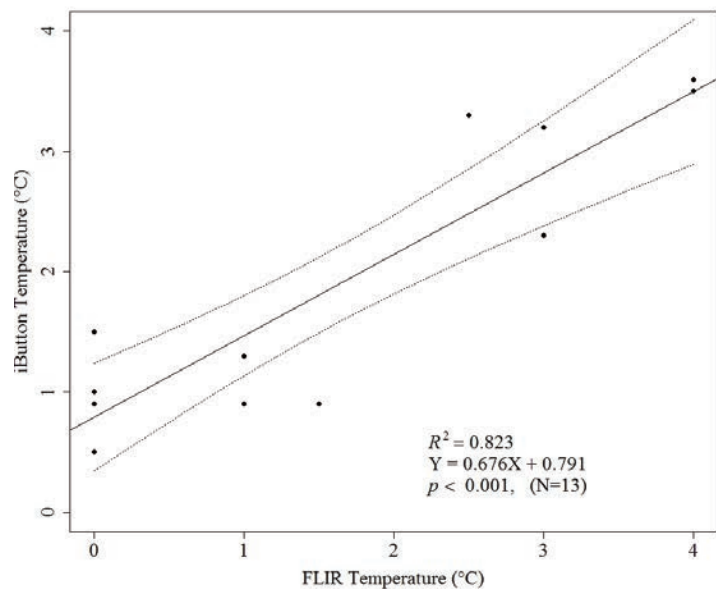


Figure 6. Linear regression between FLIR TIR (surface) and iButton (water column) temperatures. Solid line indicates the predicted regression values and the dashed lines show 95% confidence intervals.

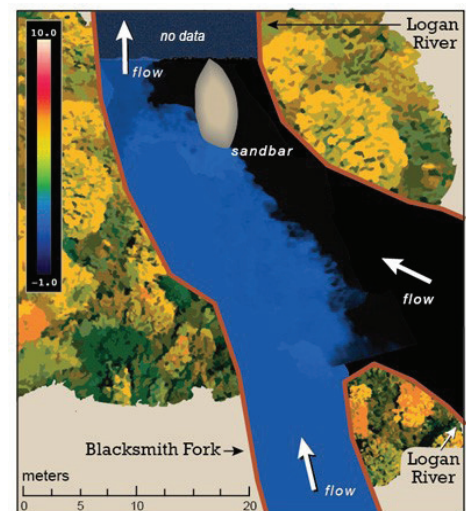


Figure 5. Mosaicked TIR imagery of Blacksmith Fork and Logan River surface mixing zone collected November 18th, 2014. Stream temperatures are in degrees Celsius. TIR image of water surface is combined with visual representation of streambank vegetation to aid the sense of space of the map.

to and following restoration or disturbance; identify thermal refugia; or evaluate changing instream habitat conditions.

Limitations

General data errors associated with TIR imaging have previously been described.^{9,27} Although reflected longwave radiation errors are minimized when the camera is directly above the target, errors from clouds, fog, and humidity may occur. These data errors can be minimized with careful mission planning. When data collection timing is flexible, TIR

imagery should be collected on days with high pressure and mild winds. Atmospheric distortion data errors from humidity, clouds, fog, or wind may be minimized by reducing the altitude of the weather balloon. They could also be corrected for with modeled estimates of atmospheric transmissivity to standardize TIR stream temperature data despite variable atmospheric conditions.

Maintaining constant weather balloon altitude was a major challenge due to wind, tree branches, varying bank height, etc. Our weather balloon TIR platform was sensitive to wind and data are best collected on calm days (wind speed less than 10 km/hr). Visible light images were distorted when mosaicked together from changing balloon altitude and stream temperatures are thus also distorted. This has long been a problem with early remote sensing techniques.³⁹ Determining the necessary height of the balloon to capture desired stream extent requires pre-flight planning. Like all stream temperature data collection, our method relies on field technicians. For this application, we used a field crew of 3-4 people. Careful collection of ground control points measured with GPS adds spatial accuracy if known reference points are unavailable.

The visible and TIR cameras on the FLIR 450sc camera are not the same resolution or spatial extent. Visible light images capture a larger area than TIR images and are higher resolution. This makes mosaicking images complicated and time consuming. We recommend mounting an additional visible light camera of the same resolution and focal length as the TIR camera to facilitate image mosaicking in future flights and for future FLIR camera development.

Benefits of weather balloon platform for TIR stream temperature imaging

Collecting TIR imagery with a ground-tethered weather balloon is a useful and viable approach to measure stream temperatures in wadeable rivers. Monitoring continuous, high resolution surface stream temperatures allows for mixing zones from seeps, tributaries, return flows, or reservoir releases to be spatially delineated. Continuity is improved over temperature loggers deployed in grids or DTS cables snaked throughout rivers to capture longitudinal and lateral thermal variability. Our method may facilitate data collection compared to higher flying TIR platforms when riparian vegetation blocks streams. Stream temperatures can be collected for longer periods of time than from drones because the weather balloon is not constrained by battery life. For example, a quick test of a DJI Premium+ octocopter with a payload of approximately 6 kg lasted about 20 minutes with four batteries. This

Item	Cost
600 gram, 8 foot diameter "Sky Probe" chloroprene weather balloon	\$72.42
Helium tank rental with 7.1 cubic meters of helium gas	\$275.00
Plastic case for camera	\$4.27
Mason line	\$20.91
3 carabiners (non-climbing grade)	\$7.90
Zip ties	\$4.36
Styrofoam padding	\$5.25
Total	\$390.11

Table 1. Itemized costs of weather balloon TIR platform

method is also a viable alternative where drones are not permitted, such as National Parks (although weather balloons are not permitted at altitudes exceeding 150 m, within 150 m from the base of clouds, within 8 km of airports, or where visibility is less than 5 km).

A benefit of our approach over satellite, helicopters, or aircraft methods is that stream temperatures can be resampled, as needed, at little expense. The weather balloon-mounted TIR imagery approach described here is beneficial for small rivers and relative short study reaches (less than approximately 3 km in length) when repeated or multi-hour temperature collection is a priority. Images can be obtained frequently to examine spatial and temporal (sub-daily, daily, seasonal, and inter-annual) patterns in stream temperature at high spatio-temporal resolution. Fixed-wing TIR imagery is more appropriate in large study reaches where many miles of stream surface temperatures are collected.²⁷ We improve upon bankside TIR collection because the field of view is widened so that a greater extent of river can be captured with each image, yet resolution remains high with hundreds of pixels representing cross-sections of streams. Also, imagery collected directly overhead reduces reflectance errors that may skew stream temperature data.

Our research corroborates findings that fine-scale TIR imagery is useful for identifying thermal variability in streams, and describes a method to collect TIR imagery with a weather balloon-mounted TIR camera.²⁸ Our method could be applied to quantify thermal refugia for temperature-limited aquatic species with high spatial and temporal resolution over study reaches a few kilometers long. The weather balloon platform that we describe is a method that is helpful for quantifying longitudinal stream temperature patterns that fit poorly with geographical or theoretical expectations and is an approach that can support comprehensive thermal refugia management strategies to identify and preserve existing thermal refugia in rivers.^{40,41}

Acknowledgments

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Gene Expression in Hardwood Tree Species Exposed to Ozone

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Abstract

*In plant species, ozone (O₃) stress is known to induce physiological and molecular changes that result in whole plant injury and loss of productivity. In this study we investigated molecular changes induced by ozone levels of 80, 125, and 225 parts per billion known to induce visual injury in three different hardwood tree species: black walnut (*Juglans nigra*, L.), green ash (*Fraxinus pennsylvanica*, Marsh.), and tulip-poplar (*Liriodendron tulipifera*, L.). Expression of genes known to respond to oxidative stress was investigated, including ascorbate peroxidase (APX), catalase (CAT), glutathione peroxidase (GPX), Cu/Zn superoxide dismutase (CSD), an ethylene forming enzyme (EFE) and rubisco activase (RCA). Real-time quantitative Polymerase Chain Reaction (qRT-PCR) was conducted with four biological replicates per ozone-treatment for each species to determine response variability among replicates. Our data showed that APX and GPX expression increased with ozone levels while RCA expression decreased as the levels of ozone increased. The CAT, CSD, and EFE genes showed little change of expression between ozone treatments and control. Variability observed within species underscores the importance of replicates in molecular studies.*

Introduction

Ozone is an air pollutant that causes visible injury and loss of productivity in crop plants. It is a highly oxidizing agent that when inside plant cells reacts with water to form hydrogen peroxide¹ that can generate free radicals which attack and destroy cellular components. The Hardwood Genomics Project has produced EST (Expressed Sequence Tags) data and other genomic resources to facilitate research and operational responses to current and anticipated forest health challenges. The goal of our study was to compare gene expression induced by ozone concentrations among biological replicates of black walnut, green ash, and tulip poplar.

Oxidative stress generally activates the anti-oxidative defense system. Consequently, changes in gene expression can be modified relative to oxidative stress. In plants there are various genes that are responsible for controlling enzymes that control oxidative stress. Ascorbate peroxidase (APX) is always present in cells and likely triggers and/or acts as a signaling mechanism of environmental stress.² Catalase (CAT) decomposes hydrogen peroxide at an extremely rapid rate and, therefore, acts as an antioxidative agent.³ Glutathione peroxidase (GPX) acts against peroxides, catalyzing the reduction of hydrogen peroxide or organic hydroperoxides to water.⁴ Superoxide dismutase (CSD) is an important antioxidant enzyme that catalyzes the superoxide anion to oxygen

and hydrogen peroxide to guard cell against superoxide toxicity.⁵ Ethylene forming enzyme (EFE) regulates hormonal pathways to protect plants against damages, producing ethylene and carbon dioxide by catalyzing oxygenation of two-oxoglutarate.⁶ Rubisco activase (RCA) is an enzyme that catalyzes carbon dioxide in photosynthesis, enhancing photosynthetic performance in certain environments depending on the light source.⁷ Given their key roles in oxidative stress response, expression of the above enzymes that are activated by certain genes was studied by quantitative real time PCR. Two house-keeping/reference genes, translation elongation factor EF1B/ribosomal protein S6 (EF-6S) and Ubiquitin 10 (UBQ10), were selected as control and normalization factors (as they do not change expression due to environmental conditions).

Materials and Methods

Healthy, two-year-old black walnut, green ash, and tulip-poplar seedlings were selected from open-pollinated families from parent trees in the Hardwood Genomics Project. The seedlings were acclimated to greenhouse growing conditions for at least two weeks after bud flush prior to commencing ozone treatments.

For detection and quantification of ozone effects on plants, the most commonly used method is greenhouse-controlled studies. In this study, ozone treatments were delivered within Continuously Stirred Tank

Reactor (CSTR) fumigation chambers as previously described,⁸ and housed within a greenhouse supplied with charcoal-filtrated air located at Pennsylvania State University. Four plants per species were randomly assigned to the ozone treatment chambers. Treatments of ten (control), 80, 125, and 225 ppb O₃ were delivered with exposures beginning at 0900 h and ending at 1659 h. O₃ was delivered in square-wave fashion for seven days a week, for 14 days.

Leaf samples (four samples/species/treatment) were collected from the seedlings at the end of the 14th day of fumigation. Leaf samples were flash frozen in liquid nitrogen and then stored in a -80°C freezer. A total of 48 leaf samples were ground crudely into a fine powder for RNA extraction following a modified CTAB isolation method with lithium chloride precipitation.⁹ Complementary DNA (cDNA) synthesis was performed by reverse transcription (RT) using 1400 ng RNA/sample in 40 µl reaction volume using Superscript III RT kit (Invitrogen) as per manufacturer's instructions. Real Time Quantitative PCR (RT-qPCR) reactions were performed in a Bio-Rad iCycler using SsoFast EvaGreen Supermix (Bio-Rad) and two µl of the cDNA into a final reaction volume of 20 µl. For technical replicates, all reactions were performed in duplicate. Primers for RT-PCR were developed from gene-specific EST sequence data using Primer3 software¹⁰, however, for some genes the primers selected

did not show amplification. Therefore results were not obtained for all eight genes in all three hardwood species. Genomic DNA (gDNA) contamination was measured using negative controls, in this case RNA-only samples (RT(-)) (Figure 1A&B).

Results

The leaf tissue damages induced by ozone exposure included stippling in black walnut, interveinal chlorosis in green ash, and necrotic lesions on tulip poplar. Stippling is the formation of black dots on the leaves due to the death of cells. Chlorosis is the loss of chlorophyll leading to the loss of the green color of the leaves. Necrotic lesions are death of the plant tissue in the leaves. Black walnut and green ash were more ozone sensitive and plant replicates showed similar responses to similar ozone exposures (all plants expressed some visual injury at 125 and 225ppb). Tulip poplar was more tolerant and only two plants showed symptoms at 225ppb.

Gene expression analysis for black walnut showed that for the genes that successfully amplified there was little variation between control and ozone exposures, with the exceptions of GPX and EFE (Figure 2). GPX showed a decrease in expression as ozone concentration increased, while EFE expression levels increased as the amount of ozone concentration increased. In general there was little difference in response among biological replicates from the same ozone treatment for black walnut (Figure 2), with the exception of the EFE and GPX enzymes expressed by genes. The box plot of gene expression for black walnut shows a greater range of expression of EFE and GPX among replicates (mean departed from the median) indicating that the biological replicates also responded differently to higher ozone concentrations for these genes (Figure 3). Thus it was possible both to detect the genes that were regulated under ozone stress, and that responses varied based on genotype in black walnut.

In green ash, APX and EF6S gene expression levels generally increased with increases in ozone levels, while EFE and RCA expression decreased; remaining genes were unaffected as the ozone level increased (Figure 4). The boxplots for green ash showed that there was less of a difference among biological replicates from the same ozone treatment (Figure 5) than had been observed for black walnut.

In tulip poplar, ozone exposure induced up-regulation in more genes than in the other two species (Figure 6). The box plot of gene expression for Tulip poplar showed that there was some variation among biological replicates for genes that also showed up-regulation in response to ozone (APX, GPX,

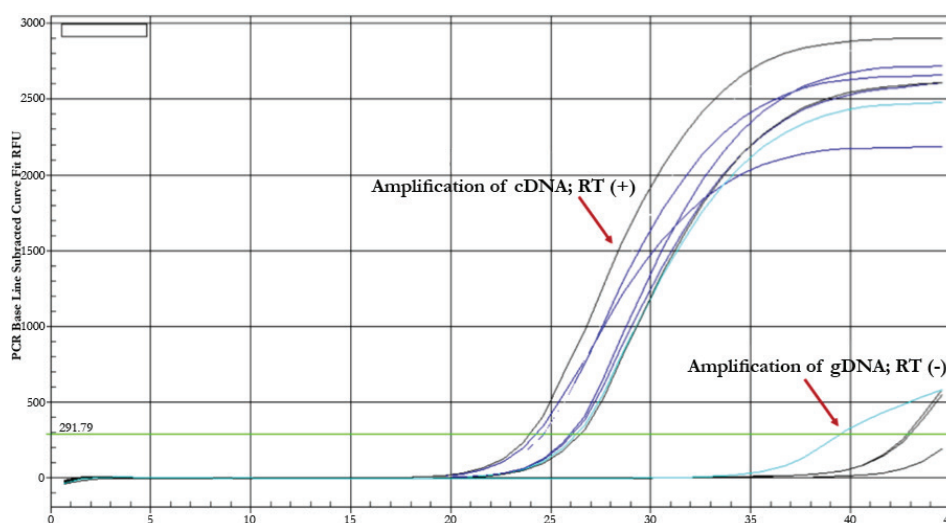


Figure 1A. Example of the cDNA (RT(+)) vs. gDNA (RT(-)) amplification for ascorbate peroxidase. Different curves represent amplification of 12 samples from tulip poplar (2 control, 2-80ppb, 2-125ppb, 2-225ppb, and 4 negative controls (e.g. genomic DNA).

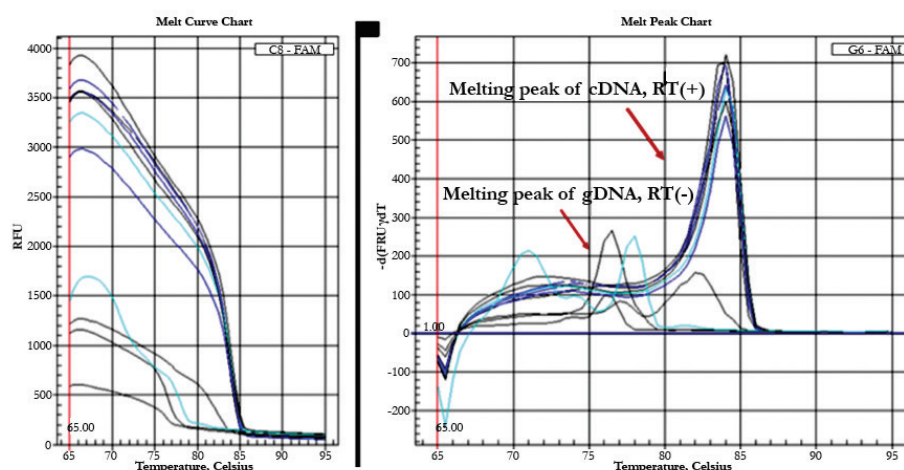


Figure 1B. Example of the cDNA (RT(+)) vs. gDNA (RT(-)) melting peaks for ascorbate peroxidase. Different curves represent amplification of 12 samples from tulip poplar (2 control, 2-80ppb, 2-125ppb, 2-225ppb, and 4 negative controls (e.g. genomic DNA).

and RCA) (Figure 7).

In general an increase in transcription of genes associated with oxidative stress was expected. It was found that APX increased in expression in response to higher ozone in all three species, while GPX increased in black walnut and poplar, but not in green ash. It was expected that transcript levels of RCA would decrease in response to higher ozone, and indeed there were decreases observed but only in two species. The other genes (CAT, CSD, and EFE) either did not show consensus of expression or did not respond to ozone stress.

Discussion

The purpose of this study was to determine changes induced by ozone stress

at the molecular level in woody plants. Ozone is a known pollutant that causes visible injury, induces necrosis, and results in early leaf senescence in plant species.¹¹ The ozone absorbed by the leaves through stomata reacts with water in the cells and produces hydrogen peroxide (H_2O_2), a highly oxidizing agent which in large quantities induces cell death. Sensitivity to O_3 varies among plant species and among genotypes within species. Based on the visual injury observed in this study, our results suggest that green ash and black walnut were more O_3 sensitive than tulip-poplar. Our results show that different plant species, respond in unique ways to O_3 exposure. However, there are areas of similarity between species that provide important insights into O_3 response at the

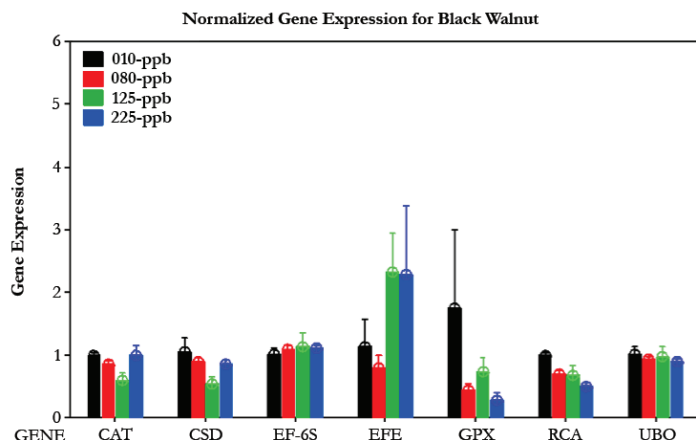


Figure 2. Gene expression levels for black walnut at different concentrations of ozone (010ppb - control). Bars represent means \pm SE, n=4.

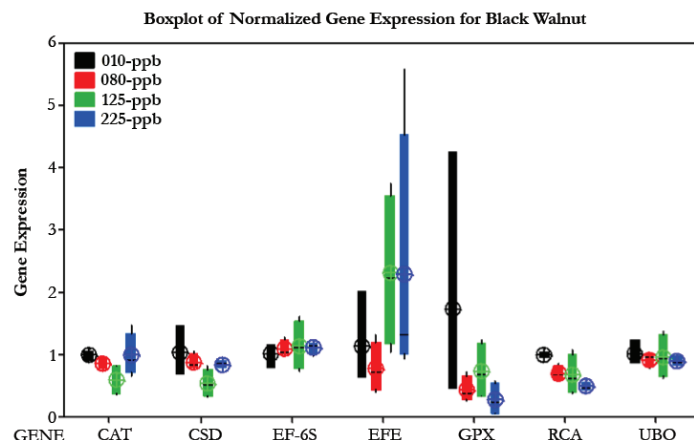


Figure 3. Boxplot showing differences of gene expression among biological replicates of black walnut within the same ozone exposure (010ppb - control).

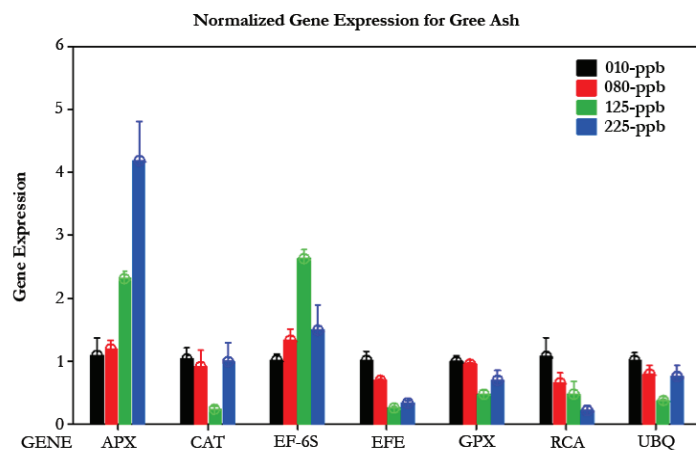


Figure 4. Gene expression levels of seven genes of green ash exposed to different concentrations of ozone (010ppb - control). Bars represent means \pm SE, n=4.

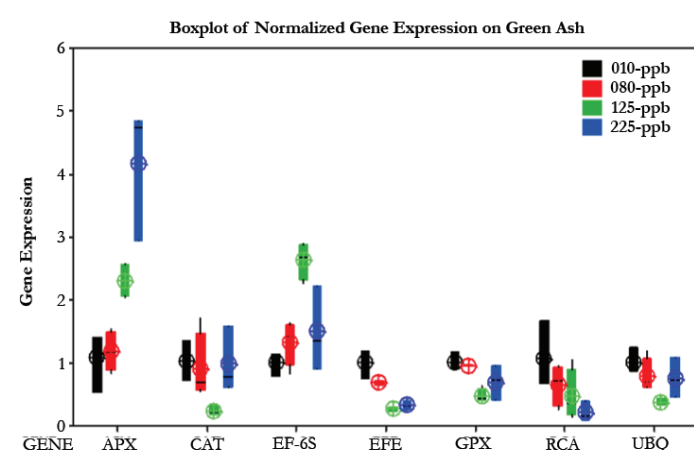


Figure 5. Boxplot showing differences of gene expression among biological replicates of green ash within the same ozone exposure; (010ppb - control).

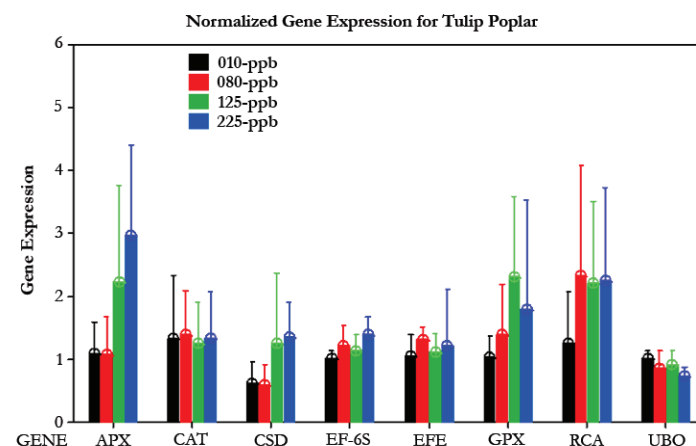


Figure 6. Gene expression levels of seven genes of tulip poplar exposed to different concentrations of ozone (010ppb - control).

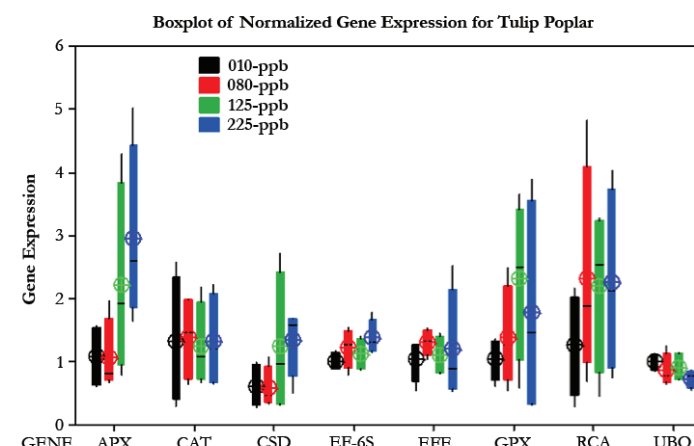


Figure 7. Boxplot showing differences of gene expression among biological replicates of tulip poplar within the same ozone exposure; (010ppb - control). Bars represent means \pm SE, n=4.

molecular level. RCA, an enzyme activated by a gene that plays a role in photosynthesis, decreased in expression in black walnut and green ash but not in tulip poplar. This suggests that the photosynthetic activity of walnut and ash was impeded by the ozone induced cell death. Among the genes tested that are known to respond to oxidative stress, APX, CAT, CSD, GPX, EFE were expressed differentially, but there was not a consensus in response among tree species. This suggests that plant species have various pathways that are preferentially employed in response to stress.

Whether the function of ant oxidative (this is what spell check said was right, it's up to the author's discretion however) genes is to protect cells from the primary oxidative attack or to act as messengers for the initiation of cell death,¹² is not clear. In all instances when ozone induced a change in gene expression there was also variation in responses among the biological replicates. This confirms that ozone induced response varies not only among plant species but also among genotypes within these species. The results confirm that even in species that respond to oxidative stress, genetic variability needs to be taken into consideration. It is also noteworthy that gene expression levels did not positively correlate to visual injury levels. In the two species showing more visual injury, fewer genes showed differential expression between ozone-treated and control tissues, which may indicate an insufficient ability to induce expression of the genes that protect against oxidative damage.

Conclusion

Based on this experiment we conclude that (i) comparative studies involving multiple species are essential in understanding how complex are the mechanisms involved in plant response to oxidative stress, (ii) biological replicates are essential factors in determining the power and viability of a study, and (iii) phenotypical responses to oxidative stress are not always correlated to levels of gene expression, and thus other factors may need to be taken into consideration, such as fixed structural or physiological differences among species.

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An Analysis of Gene Expression Induced by Elevated Atmospheric Ozone in Hardwood Trees Native to Eastern North America

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Abstract

*Analysis was performed on gene expression induced by elevated atmospheric ozone in two hardwood trees: tulip poplar (*Liriodendron tulipifera*, L.) and black gum (*Nyssa sylvatica*, Marsh). The two species were treated at three levels of ozone (80, 125, 225 ppb) covering the EPA's Air Quality Index range of exposure.² From visual observation, elevated ozone caused foliar injury (stippling) in tulip poplar, but not in black gum. Total RNA was isolated from control and ozone-stressed leaf tissue samples for transcriptome analysis. De novo assembly of the RNA sequence data generated 46,794 unique transcripts for black gum and 39,224 unique transcripts for tulip poplar. Differential gene expression among transcripts was quantified as fold change in expression between ozone treatments and controls. Differential gene expression analysis revealed that increasing the ozone exposure increased the number of up-regulated genes. This study provides evidence that ozone exposure induces gene expression in hardwood trees. Oxidative stress triggers complex responses that cannot be explained entirely by global gene expression analysis.*

Introduction

Tropospheric ozone (O_3) is a secondary air pollutant resulting from emission of nitrogen oxides (NO_x) and volatile organic compounds¹ (VOC) under the influence of sunlight. Oxidative stress from elevated levels of tropospheric ozone affects sensitive vegetation by inducing cell death in leaf tissue that in many cases leads to early leaf senescence.² A previous study demonstrated that, in the ozone-sensitive tobacco cv Bel W3, high levels of ozone-induced SA can trigger ROS (H_2O_2) production and subsequent cell death.³ Ozone can reduce the competitive fitness of sensitive genotypes, including extirpation of the most sensitive. Some of which may provide important ecological or economic services.⁴⁻⁶ In addition, decreased genetic variability as a result of ozone stress on sensitive genotypes may alter the ability of plant populations to adapt to other changes in the environment. To prevent cell damage induced by oxidative stress or repair injury plants use a complex defense system, involving a number of stress-related defense genes.⁷ Response to ozone-induced stress is often estimated by evaluating the transcript abundance of defense-related genes.

The trees used in this study were chosen for their geographic distribution and economic and ecological importance. *Liriodendron tulipifera*, also known as yellow poplar, grows taller than any other

hardwood tree species in the United States and accounts for approximately 11.2% of U.S. commercially available hardwoods, which makes its economic value difficult to ignore.⁸ The main uses of tulip poplar include: furniture, kitchen cabinets, doors, musical instruments, exterior trim and siding, paneling, moldings and millwork. Uses for black gum primarily include landscaping in urban areas. They also thrive in regions that experience drought or flooding conditions. The tree itself is usually overlooked in spring, but in the fall the foliage of this species radiates a deep reddish, purple color which makes it an aesthetically appreciated specimen in the eastern hardwood forest.⁸

The main goal of the project was to provide lasting genomic and biological resources for addressing future forestry challenges including growth, adaptation, and response to abiotic and biotic stress factors (i.e. drought, insect pests, disease, etc.). In this study we analyzed and compared whole transcriptome responses of two tree species to three ozone levels. This transcriptome study provided an overall comparative evaluation of gene expression changes induced by oxidative stress among trees differing in their sensitivity to ozone, and was a part of a larger project dedicated to enhancing genomics resources for hardwood trees native to Eastern North America.

Materials and Methods

Ozone treatments

Seedlings from the two plant species were randomly assigned to four continuous stirred tank reactor (CSTR) chambers. These chambers are effective in creating controllable environments for each simulated condition. The chambers utilize a single fan at the top of the chamber that stirs the air within the system to ensure even distribution of ozone treatment within the tank. The control chamber condition was set to 10ppb which approximates the fluctuating natural baseline levels of tropospheric ozone in the environment without the presence of additional exogenous ozone. The chamber setting of 80ppb represents the former national air quality standard for ozone set by the EPA.⁹ Some of the more heavily polluted cities occasionally see tropospheric ozone levels around 125ppb, so it was deemed necessary to monitor the effects on plant tissue at this level as well. The fourth chamber setting was maintained at 225ppb to depict results at an extreme level of ozone pollution. The exposure of the seedlings to ozone for only eight hours a day reflects the importance of sunlight in ozone uptake. Ozone levels are higher during the day, so eight hours of exposure creates a more authentic model of an environment that fluctuates as a natural ecosystem would.

DNA library construction

Three collections of whole leaf samples taken from each of the individually numbered tree saplings were made over the course of 28 days. The first sample was collected after seven hours of exposure to detect immediate changes induced by ozone exposure. Samples thereafter were collected after 14 days and 28 days of ozone exposure; which provided ample time for noticeable change between treatments. After collection, each sample was immediately flash frozen in liquid nitrogen and stored at -80°C until RNA extraction. Leaf tissue was ground into a fine powder under liquid nitrogen, from which RNA was extracted using a modified CTAB protocol.¹⁰ Conversion of mRNA into cDNA libraries for sequencing was accomplished using the reagents and protocol provided in the Illumina® TruSeq™ RNA Sample Preparation Kit (Illumina, San Diego, CA). Separate cDNA libraries were prepared for each ozone treatment and each time point of the study resulting in a total of 12 libraries per plant species.

Sequencing and data analysis

Sequencing was conducted by a rapid run on an Illumina MiSeq 2500 machine at the Genomic Analysis Core Facility at Pennsylvania State University. The reads (individual sequences) have been made publicly available through NCBI's Sequence Read Archive, for black gum accession: SAMN03289128 ID: 3289128 to SAMN03299126 ID: 3299126, for tulip poplar accession: SAMN 03289111 ID: 3289111 to SAMN03299129 ID: 3299129. The resulting Illumina FASTQ reads were trimmed and assembled into contigs using CLC Genomics Workbench (CLC Bio, Qiagen). RNA-Seq analysis was performed by mapping sequence reads to the transcript contigs, then counting read numbers and distribution across transcripts. Subsequently, expression analysis was conducted using the Transcriptomics Analysis toolbox in CLC Genomics Workbench (CLC Bio, Qiagen).¹¹

Results

Based on visible injury, black gum seedlings appeared to be more ozone tolerant than tulip poplar without measure of fitness or productivity. Tulip poplar displayed ozone-induced foliar injury expressed as both stipples and necrotic patches as a response to the highest ozone treatment (225ppb) (Figure 1), while black gum seedlings showed only signs of slight chlorosis of leaf tissue at 225ppb (Figure 2).

Over 12 million sequence reads were generated from sequencing 12 cDNA libraries from black gum and 14 million for tulip poplar. After quality assessment



Figure 1. Stipples and necrosis on a leaf of a tulip poplar seedling treated with 28 days with 225 ppb ozone concentration.



Figure 2. Interveneal chlorosis on leaves of a black gum seedling treated for 28 days with 225 ppb ozone concentration.

and trimming, the black gum and tulip poplar reads were assembled into 46,794 and 39,224 transcript contigs, respectively. The sequencing and assembly statistics are summarized in Table 1; where N is the number of contigs or set of overlapping genetic segments. Of the contigs assembled

for black gum, app. 70% could be annotated with functional gene ontology. For tulip poplar, only 50% of the transcript contig sequences could be annotated with known functional gene ontology (GO) and assigned to a GO category (biological processes, cellular components, or molecular function

GO-Biological Processes for Black Gum

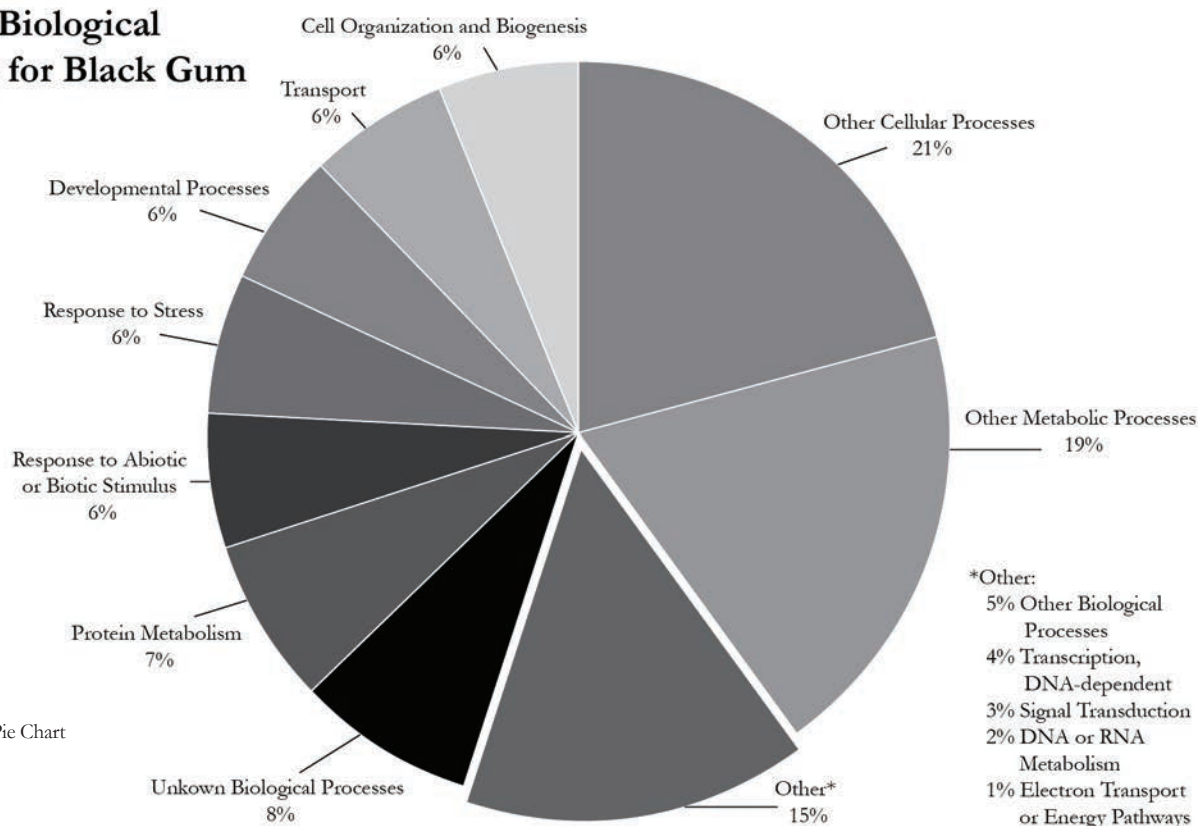


Figure 3. Black Gum Pie Chart

etc.). It should be noted that the different GO categories are non-exclusive, resulting in some contigs being placed into more than one category. For both species the most dominant biological processes represented were in the cellular and metabolic categories. Various biotic and abiotic stresses categories were also identified in major biological processes (Figures 3 and 4).

Figures 3 and 4 show that there was little difference overall in the various biological processes represented within the transcriptomes of the two species; yet, tulip poplar displayed more ozone induced injury than the black gum after qualitative analysis. This suggests three possibilities to explain differences in visible ozone injury: 1) that the physiological and metabolic processes occurring in response to stress in black gum are more efficient in preventing ozone toxicity than in tulip poplar, 2) that differences in levels of expression of individual genes are more important than the number of genes represented in each category, or 3) or that there are yet other uncharacterized processes, such as constitutive structural differences, that make some species more tolerant to ozone than others.

To investigate gene expression in more detail, the RNA-seq approach was used to identify genes (transcript contigs) that were

	Avg. Length (bp)	Count	Total Bases
Black Gum			
Reeds, total	132	12,229,343	1,619,402,038
Assembled reads	131	9,262,527	1,221,528,338
Unassembled reads	134	2,966,816	397,873,700
Contigs	729	46,794	34,127,914
N75	507		
N50	938		
N25	1,608		
Minimum	104		
Maximum	8,508		
Tulip Poplar			
Reads, total	135	144,118,935	1,901,357,265
Assembled reads	135	11,649,363	1,567,160,429
Unassembled reads	135	2,469,572	334,196,836
Contigs	822	39,224	32,246,212
N75	566		
N50	1,148		
N25	1,943		
Minimum	102		
Maximum	7,876		

Table 1. RNA sequencing and transcript contig assembly statistics summary.

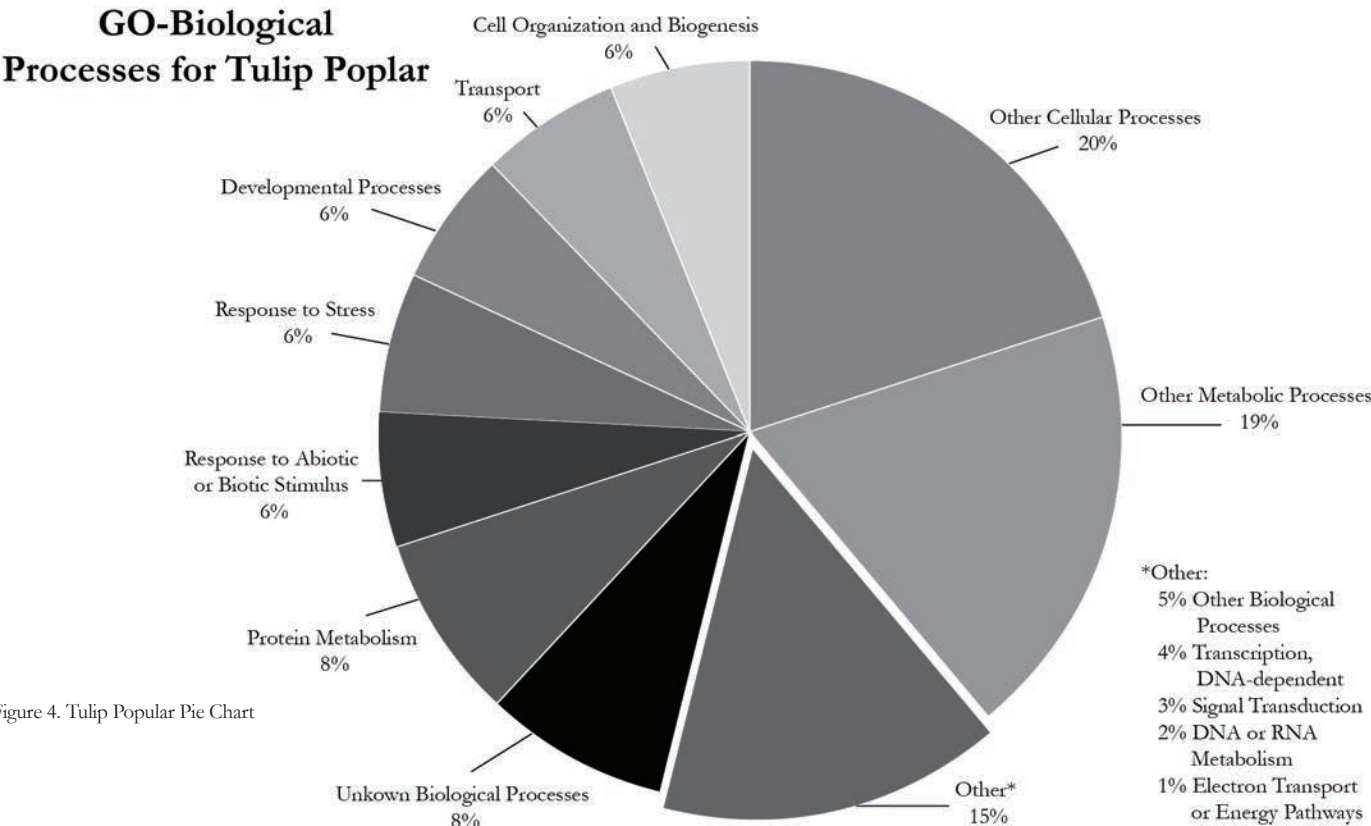


Figure 4. Tulip Poplar Pie Chart

Table 2.
Number of differentially expressed genes identified in black gum at different magnitudes of expression, at each ozone treatment level.

Black Gum	80 ppb vs. CO	125 ppb vs. CO	225 ppb vs. CO
2-fold	2517	2928	4426
2-fold upregulated	51%	47%	47%
4-fold	1541	1619	2385
4-fold upregulated	51%	47%	54%
8-fold	902	858	1229
8-fold upregulatd	50%	46%	54%

Table 3.
Number of differentially expressed genes identified in tulip poplar at different magnitudes of expression, at each ozone treatment level.

Tulip Poplar	80 ppb vs. CO	125 ppb vs. CO	225 ppb vs. CO
2-fold expressed	2236	2191	4114
2-fold upregulated	51%	44%	47%
4-fold expressed	1426	1425	2391
4-fold upregulated	54%	49%	48%
8-fold expressed	829	761	1345
8-fold upregulatd	50%	47%	44%

differentially expressed between ozone treatments and control. A summary of the results is presented in Tables 2 and 3. Plants, in general, respond to oxidative stress through a series of complex interrelated processes. In that context, we found that differential expression analysis identified a higher percent of genes that were up-

regulated in black gum than in tulip poplar, but only at the highest ozone level (Tables 2 and 3).

Discussion

The goal of this study was to identify the overall pattern of gene induction under oxidative stress. Our results indicate that

the response of the two selected species was transcriptionally similar except at the higher ozone exposure, where we also detected visual differences. Both functional annotation and differential gene expression analysis showed that there was high similarity in plant response to ozone stress even though the two species had differential response in terms of severity of leaf injury. A potential limitation of our approach is that while high throughput sequencing technology provided us with opportunities to study transcriptome dynamics by providing a wealth of information, emphasis on detailed examination of the differentially expressed genes may provide better insights into mechanisms than global comparisons of expression.

Gene expression analysis through RNA-seq and high throughput sequencing provides an effective method for investigating the response of non-model species to oxidative stress. The study of harmful ozone effects on plant tissue is widely applicable to oxidative stresses, because plants with an ability to respond to ozone stress might have an advantage in the context of pollution. Our future research will thus emphasize more detailed studies on the roles of differentially expressed genes. Particular interest should be placed on the expression of genes encoding

the enzymes involved in the metabolic pathways related to stress signaling.

Conclusion

Our report is one of the first on the comparative transcriptome analysis of ozone stress in hardwood species. Our results show that black gum was more ozone tolerant than tulip poplar in terms of foliar injury but the differences in leaf injury cannot be explained by the overall gene expression patterns. Therefore, identification of specific genes with protective function could provide more insight into sensitivity/tolerance to ozone stress. These results provide a foundation for understanding the molecular mechanisms of the oxidative stress response in woody species.

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An Analysis of American Drone Strikes in the Middle East, North Africa Region and the Development of Radical Anti-Americanism

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Abstract

Drones, or unmanned aerial vehicles (UAVs), are remotely piloted aircraft that have been widely used by Western militaries and governments, particularly the United States of America, in a number of conflict situations. Because of the current gap in research and literature surrounding this topic, as well as secretive operations that subsequently lack public accountability, the full extent of the American drone program is undisclosed and its impacts unknown. Through analysis of available opinion and empirical data, this paper examines the incidence of radical ideologies in the Middle East and North Africa (MENA) area related to the military deployment of drones by the government of the United States. Ultimately, while drones and radicalization in the MENA area are correlated due to a number of complex factors, there is no definitive direct causation between drone deployment and radicalization that can be determined at this time, however the longitudinal effects not yet observed could appear in the future.

Drones, or unmanned aerial vehicles (UAVs), are remotely piloted aircraft that have been widely used by western militaries and governments, particularly the United States of America, in a number of conflict situations. The technology boasts a number of benefits for militaries, from removing troops from combat situations and reduced costs, to having superior surveillance compared to traditional techniques such as fighter jets or boots on the ground. Furthermore, the most prevalent models (Reaper and Predator drones) can be used for both surveillance activities as well as armed capabilities by attaching and removing a payload that is used for striking and targeting combatants as well as extended monitoring missions. With these pragmatic benefits we have seen a proliferation of drone related activities in the Middle East and North Africa region in the last 10 years, notably with the continued War on Terror and the second term of Barack Obama's presidency.¹ This time period has been characterized by drones due to their use as a significant tool in the strategy for combatting insurgent groups unilaterally in Pakistan, multilaterally in Libya, and as a part of coalition forces supporting the AMISOM mission in Somalia.^{2,3}

Given this proliferation and extended uses of UAVs in countries like Pakistan, Iraq, Afghanistan and Libya, there are humanitarian and ethical concerns regarding strikes and the impact on civilian lives as well as the unintended radicalization of civil society. Scholars highlight the dangers that drone use poses in terms of creating more radical militants – as “more civilians [are]

killed” more militant attacks are provoked and anti-American sentiment is promoted.^{1,4,5} These claims have been refuted by the government on a number of occasions, like CIA Director Brennan's comments that drones deliver “targeted, surgical pressure” with civilian casualties being “exceedingly rare” and President Obama's claims in 2012 that “drones have not caused a huge number of civilian casualties.”⁶ It is undeniable, however that the apparent rapid growth of insurgent groups such as Daesh, al-Qaeda and al Shabaab have been correlated with American military ambitions in the region.

This paper will focus on the problematic impacts of drone strikes including extrajudicial killings, civilian casualties, sovereignty violations and the lack of transparency that results from signature Western state strikes. It will attempt to critically examine the relationship between UAV deployment by the United States for use in the Middle East North Africa region in a military context and the extent to which an argument can be made that civil society becomes radicalized into pursuing purposeful retaliation against the United States as a result.

Applications of Drones

The uses of UAVs are incredibly varied. While most often associated with targeted strikes using missiles, drones can be applied in the context of unarmed activities for surveillance and reconnaissance as well. Drone surveillance has become a fundamental pillar to military intelligence and has proven to be an invaluable resource

to military operations. The remotely operated vehicles are flown by operators as far as a few thousand miles away through sophisticated satellite relay and a live video feed from mounted cameras on the belly of the machine, or within a smaller range via direct video feed. They have capabilities to monitor the movements of rebel groups over vast areas of terrain such as deserts and other geographically hostile regions. Long-term surveillance capabilities are possible as UAVs can hover over targets for more than 14 hours without refueling or stopping for pilots to rest.⁷ A huge advantage of drone use is that they are unseen and undetectable. Further uses include monitoring internally displaced people and refugees, and surveying zones affected by natural disasters. Officials have used drones to monitor the aftermath of the Nepal earthquake and recent industrial explosion in Tianjin, highlighting civilian application of drones.⁸ These surveillance drones can take the form of the largest UAVs, such as the Predator drones and the Global Hawk, or cheaper, smaller hand-launched drones like the Switchblade or Nano Hummingbird.⁹

More important in the context of this paper are the armed, military applications of drones. Similar to their surveillance counterparts, armed military drones can come in a variety of forms with similar control systems, though the prevailing varieties are the American produced Predator and Reaper drones which are equipped with Hellfire missiles or other payloads. The precision strikes that are characteristic of armed military drones target militants that

have been identified through previous surveillance and intelligence gathering. A drone will regularly monitor a compound in which a suspected combatant or terrorist is hiding in by hovering in the air for as much as 36 hours, and will wait for the authorization to conduct a strike to eliminate the threat.

In the Middle East and North Africa drones have been used extensively to fight terrorism since 2002.¹ UAVs have seen significant deployment in Pakistan, Afghanistan, Iraq and to a lesser extent in Iran, Syria, Palestinian territories, Yemen, Egypt, Libya, Sudan, and Turkey. Additionally, there are drone bases located throughout the region and within striking distance of a number of states, from Djibouti, Ethiopia and the Seychelles, to Saudi Arabia, Israel, Qatar, Bahrain, the United Arab Emirates, Afghanistan, Pakistan, and Turkey.

Problematic Associations with Drones

While the government of the United States maintains that the missiles used by drones are incredibly precise compared to the capabilities of fighter jet alternatives, the resulting property damage and civilian casualties have long been a criticism of the technology. Moreover, as a UAV gives its operator a live video feed of what is underneath, a minor lag in the images exist and many have brought up the issue of context in relation to what UAVs can 'see.' The scope of a drone's video feed has been compared to the view from a straw, with only a small aspect of the wider scene being taken into account. An operator will not be able to see a school or hospital out of the frame of the images they receive for example, and the effects of a strike can be devastating by resulting in unintended casualties and damage to civilian property. In the past drone strikes carried out by the American military have inadvertently killed U.S. citizens, for example in a January 2015 strike on the Afghanistan-Pakistan border region that killed an American and an Italian hostage, as well as the targeted militants.¹⁰

Along with the accidental killing of civilians and collateral damage, a major issue emphasized by the United Nations Human Rights Council (UNHRC) is the prevalence of extrajudicial killings that are a significant aspect of armed strike strategy.¹¹ The UN has otherwise been unable to address the issue of drones through a binding resolution at the Security Council due to the permanent five vetoes (China, France, U.S., Russia & U.K.) being highly invested in the manufacturing and deployment of drones. At the current time there is little political will from the P5 to address the issues of drones at the UN level. There has been a UNHRC Resolution passed in 2014 that challenges the legality of U.S.

drone strikes, however the U.S. delegation dismissed the vote saying they "do not support efforts to take [the UNHRC] in that direction... or well suited."¹²

In Yemen, Pakistan, and Afghanistan, among other countries, alleged militants are subjected to lethal force without any legal process or the right to a fair trial. In these cases, UN Special Rapporteur Christof Heyns argues that suspects are denied due process and the requirements of international human rights law are abandoned under the assumption that suspects are "terrorists" without sufficient evidence, or the right to defense in a court.¹³ A prime example is the controversy surrounding the 2011 killing of American-Yemeni Anwar al-Awlaki in Yemen who was targeted and killed in a strike without a trial, the ability to respond to claims against him or defend himself through due process in a court of law, in a country against which there is no declaration of war. His son, Abdulrahman al-Awlaki, was also later killed by a drone strike in Yemen, in the same year, despite not having any connection to terrorism.¹⁴

In most cases the results of these extrajudicial killings via strikes are unavailable to analyze as exact death tolls unavailable for public scrutiny. These conditions, exacerbated by the general ignorance of American civil society about drone issues, have kept domestic pressure off of the American drone program. This has resulted in a sense of impunity, despite controversial strikes and numerous civilian deaths. As of 2015, the American military is not obligated to investigate or report the effects of their drone strikes, and with a lack of information available it is very difficult to examine and know the full extent of drone deployment in the Middle East and North Africa.

Between 2004 and 2011 alone, the number of deaths from drone strikes in Pakistan ranges from 1,500 to 2,500 people.¹ Moreover, under the rules of engagement all "males of fighting age" are deemed permissible targets.¹⁵ With combatants' increasing use of civilians and urban areas to disguise and shield themselves, the distinction between the "bad guys" and civilians is becoming less distinguishable. Incidents are rarely investigated and even today precise numbers of civilians and militants killed in strikes remains unknown and unavailable beyond secretive government operatives such as the CIA.

The marked impunity enjoyed by the American government and lack of transparency and accountability for the effects of targeted strikes creates a highly problematic precedent regarding the use of force by powerful state. While international law and the United Nations states clearly

that arbitrary and extrajudicial killings are both unethical and illegal, the United States justifies its operations through its domestic legislation of the Authorization of the Use of Military Force passed shortly after 9/11. This legislation is what the U.S. government argues gives it the legal ability to conduct strikes internationally when an al-Qaeda (or affiliate) is arbitrarily deemed to pose a threat to the "American Homeland." Where American domestic law vindicates drone activity in the Middle East and North Africa, the incursions and disregard for state sovereignty in countries where covert drone use has been prolific (for example in Yemen where there is no declaration of war yet American strikes have been conducted) is undeniable.

The Relationship Between Radicalization, Terrorism and Drones

Amid the problematic, illegal and unethical circumstances associated with drones, is the argument made by scholars in the social sciences that their deployment works against Western interests and actually radicalizes otherwise moderate civilians as a consequence.

Drone use has demonstrated clearly the undermining of the protection of life and personal security through their deployment as a deadly weapon since their debut in the Middle East and North Africa in the early 21st century.¹³ By March 2011, according to some estimates, drones had killed 33 Taliban and al-Qaeda high value targets and anywhere from 1,100 to 1,800 insurgent fighters.²³ In the same time period the frequency of strikes and related deaths have increased in the area, and other sources cite death tolls in Pakistan hovering "imprecisely between 1,500 and 2,500 people."¹

In Pakistan to date, the predictions of civilians killed by CIA drone strikes ranges from 2,471 to 3,983.¹⁶ Another 476 to 705 estimated people have been killed when the statistics from Yemen are factored in, and from Afghanistan an additional 416 to 592 deaths, from the same source. An overwhelming majority of these deaths have occurred under the Obama administration since 2009, with a possible total number of deaths reaching more than 5,000 between just those three countries in the past 10 years. Moreover, at least 2,464 people have been killed by American drone strikes outside of declared war zones since President Obama took Office. Research by the Bureau of Investigative Journalism further shows that there has been nine times the amount of strikes carried out in Yemen, Somalia and Pakistan under Obama than his predecessor. Within these unstable states, prosecuting combatants is "inefficient" and the intelligence against the suspects is often

inadmissible, so it has become “more politically palatable to kill suspected terrorists.”⁷⁷

The argument follows that drone strikes and the deaths associated with them increases anti-Americanism and recruitment for terror organizations, and that American counterterrorism efforts have intensified violence and instability.⁵ The non-militants who are impacted disproportionately and negatively by strikes in the Middle East and North Africa have provoked the creation of additional “adversaries.”

Eland, a defense analyst, posits that drone strategy is counter intuitive to counterinsurgency efforts by killing civilians, thus creating more radical militants and “breeding more terrorists.” Instead of civilians recognizing the over arching goal of eliminating al-Qaeda terrorism and stabilizing states they see “missiles raining from the sky” and seek to rebel against those whom they see as the hostile force.¹⁴ Drone strikes can give radicals the impetus for recruiting terrorists and expanding their organizations and may “convert entirely non-radical individuals” due to the “havoc wreaked” by American drone strikes.⁵

When civilians are killed in drone strikes the level of trust is eroded between civil society in the MENA affected countries and the West, resulting in a “blowback.” Hudson identifies distinct forms of unintended consequence due to drone strikes in the Middle East:

- i. Purposeful retaliation against the United States;
- ii. Creation of new insurgents;
- iii. Further destabilization;
- iv. Deterioration of American-Eastern relationships.¹

If we consider the recent trends of terrorism in the last decade however, Hudson’s theoretical approach claiming purposeful retaliation against the West as opposed to other targets, arguably the primary claim of the “blowback” theory, is statistically unsubstantiated and distorted.

In the first decade of the 21st century as the World Development Report shows, the overwhelming majority of attacks resulting in fatalities were aimed at non-Western targets, with the exception of the 2001 World Trade Center attacks in New York, which is an anomaly.¹⁷

The American drone program has expanded significantly since 2002, and with Western-aimed attacks remaining at the same level over the last ten years of available data from the National Counter Terrorism Center and Global Terrorism Database, the theory is severely weakened in relation

to the claim that the drone program has incited increased “purposeful retaliation” against the West with any significant impact compared to attacks carried out in the rest of the international arena. The graphic further illustrates that international terrorist attacks against the United States of America has decreased considerably since the 1970s, with the most active five years for attacks being between 1987 and 1991.¹⁸

Furthermore, even as U.S.-aimed terrorism has remained relatively stable in the years since 2001 in relation to global levels, the frequency of media reporting on terrorist activities has sharply increased and remained comparatively high. This is despite the data that suggests that the American experience (where a significant proportion of media content is coming from) of terrorist incidents in 2009 is less than the levels in 1999. The data provided by Factiva (as contained in World Development Report 2011) shows that the media has consistently reported on terror at a high rate in the first decade of the 21st century giving the public perception of an increase in terrorist related activity in relation to the West.¹⁶ In reality, the scope of social media and 24-hour news cycles have given terror-related stories an increased exposure compared to other themes.

The second dimension of the analysis provided by Hudson et al. (creation of new insurgents via drone activity) is supported through data to a certain extent as seen in a study conducted by Boås et al., as contained in World Development Report 2011. Rebel participation is generated through three statistically significant factors: unemployment/idleness (39.5%), to feel more secure/powerful (15%), and due to belief in the cause/revenge/injustice (13%).¹⁷

Where these three factors are considered to contribute to rebel or radical participation they can be rationalized as by-products of Western military activity and state dynamics rather than drone deployment specifically. Unemployment and insecurity are benchmark characteristics of conflict zones and economic strife in the affected Middle Eastern and North African countries and cannot be attributed directly and solely to the deployment of drones.¹⁷ Additionally, it is impossible to “prove direct causality from data analysis alone.”¹

There is merit to the argument that American engagement is unintentionally creating “accidental guerrillas” through military activities, which includes drones. Throughout the region there are a number of groups that have pledged allegiance to al-Qaeda or Daesh, and are fighting the United States in the years since the War on Terror

began. There has been more exposure of American personnel in the area and their military strategies have not been without controversy (for example Abu Ghraib).¹³ The recent expansion of Daesh through recruitment of over 20,000 foreign fighters and the ramping up of threats against the West is a distinct example of how American and Western coalitions have pushed radicalization to a certain extent. With the United States now deploying UAVs for strikes on Daesh targets from Turkey, this will almost certainly result in an aggravation of increased anti-American, anti-Western doctrine in the coming months as Daesh targets are eliminated.^{19,20}

Similarly, the claim that drones further destabilize the countries they are used in is difficult to definitively prove through data, though Gulmohamad presents a compelling narrative of how destabilization could occur when high-value targets are destroyed. It is known that Daesh was formed as a splinter out of al-Qaeda, due to diverging ideologies and the changing leadership generated by US and Iraqi forces eliminating commanders. Overtime, as these terrorist organizations have cycled through leaders with differing and increasingly more radical objectives, they have become better equipped to “exploit the vulnerabilities of the region” having learned from their predecessors in al-Qaeda or Jabhat Al-Nusra.²¹ As Western governments eliminate commanders and high-value targets from the membership of radical groups in the Middle East and North Africa, they risk expediting the evolution of ideologies into ones that are more extreme and prolific as new leaders take over. This is an obvious facet of the formation of Daesh in Iraq post-American disengagement in 2011 where a political void was left to be filled by the next regional hegemon. Moreover, the expansion of Daesh into the Sinai and the Sahel throughout the past year illustrates that destabilization can spill over into nearby areas and even across continents. The argument that instability prompted by the drone threat begets further instability is certainly passable in this context.

Finally, the last dimension of the theoretical approach brought forward by Hudson et al. is the “loss of the hearts and minds” of the people because of U.S. drone strikes. In a 2011 Pew Global Attitudes poll of Pakistanis, 95% of the population who knew of drone strikes believe that “they are a bad or very bad thing” and 69% of respondents disagree that strikes are “necessary to defend Pakistan” from extremism. A further 91% agree that drone strikes “kill too many innocent people.”²⁵

Similar polls were conducted in 2014 for national samples in Egypt, Jordan, Lebanon,

Palestinian territories, Tunisia, and Turkey by the Pew Research Center. The question was phrased as an approval or disapproval of the "United States conducting missile strikes from drones to target extremists in countries like Pakistan, Yemen, and Somalia." The disapproval rates in these Muslim-Arab countries were recorded as 87%, 90%, 71%, 84%, 77% and 83% respectively.²² There is a clear narrative in civil society across the region that drone strikes conducted by the United States are not welcomed and are generally seen as unproductive in the Middle East and North Africa.⁹

Conclusion

Scholars in the social sciences, journalists, and experts alike have hypothesized about the relationship between drone use and radicalism in the Middle East and North Africa since 2004. While some theories and articles claim to show a direct causal relationship connecting the deployment of UAVs and terrorism as a consequence of civilian casualties, destabilization, and increased recruitment, this paper has demonstrated that while these factors do contribute, there is not a sufficient body of evidence that suggest drones create new insurgents, purposeful retaliation, or further destabilization. Conversely, there is research that shows the opposite effects and that drone strikes in Pakistan have decreased terrorist activities and lethality of attacks.²¹ Political and economic aspects including unemployment and disenfranchisement, as well as sentiments of injustice and revenge against military activity, are imperative to consider. Furthermore, distortions in media over the last decade have perpetuated a fixation on terrorism-related stories that carry forward the idea that terrorism is increasing as the American drone program has expanded.

Ultimately, while drones and radicalization in the Middle East and North Africa are correlated due to a number of factors, there is no definitive direct causation between drone deployment and strikes being the primary mode of radicalization that can be determined at this time. More realistically, as a complex process, radicalization and anti-American "blowback" results because of a number of aggravators, including upbringing, unemployment, unrelated social grievance, as well as injustice related to American military interventions. It is within reason to extrapolate that commonly observed dimensions today, including anti-Americanism and terrorism, would still be prevalent even if traditional "boots on the ground" strategies were more widely used compared to UAVs.

Likewise, the possibility exists that the

complete effects of drone deployment and subsequent related radicalization have not fully flourished in the ten years since drones have been used in the Middle East and North Africa to fight terrorism. There could be a delayed, more longitudinal response to the drone regime of the Americans in the region that has not been fully anticipated or felt in recent times. With the emergence and expansion of Daesh and militant groups increasingly pledging allegiance to them, like Boko Haram, AQIM, and possibly al-Shabaab, the full effects of the American drone program might have yet to be experienced.

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The Tarnishing of the Golden Years: The Economic Ramifications of Ineffective Long-Term Care Policy

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Introduction

Americans are living longer and as more baby boomers begin to retire, there are and will continue to be an unprecedented number of seniors requiring a plethora of services and accommodations. Presently, the United States is ill-equipped to manage the rising costs associated with this vulnerable population. When older individuals cannot afford to pay for home health care services, their spouses and other younger family members often become their informal caregivers. However, many are unprepared for the ensuing emotional and physical burdens of this role.

Relatives attempting to procure financial resources for an older individual must navigate the murky and often unfriendly waters of the health care system, and must become experts on Medicare and Medicaid. Many people are shocked to discover how complex the national health care system is and may become overwhelmed by its flaws and fallacies. Initially, many individuals falsely believe Medicare will fully subsidize long-term care (LTC) costs. Upon learning otherwise, those with higher incomes may opt to pay out-of-pocket for their own care until they deplete their savings. Consequently, Medicaid becomes the standard means in which many Americans finance exorbitant LTC expenditures. Seniors may gift their homes and other belongings to their adult children or grandchildren to meet Medicaid's strict eligibility requirements, a common practice referred to as "spending down." Older Americans must have incomes below the federal poverty line (\$11,700 for an individual and assets totaling \$2,000 or less) to qualify for Medicaid.¹ A shortage of college students and young professionals choosing to specialize in geriatric care further jeopardizes the ease and accessibility of providing social service delivery to this vulnerable population group. This paper will explore the national crisis of LTC and its impact on seniors, family members, the economy, and policy regulations.

Redefining Aging

Irrefutably, Americans are living longer and advances in modern medicine coupled with emerging insights into fostering healthy and more sustainable lifestyles are redefining conventional standards of aging in contem-

porary society.² An estimated 71.5 million people aged 65 years and older, almost twice the number in 2004, will live in the United States by the year 2030. Additionally, the 85 and over population is projected to increase from 4.6 million in 2002 to 9.6 million in 2030. This increase in life expectancy greatly impacts the structure and function of American society.³ Health policy scholars estimate that 35 percent of all Americans who turned 65 in 2005 will need institutional care. Moreover, individuals over 85, or those most likely to need LTC, will increase from 1.8 percent in 2010 to 4.3 percent in 2050.⁴

This unprecedented and exponential growth rate bleeds into the social and economic landscapes, and highlights the national need for more comprehensive bipartisan policies to meet the needs of older Americans. In 2010, Congress created a voluntary long-term-care insurance program as part of the health care law known as the Community Living Assistance Services and Supports (CLASS) Act, but it was repealed in 2013 after the Obama administration determined it was financially unsustainable.⁵ Consequently, the House Speaker and Minority Leader, the Senate Majority and Minority Leaders, and the President created a new 15-member Commission to make LTC support service recommendations to Congress.⁶

Whereas most major industrialized nations have adopted a social insurance model to provide LTC services to meet the needs of their aging citizens, the United States has focused on enhancing private insurance to drive down health care costs. Many individuals, however, cannot afford to buy these pricy plans with high premiums. To date, only about 10% of American seniors have purchased private LTC health insurance. If and when the remaining 90% of this rapidly expanding population group should require LTC services, the options are few and not always satisfactory.⁷

LTC policy remains ineffectively flawed, casting more shadows of doubt as to whether the government, both at the federal and state levels, is presently able to provide adequate funding for services to meet an increasing demand. The majority of older Americans must contend with a complex, unforgiving healthcare system, ill-equipped to deal with the staggering costs of aging.⁸

Many seniors, as well as their caregivers, remain unaware about the nuances of existing services and may have difficulty accessing the benefits they need. Social workers can play a pivotal role by advocating for vulnerable aging Americans and their families. They can educate concerned individuals about what Medicaid and Medicare will and will not pay for, as well as empower caregivers to seek emotional support for the exhausting roles they play.

Defining the LTC Crisis

An estimated 70 percent of Americans over the age of 65 will require some kind of LTC for at least three years.⁸ Twelve million Americans over the age of 65 are currently in need of long-term services and supports (LTSS). LTSS encompasses any institutional or home-based assistance including bathing, dressing, medication management, and other activities of daily living.⁹ By 2050, the number of older individuals utilizing LTSS will more than double and 35 percent of this population group will eventually enter a nursing home. There were 1.4 million people in nursing homes nationally in 2012.¹⁰ Moreover, 20 percent of seniors will incur more than \$25,000 in lifetime out-of-pocket LTC costs.¹¹

Total spending (public, private, and out-of-pocket) for LTC in 2012 was \$219.9 billion. This is projected to increase to \$346 billion in 2040.¹² Roughly one-third of all Medicaid Spending is for LTSS, and the Office of the Actuary of the Centers for Medicare and Medicaid Services (CMS) estimates that Medicaid spending on LTSS will grow by an average of six percent annually from 2012 to 2021, which is far faster than the Gross Domestic Product (GDP).⁹ Since health care analysts project long-term care expenditures to triple, policymakers must address the challenges of financing and delivering this type of care to its rapidly aging population.⁹

Despite the national trend toward providing seniors with home or community-based long term care services, the number of nursing home residents is projected to increase by two million by 2030. Health care administrators estimate they will need at least a 40 percent increase in nursing staff to meet this demand.¹³ The high costs of institutional care and the Supreme Court's 1999

Olmstead Decision, which mandates states to provide health care services in the least restrictive setting, has initiated a national dialogue about how to fund and deliver appropriate services to seniors.¹⁴

The face of LTC is changing and today's typical nursing home appears vastly different, if not unrecognizable in many regards, than it did even 10 years ago. The amount of time a patient stays in a skilled nursing facility is becoming less as LTC continues to focus on expanding community services.² Current LTC no longer implies custodial nursing home stays as it did in previous years. With annual nursing home care averaging about \$81,000 yearly as compared with part-time community and home care assistance costing \$22,000, it is easy to see why the latter is emphasized, as reflected in policy implementations and funding.⁸

Many Americans falsely believe Medicare will finance LTC costs. Medicare will only cover some LTC services for short durations, such as post-acute care after a hospitalization. Since a large percentage of Americans have not financially planned for LTC, Medicaid has become the primary way to pay for these services. This heavy usage of Medicaid undermines the original purpose of the program as a safety net for the poor and threatens its survival. Medicaid enrollment for dependent elderly continues to surge at unprecedented rates. Since state revenues are growing slower than Medicaid outlays, other national priorities such as higher education are getting squeezed so the United States can finance rising LTC costs.¹⁵

Caregivers

Informal caregivers, the friends and family assisting older individuals, provide \$450 billion of LTSS services yearly, making them the largest service providers for this population.¹⁶ Policymakers project it will be difficult for family caregivers, the backbone of today's system, to continue meeting this huge demand without adequate compensation. Publicly funded consumer-directed services offered under individual state Medicaid plan programs are a promising new development to help seniors stay in their homes and reduce national LTSS costs. Additionally, the 2016 Presidential Budget contains \$50 million for caregiving services, including assistance for respite care and transportation.¹⁴ Democratic Presidential candidate Hilary Clinton is proposing a plan to offer a \$6,000 tax credit for caregivers helping an elderly parent or grandparent. Additionally, she is seeking to expand Social Security benefits for caregivers.¹⁷

Generating more student interest in gerontology

With greater numbers of older Ameri-

cans needing health care and social services than ever before, it is concerning to realize social work and nursing students are eschewing employment positions working with seniors. Research indicates young students prefer to specialize in other health-care sectors that promise more prestige and correlates to a higher pay scale. LTC also has challenges in recruiting employers due to difficult workloads and the negative images associated with nursing home employment.

To meet the needs for this expanding population group, the current trend in many educational programs is to spur student interest in gerontology by offering specific training opportunities within the field. If students have unique opportunities to work in settings providing them with positive clinical experiences geared toward advancing their skill sets in age-sensitive geriatric care, they are more likely to pursue similar employment prospects upon graduation. Nursing students, for example, will likely benefit from participating in training seminars highlighting some of the intricacies of insurance reimbursement, as well as learning how to complete certain sections of the minimum dataset (MDS) that is used in nursing homes to assess activities of daily living, medical needs, and mental status to help develop a comprehensive plan care for seniors. Similarly, social work students can enroll in undergraduate and graduate courses exploring issues relevant to aging individuals, such as death and dying, hospice care, and the complex role of caregiving.¹³

Conclusion

Although people are living longer and requiring more assistance, LTC gets neither the public attention nor the policy focus that it deserves. According to an Associated Press poll, many Americans remain uninformed and unsure of what to do about LTC. Researchers found that 60% of Americans report never having talked to family about their care preferences and 44% of individuals incorrectly assumed that Medicare covers all LTC costs.¹⁸

According to a March 2010 Age Wave/Harris Interactive survey, Americans said they were more worried about becoming a burden to their family than dying. Furthermore, such individuals maintained that the emotional strain of being elderly and sick was more terrifying than even skyrocketing financial costs.⁶ Informal caregivers are providing the majority of LTC services and are in dire need of emotional support and financial compensation for the taxing roles they undertake. Social workers should encourage caretakers to practice self-care and to seek support as needed.

While medical breakthroughs are en-

abling some seniors to live well into their eighties and nineties, doctors are quick to point out that people are not necessarily living longer, but rather taking more time to die. Such pessimistic perspectives should force concerned individuals to reevaluate the current health care system in terms of how this nation is addressing the needs of its fastest growing population. Legislation must address pivotal issues such as the current and future retirement age, the prevalence of seniors in today's workforce, and offering financial incentives for caregivers.

It is increasingly important for social workers to help older Americans understand the basics of Medicare and Medicaid and to assist them with accessing their health care benefits. Since research shows that the majority of Americans are misinformed about the intricacies of what Medicare will or will not cover, social workers must educate seniors and family members to discern the differences between Medicare Parts A, B, C, and D as well as provide them with information about Medicaid, Social Security Supplemental Income, Social Security Disability and any other LTC insurance benefits.²

Policymakers should engage the public in conversations about affordable LTC service options, using simple language devoid of complex terminology and acronyms. Since research indicates most people want to age at home with dignity, independence, and choices, perhaps it would be more beneficial for legislators to talk about what people want and what can be achieved, rather than focusing on deficiencies in the system.¹⁹ In doing so, Daschle and Thompson argue that Americans will be more empowered to make smarter financial and health-care decisions earlier in life.¹⁶

Long-term care reform in the United States, which has thus far focused on expanding private insurance more attractive by offering tax incentives, has not been successful. A new long-term care model that combines social insurance and personal responsibility will likely benefit American society as a whole.⁷

Most people can now expect to live well into their golden years, but only a privileged few will be able to live comfortably, both physically and financially. Unfortunately, many seniors will require health care services they cannot afford. Countless others will remain uninformed about the complexities of the systems they will need to navigate should they become sick or injured. Without knowledge, insight and fortitude, older Americans will stay vulnerable victims as the long-term care crisis continues to mount.

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Popular Psychology and the Public Image

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How Freud still manages to give us a bad name 100 years later

"The real impact of psychology will be felt through its effects on the public at large, through a new and different public conception of what is humanly possible and what is humanly desirable."

-George Armitage Miller, 1969

You are sitting on an airplane, settling in for a long flight, when the person next to you turns and asks you your least favorite question:

"So what do you do for a living?"

You don't want to share but you also don't want to be rude and the CIA fib is a lot harder to pull off. So with a sigh you respond, "I'm a psychologist."

Chances are you won't be met with any kind of impressed response. No one exclaims, "Wow psychology! I hear that's a really tough field!" like they would for most other sciences. Instead, they will smile blankly and nod. They may even cheekily ask, "So what am I thinking about?" to which you generally know the answer; they're thinking about a petite balding man smoking a cigar and peering over his tiny glasses at a patient lying on a chaise lounge talking about their childhood.

This is a common image that comes to mind when discussing psychology. Most people who know very little about the subject tend to think about Freud, Rorschach tests, mind-reading, telekinesis, hypnosis – the list goes on. Although these are frequently associated with psychology and are even still studied by some, they couldn't be farther from what the field truly represents. Often thought of as a soft science, psychology has to fight hard to be taken seriously in the realm of research and scientific study, losing out to other fields like chemistry and biology in terms of importance and credibility. There are many reasons for this perceptual distinction between science fields, but much of the bad name that psychology gets is due to common lingering misconceptions about psychological practices and aims.

There seem to be two competing fields when it comes to psychology: psychology and popular psychology. Topics of popular psychology tend to include anything that will capture the public's attention while actual psychology focuses on ways to study and apply concepts and ideas, either with the goal of furthering science or creating help-

ful new techniques for assessing, diagnosing, and treating disorders. The line can become somewhat blurred, as many of the punchy news headlines build off of real evidence. However, they generalize, exaggerate, misinterpret, and often only focus on high-impact results. This creates an oversimplified depiction of psychology that focuses on irrelevant topics that are often studied by peripheral experimenters or are side projects to the main work of many respected researchers.

One way this is done is through the use of misleading headlines that help news outlets gain more readers, but fail to actually deliver any corresponding results. Studies have shown that headlines can influence how a news article is processed and lead to misinformation about the actual content of the article.¹ One example of this was a recent article that had the title "REVEALED: How these colors affect your mood" and a sub-header that stated that yellow makes people happy.² The article described a "study" that supposedly provided insight into the "psychology of color" by interviewing people about how they felt about certain colors. There was no indication that any color affected mood or elicited a particular emotion, but this wasn't clear from the headline. They also didn't include any information about methodology, participants, or where the original study could be found. Instead they provided vague references to the milk company that conducted the study to determine what color to make the lids of their milk containers. By using misleading headlines and describing the presented information as "psychology", the article was able to make readers jump to false conclusions. Articles like this pop up a lot on social media websites. They take the term psychology and apply it to fluffy topics that loosely fit into the public perception of what psychology is and further damage the already fragile scientific image that psychology has.

However, the largest contributor to common misperceptions surrounding psychology is one of its most talked about figures: Sigmund Freud. Although he helped provide

direction in psychotherapy and proposed some reputable theories, Freud also created a flawed image of psychology that still lingers. Freud's work began in the 1880s, but this doesn't mean that everyone has abandoned his expired ideas.³ His debunked theories and ideas – such as the Oedipus complex, unconscious sexual drives, the id, dream analysis, and many more – are still discussed and taken seriously today due to his lasting legacy. His theories are taught in most basic psychology courses, often having a whole class period devoted to them, and they tend to be what people talk about the most.⁴ It's not unusual to hear someone refer to a verbal blunder as a Freudian slip and many phrases such as "being anal" or having "penis envy" are still commonly used.

Freud's ideas have contributed to the popularity of many questionable topics of psychology. Much of this is based off of Freud's obsession with the unconscious, as he liked to analyze everything for a deeper meaning. While unconscious processing and the idea of a "hidden mind" are both valid ideas that have scientific backing, Freud's application of the unconscious was dubious.⁵ From our feelings about our parents to verbal slipups and dreams, everything was fair game for having a darker, murkier backstory submerged in our unconscious mind. Dream analysis has become especially popular. Freud's book *The Interpretation of Dreams* resulted in many other "interpretation guides", such as *Dream Interpretations for Beginners*, *Dream Decoder*, *The Dream Book: Symbols for Self-Understanding*, *The Meanings of Dreams*, *Llewellyn's Complete Dictionary of Dreams*, and many, many more. These started becoming popular in the 1970s as a do-it-yourself way to get to know yourself better and use your dreams to interpret the world you live in. However, dreams serve no function in revealing anything about future events or deeper feelings.⁶ There are no underlying sexual meanings to every scenario that you mentally experience while sleeping. Instead, dreams serve a more important function in

memory and learning. Research has shown that dreams are a method of memory consolidation and integration that occur during sleep.⁷ While this may not be as exciting as looking for the deeper meaning of phallic shapes in your dreams, it's certainly more practical.

From the obsession with what lies beneath our own mental messages a new obsession with what lies beneath the messages of others began to surface. The spillover of Freud's "fixation" on the unconscious can be seen in the research done on subliminal advertising and how it targets our subconscious. This has yielded some valid results, such as the effect of subliminal messaging on participants in a controlled laboratory environment.⁸ However, it has also served to cause panic, induce fear of "mind control", and to—once again—muddy the public image of psychology. Subliminal advertising is a commonly discussed topic, but the very foundation of its effectiveness has been proven wrong. It first surfaced in the 1950s with Vance Packard's book *The Hidden Persuaders* and persisted with the increasing number of publications on the topic. However, most of these books were based off of the work of James Vicary, who claimed that he could increase popcorn and Coca-Cola sales by using subliminal messages during movies.⁹ He later admitted to fabricating his work but this did not stop the belief in the effectiveness of subliminal messages from spreading and becoming a widely accepted phenomenon today.^{10,11}

Some incorrect experiments pertaining to subliminal processing are still taught in classrooms today. Social psychology courses often describe the experiment in which participants are primed with either neutral words or words pertaining to old age, and then, as they are leaving and under the impression that the experiment is finished, timed on how long it takes them to walk from one point to another.¹² The researchers found that those who were primed with "elderly words" took considerably longer when leaving.¹³ However, the results of this experiment are questionable, as replication studies have failed to get the same results unless the person who measures walking speed is aware of which word group the participant receives. This suggests that there was no difference in walking speed, just in perceived walking speed. When the experimenter was unaware of which condition the participant had received, the walking times were comparable.¹⁴

Another major misconception—and often the subject of many newspaper comics and cartoons—is the use of the Rorschach Inkblot test by psychologists. Projective tests—or tests that use an ambiguous stimuli and

require the patient to "project" their feelings and personality onto it—include the Rorschach test, word association tasks, many picture drawing activities, and the Thematic Apperception Test in which subjects interpret a scene.¹⁵ The Rorschach test was created by a Freudian psychoanalyst named Hermann Rorschach.¹⁶ While this test was not directly produced by Freud, it was loosely based off of projection, one of his proposed defense mechanisms in which we impart our feelings or emotions onto others in order to shift blame.¹⁶ Projection, along with the other defense mechanisms that he discussed, have been found to be fairly valid observations about human behavior and have been expanded on greatly by modern psychologists.^{17,18} However, this does not mean that projective tests are also valid. While they may be good tools for getting a patient to open up and talk about their problems, there is no evidence to support the idea that the patient is revealing anything about their individual issues that would help a clinician in assessing, diagnosing, or treating problems.¹⁹ In a meta-analysis of Rorschach Inkblot scores, a group of researchers found that there is an alarmingly high false positive rate for psychopathology and that it is a weak tool at best.²⁰ However, the popularity of projective tests persists despite our inability to tell anything about a person from what they might see in a smudgy grouping of ink blobs.

Freud has not only influenced what ideas people associate with psychology, but also what images. The "typical psychologist" tends to look an awful lot like Freud, and the mental depictions of therapy sessions often involve the classic Freudian structure of a patient lying down talking to a therapist. This Freud-infused image has become so pervasive in comics, television, and movies that many now associate psychologists, and therapists in particular, with men. This image made more sense in the 1970s, when women only made up about 20% of doctorate recipients in psychology, but this number has since flipped.²¹ According to APA's Center for Workforce Studies, the gender gap is widening and men now make up less than 20% of Master's degrees in psychology. As of 2013, 68.3% of active psychologists were women.²² Despite this drastic change in demographics, psychologists are still generally thought of as male. There is also an overemphasis on therapists, when in reality there are many different branches and classifications within the broad overarching title of "psychologist". While this is not a myth so much as an incorrect depiction, it also owes much of its basis to Freud and his inexplicably lasting hold on psychology.

There are still plenty of other myths about psychology that are floating around

and that remain popular with the public: self-help books, Baby Einstein, polygraph tests, parapsychology, manifestations of schizophrenia and bipolar disorder, and many pieces of "folk wisdom". Psychology is not without its problems, such as replication failures and previous unethical practices, but the public obsession with popular psychology is detrimental to the field as a whole. It contributes to the stigmatization of those who have mental disorders, degrades the credibility of psychology in the research community, and tells a story of psychology that is incomplete and incorrect. This strengthens our status as an unethical bunch of pseudoscientists and results in a strange desire to lie to strangers on airplanes.

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