**Lengthy Personal Statement by a Mechanical Engineering Student—5 pages**

As long as I can remember I have always gravitated towards mathematics and science, tinkering with alarm clocks, launching model rockets, excelling in calculus and physics courses, and reading about great scientists and inventors like Albert Einstein and Thomas Edison. When I came to Mythic University, I knew that I wanted to pursue a major that involved science and mathematics, but I wanted to be able to apply these concepts to inventions and developments that would benefit society. Consequently, I decided to study mechanical engineering, taking classes in and engaging in research about combustion, fluid mechanics, and propulsion.

While I had enrolled in mechanical engineering in freshman year, it was not until the first semester of junior year that I realized I wanted to be a mechanical engineer. That semester, I took six engineering classes, and two of them especially drew me in: fluid mechanics and thermodynamics. Since then, I have taken an elective laboratory class in fluids, I have enrolled in a class on compressible flow next semester, and I am currently studying small-scale fluid mechanics for my senior honors thesis. Additionally, I was finally able to answer my dad, an avid baseball fan and reader of Robert Adair's *The Physics of Baseball*, when he pestered me, "John, you're the scientist in this family. Why does a curveball curve?"

When I began my research with Dr. John Teacher in the Propulsion Engineering Research Center, I was also given the opportunity to apply my knowledge to a laboratory setting. My first project was to design and assemble a portable gas flow system. I learned invaluable information about experimental methods by conceiving this system, finding the necessary parts and looking up specs sheets, and finally putting it all together. Now that I have almost finished constructing the system, I feel a strong sense of accomplishment knowing that this is my own creation.

At the beginning of this semester, I began engaging in my senior honors thesis project. My thesis satisfies the innate curiosity that I had when I was eight years old and taking apart alarm clocks. In my thesis, I am examining the propagation of a flame in a small glass tube. Right now, I am at a very exciting stage of the project, having just created my experimental apparatus and begun gathering data. Taking the first pictures of the flame and gathering the first velocity measurements with the photo diodes has been a thrilling experience. This stage of the research process has made me aware that I love doing research. For me, it's an opportunity for constant intellectual stimulation, satisfying my yearning for knowledge and serving as an outlet for my creativity. My thesis project experience has motivated me to continue in research in graduate school and hopefully afterwards as a college professor.

The most exciting aspect of my research experience thus far was helping to create an instrument to be used in my lab. I designed, ordered parts for, and helped assemble a portable experimentation station for our laboratory. It is a self-contained tabletop device (approximately 19” x 17” x 6”) that produces regulated gas flows at precise flow rates to be inputted into an experimental apparatus.  It also measures data from the experiment. The purpose of this device is to enclose all the necessary hardware for running combustion and propulsion experiments into one compact, portable apparatus. Figure 1 shows the portable system in the assembly stage.

*Figure 1: Portable Experimentation System.*

The device utilizes a choked nozzle of ~100-μm-diameter to produce a known, constant flow rate, independent of downstream conditions. The flow rate can then be adjusted by regulating the pressure upstream of the orifice. The portable station houses three 300-mL gas supply tanks (to store the gases at ~1800psi), pressure transducers and thermocouples (to take the upstream pressure and temperature measurements used in the calculation of flow rate), and compact pressure regulators (to adjust the upstream pressure and, hence, the flow). An external digital data acquisition card and laptop computer with LabView will then be utilized to record the data and calculate other parameters, such as mass flow rate. The system is designed to produce flow rates ranging from 0.2 to 1.5 LPM. My fellow lab members and I intend to use this portable system to perform experiments in other laboratories, for technical demonstrations in college classrooms, and at scientific conferences. Now that I have almost completed that project, I am engaging in my senior honors thesis project. I am performing an experimental study to determine the prevalence and nature of frictional effects in narrow channels (on the scale of 1 mm), by studying the propagation of a flame.

Since conventional fluid mechanics is based on the assumption of a continuous fluid (i.e., not a substance composed of many individual particles), there is a lower limit at which the laws of traditional fluid mechanics break down. This is because of the increasing significance of the behavior of individual particles that no longer allow the fluid to be considered continuous. I am attempting to determine this lower limit in circular channels and analyze the behavior of fluids under those limits. Several papers have been dedicated to small-scale flame propagation, such as James D. Ott's "A Mechanism for Flame Acceleration in Narrow Tubes," but currently no experimental work has been done to establish the actual behavior of small-scale fluid mechanics and combustion. This project will shed new light on the concepts alluded to by Ott, by essentially mirroring this study with an experimental rather than computational approach.

Theory predicts an acceleration of the flame as it propagates for two main reasons. The first is that the burned mixture, at high temperatures and high local pressures, behind the flame, act as a piston propelling the unburned mixture, through which the flame is traveling. Since a subsonic flame travels at the laminar flame speed relative to the unburned mixture, propelling the unburned mixture will result in a faster flame speed relative to an outside observer. Additionally, frictional effects actually serve to accelerate the flame even further, due to the formation of a boundary layer in the unburned mixture. This boundary layer restricts the cross-sectional area available for the propelled unburned mixture and thus the area available for the flame to travel. Since mass flow rate remains constant due to conservation of mass, the velocity must increase. Thus, by studying the acceleration of a flame through a narrow channel, I can gain insight into the nature of frictional effects and other behavior of fluids on such small scales.

As noted above, I have created the experimental apparatus and have begun to perform experiments. My setup includes a 91-cm-long, 1-mm-diameter glass tube with a tungsten filament at the center to ignite the ethylene-oxygen mixture, photo diodes to record when the flame reaches certain points in the tube in order to determine velocities and accelerations, and a digital camera triggered by the photo diode signal to gather information about the flame profile. Figure 2 illustrates the glass tube assembly.

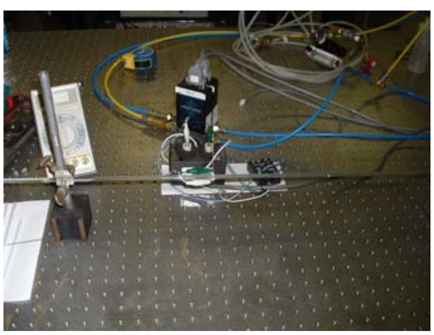

*Figure 2: Glass Tube Assembly.*

Preliminary results indicate that the flame reaches supersonic conditions. A picture of the flame integrated over its entire path reveals a bright spot followed by a luminous streak at ~25cm from the point of ignition as depicted in Figure 3. I suspect that the flame achieves detonation at this location. I performed a calculation in CEA (NASA computer program, Chemical Equilibrium with Applications) and determined the detonation speed to be ~2470 m/s, which coincides with the measured velocity of ~2400 m/s. Building on this small initial success, I need to do more work to gather a complete velocity profile though the tube and compare my results with those predicted computationally.

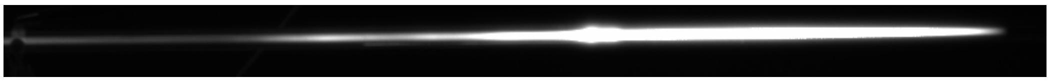

*Figure 3: Integration of the Entire Flame.*

For further study, I may employ smaller tubes to carry the flame, gather pictures of the flame with a high-speed camera to ascertain the flame shape, or obtain schlieren images to analyze shock formations. When I take the glass tube assembly to other specialized labs with such sophisticated instrumentation, such as a high-speed camera or schlieren imaging apparatus, I will utilize my portable experiment station to supply regulated concentrations of combustible mixtures to the tube.

My results will ultimately be used in designing MEMS (Micro Electromechanical Systems) devices as applied to micro-propulsion thrusters for station-keeping of small satellites, a major area of study in our group.  Additionally, since this information has wide-ranging applications to numerous other fields, I plan to publish a technical paper in a scientific journal in order to share my findings with other engineers and scientists.

In graduate school and likewise in my career, I want to pursue research topics that have application in future energy use in the United States and other countries around the world. As a mechanical engineer, I can address those issues by exploring the fundamentals of and designing new methods of clean combustion and alternative fuels. One particular topic I am intrigued by is electrochemical fuel cells. These devices have the potential to be the future of our energy storage and conversion. Fuel cells are a possible method of providing power that is both clean and efficient. Potentially, they will have applications in powering laptop computers, cellular telephones, and automobiles. As of now, fuel cells are still a rising, albeit crude, concept that requires time and the attention of our country's great scientific minds to come to fruition. I want to do my part to help advance this budding and exciting idea, which I consider to be the future of energy.

Currently, however, there remain serious problems with the practicality and feasibility of this concept that need to be solved. First of all, hydrogen, in and of itself, is not actually an energy source. Consequently, an energy source such as coal power, which accounts for 51% of the United States power generation, or gas, which accounts for 16%, is needed to produce pure hydrogen, in which case we are still faced with harmful emissions and waning hydrocarbon resources. Additionally, since hydrogen is a gas at atmospheric pressures and reasonably achieved temperatures (T>20K), hydrogen must be stored in a high-pressure vessel, which has the potential to burst, or in the form of methane or methanol, which must be processed to obtain pure hydrogen by a reformer (a catalytic heated chamber that strips the hydrogen from methane) that releases carbon dioxide, a greenhouse gas, and reduces efficiency by about 30-40%. Another concern that requires attention is the efficiency of the fuel cell itself. Electrochemical fuel cells have ideal efficiencies of around 80%. However, efficiencies achieved now are much lower—around 40-70%.

As a mechanical engineer, I want to investigate this aspect of fuel cell design and development, as this is the area in which I have the background and desire to study. Dr. Fredrick Prinz of Stanford University has determined that higher efficiencies can be achieved by utilizing smaller channels. Such information might also be implemented in the design of higher-efficiency, large-scale fuel cells composed of these smaller channels. Considering my interest and background in small-scale fluid mechanics and MEMS (Micro Electro-Mechanical Systems) devices, I aim to explore topics related to the micro-fluidics and scaling effects of these fuel cells.

My current study of the frictional effects and fluid behavior in small channels will provide me with the proper knowledge and experience necessary to pursue this topic. In my graduate study at Stanford University, I intend to study under Professor Prinz to advance the development of electrochemical fuel cells, which have extensive capabilities in the future of energy, by improving their efficiency. My communications with Dr. Prinz thus far have been promising, and I hope to have the opportunity to realize this promise during the coming fall at Stanford University.

**Lengthy Personal Statement by a Liberal Arts Student—3 pages**

*Personal Statement—John Lerner*

Mythic College has been my home for more than three years. Our relationship started very innocently with an advertisement campaign in which three separate postcards arrived at my house over the course of a month entitled simply *Think*, *Evolve*, and *Act*. At the time, I was like many other high school kids: I knew everything. I was in the top ten percent of my high school class—I knew academics. I lettered in track three years in a row—I knew athletics. I was actively involved in community service—I knew how to change the world. I served as the leader of my church youth group region, gave sermons, and led discussions—I knew Truth.

Of course, like a proper liberal arts institution, Mythic College was quick to tell me that I knew nothing. It created a vacuum into which new and original thoughts could be harnessed and developed, only to be questioned once again at a later time.

Looking back, I realize I once saw education simply as a means to the end of financial security. I completed numerous computer courses and certifications in high school since both promised a profitable career. Today, I understand education as an ongoing process in which my thoughts and actions are continuously being molded by every new experience. Each new experience generates a unique lens through which to view the world with a fresh set of priorities. But the most influential portion of my college experience has been my ability and good fortune to expand my education beyond the classroom through travels abroad. While the lessons learned in these journeys are too numerous to list, I will attempt to concisely encapsulate their essence.

During a ten-day service learning trip to Costa Rica, I was exposed to negative impacts of globalization as I walked through a teak forest that a foreign company would be turning into souvenir pencils. Since teak trees make rainforest soil so acidic that it cannot be reclaimed by the natural foliage for over 100 years, the impact of such an act is felt by several generations.

As part of a three-credit course focused on Gandhi and Nonviolence, I traveled to India to study at the Institute for Gandhian Studies. There, I lived the ritualistic lifestyle of the Mahatma and met individuals who did not abide by Western ideals of “the developed world.” Nonetheless, I found their lives contained a certain spark, guided by love and a conception of Truth stronger than could ever be found in any material possession.

On a spring break service trip to Guatemala, I witnessed the results of brutal regimes that controlled their people through coercion and fear. At the same time, my hope for a better future was renewed as I looked upon smiles and the peace signs of the children at the Colegio de Miguel Angel Asturias.

In my most recent semester, I studied abroad in Belgium and served part-time as an assistant to a member of European Parliament. Through this opportunity, I was able to attend committee meetings and experience the process which has brought peace and integration to a continent that was once consumed by bitter hatred and war.

In all I have done, I discovered there is a chasm between the textbook analysis about the present global situation and the reality of personally experiencing it. These opportunities have helped my educational goals to coalesce into a unique program of study. Mythic College supports the idea of students designing their own study programs to suit their individual needs. My self-designed program of "Peace and Conflict Studies with an emphasis in Technical Revolution" combines elements of Peace Studies, Politics, Philosophy, and Information Technology.

With this diverse focus, I plan to study how the dissemination of communication technologies can foster the development of a common global humanity—centered on themes such as government accountability, the promotion of human rights, and transnational cooperation in dealing with collective problems of the global community.

My research in this field has already taken many forms. In one recent project, I considered the way political activists have utilized communication technologies to undermine or overthrow authoritarian regimes which had kept them in silence and slavery for so long. In another paper, I analyzed the way the transition from an oral culture to a literate culture led to the emergence of the nation-state and a national identity for which people could be mobilized to kill others; I then argued that today a transition is occurring from a literate culture to a digital culture, which will lead to the emergence of a global identity, cosmopolitanism, and a greater focus on collective goals.

In my dual role as a student at the Irish Institute in Leuven, Belgium, and an assistant to a member of the European Parliament, I produced a paper entitled "A Knowledge-based Society and the Digital Divide" in which I explored the perpetuation of information communication technologies in developing countries and how such developments could either provide economic growth or represent a new covert imperialism. The Director of the Irish Institute noted the work as "impressive" and suggested that I should keep her informed of future research plans.

I am currently working on a senior research thesis for Peace and Conflict Studies that will attempt to prove that the shift from a literate culture to a digital culture will undermine the nation-state based identity. Next semester, I will write a senior research thesis for Information Technology, addressing some aspect of technology-enhanced cooperation. In May of 20xx, I plan to graduate with distinction in both majors.

After completing my undergraduate work, I hope to find a graduate program that will allow me to combine fields such as Peace Studies or Global Governance with my previous studies regarding the impacts of communication technology dissemination. I wish to find a program that combines classroom theory with first-hand experience and would not hesitate to send a student abroad to conduct research inquiries. After graduate school, I plan to move beyond research to work for an organization such as The Carter Center which engages in need-based development work at a people-to-people level.

While all of these research plans may seem to imply that I hold all of the answers for solving the world's problems, Mythic College has certainly taught me at least one important thing: I do not know everything. In fact, in many instances, that which I know may be based upon false suppositions. However, knowledge and acceptance of such a mental void appropriately undermines the fanaticism of one's own convictions, provides for the time to make one listen instead of trying to prescribe, and allows for the constructive acceptance of critique to spawn new and truly creative approaches to common problems.

The last three years of my life have brought great transitions in both attitude and action. Along with the creation of a void comes the desire to fill that void with something. I now have more questions. I talk to more people. I engage in the world. I offer my viewpoint from my own experience and actively listen to those of others. Through it all, I hope that I can play an active role in this globalization process and promote those principles that I have found in my travels to be common to all of humankind—the desire for a safe and peaceful living environment, the passion for quality education, the hope of being able to decide one's fate. Such principles unite all of humanity by one common thread, and drive me forward as I reach towards graduate study.

## Lengthy Personal Statement by a Film Student—3 pages

Personal Statement by John Lerner

*Poetry*
Steven Spielberg has said that he makes the movies he loved to watch as a child. Woody Allen has expressed the same approach. I can say no such thing.

I remember hating the cinema as a child—at least those films that were prescribed to my gender and age group. While my father studied cinema in college (and my mother theater, no less), the medium had no appeal to me. My three adopted siblings frequented the local Ritz Theater on Saturday afternoons. I chose not to go.

In the fall of my senior year of high school, everything changed—I fell in love. My father recommended *Annie Hall* to me, and I rented it on a whim, finding it stuffed into a rack in a dirty little corner of "Video Stars" and priced conveniently at forty-seven cents. I watched the film at 2 AM that night and did not get a wink of sleep. I had discovered the cinema. Jean-Luc Godard, who had original intentions of being a novelist but was "crushed by the spectre of the great writers," likens his discovery of the cinema to discovering a new poetry, perhaps a new voice. "I saw a film of Jean Vigo, a film of Renoir, and then I said to myself, I think that I could do that too, me too." For me, I had found a new poetry and a new poet in Woody Allen, and he revealed to me other poets, including Godard.

*Plastics*
One year later, a jump into the study of film was not an immediate decision. With a high school education grounded rigorously in math and science, I entered Mythic University on an academic scholarship with Polymer Science and Engineering as my intended major. I like to joke that, after seeing Mike Nichols' film *The Graduate* and hearing that terrific line, "plastics," delivered poolside to a wayward Benjamin Braddock (Dustin Hoffman), I was inadvertently led into the hands of the great polymer Satan. But, by sophomore year, I quickly escaped the plastic devil's clasp and found a new home in the film department.

*Children*
I remember being told once as an undergraduate (and the actual source of this like so many other pieces of great advice has slipped away into some crevice in my mind) that directing your own material is like parenting—you don't have to know what you're doing so much as have an idea, and try very hard, and listen, and be honest, and your

children will still turn out all right, and you will likely even have some insight into and influence on them. To be honest, I really have no idea if this advice will prevent me from raising a serial killer one day, but I have found it to be an accurate description of directing my own material as a student and usually a favorable approach to take with a cast and crew of peers. Despite this reassuring advice on directing and my degree in film production, I still feel that my writing abilities are far more developed and refined than my visual storytelling skills. This is a major reason for my interest in graduate-level study of directing.

The culmination of my student film work was a nineteen-minute child called *Burying Dvorak*—a coming-of-age comedy about a fourteen-year-old boy and his taxidermist-stuffed basset hound. The film, since its premiere at Mythic University's Annual Student Film Festival (which routinely sells out the 700+ seat Mythic University Auditorium), has now appeared in more than a score of festivals, including the Los Angeles International Short Film Festival and the New York Expo of Short Film and Video, and has won several awards. I dislike awards in art, however—as treasurer of Mythic University's Student Film Organization I strongly advocated the removal of awards from the student film festival—and am most happy through film festivals just to reach new people with the work and similarly meet other wonderful filmmakers. This was an opportunity only afforded to me because I took a year off after my undergraduate studies to save money, travel to arts and film festivals, and write.

*Geography (Plastics Reprise)*
I return to the subject of plastics because I never fully left them. Mythic University's Polymer Science Department is housed within the same college as the university's Department of Geography. On a suggestion from my first honors advisor, I took a few geography courses during my freshman year and was a Geography and Film double major since.

What do Geography and Film have to do with one another? My fellow students have spared no creativity in rearticulating this question. "So, do you wanna, um, make documentaries for National Geographic…or create chloropleth maps of celebrity sightings?"

Geography is not, despite what we may have garnered from our high school educations, simply state maps and capitals. It is the study of any phenomenon over space. In the Kantian sense, at least in terms of his *a priori* human categorizers of time and space, Geography is as essential as History—the study of any phenomenon over time. While most academic disciplines, including the cinema, thoroughly examine themselves in relation to time, they miss an opportunity to do so with space. For me then, Geography enables the intellectual development of one's capabilities to render and analyze space. After all, when a director blocks characters and camera, what is he or she doing but creating spatial relationships that reinforce the emotive content of a scene? Furthermore, the concept of *place* is intimately bound within multiform relations of power (conceived here in Foucaultian terms) that "direct" such *geographical* choices as where films are made, where films do or supposedly do take place (setting), and where the people come from who make the films (actors, writers, directors, producers, etc.).

*Columbia University*
My choosing Columbia University is not because I want to be a New York filmmaker or make films about New York City. How could I make a more meaningful film about New York than that person, Woody Allen, who allowed me to fall in love with the cinema in the first place? At the moment, I doubt that I will even want to stay in the city beyond graduate school. My interest is elsewhere in a more rural aesthetic—not the imaginary/metaphorical rural of the western, but an authentic rural as told by such filmmakers as Terrence Malick and more recently David Gordon Green.

What I want from New York and Columbia is an opportunity to let my talents and personal vision marinate with those of other filmmakers and artists who are working at the highest level. I want to influence and be influenced, experiment and fail, and develop as a visual storyteller under the guidance and support of a faculty and program renowned for their narrative work—which is, despite my fondness for both my professors and friends, not Mythic University. Most importantly, I do not want to need each short film to make or break me like so many independent filmmakers I meet at festivals—most of whom do not get anything but a new audience at each festival to their disappointment, although this is really the most wonderful thing, to my lights. At Columbia, I want to work with the same zeal and spirit as when I was a high school senior making VHS movies after seeing *Annie Hall*. I want to create more of my own cinematic children, and, in doing so, continue to discover my own voice, my own poetry.

# Lengthy Personal Statement by a Biological Science Student—7 pages

## Motivation and Background

Since C.S. Elton's observations first began the field of invasion biology in 1958[1], the problem of invasive species management has continued to be a prominent issue, despite advances in science and technology. Biological invasions of pest species pose a threat to the stability of ecosystems, both natural and managed.[2] A tremendous amount of effort is put into the detection and eradication of invasives, but not necessarily in the most economically or biologically efficient manner. In my research, I am using optimization with Stochastic Dynamic Programming (SDP) as a tool to examine the best spatial strategy of attack on a particular invasive species—the gypsy moth (*Lymantria dispar)*.

The ongoing gypsy moth invasion in North America makes an exemplary case study because of the extensive life history data available describing its spread, and because of prior research to examine various methods to slow that spread. The gypsy moth has been moving across the U.S. since its accidental release in Boston in 1869.[3] The spread rates of the gypsy moth were estimated to be fairly high (9.45 km/yr) from 1900 to 1915, low (2.82 km/yr) from 1916 to 1965, and finally very high (20.78 km/yr) from 1966 to 1990.[4] Gypsy moth caterpillars are responsible for changing entire ecosystems because of their wide-ranging diet consisting of trees, shrubs, and plants. Their feeding weakens trees through defoliation, leaving forests vulnerable to disease and other attacks.[3] Nearly 311 million acres of forest land and urban and rural treed areas in the U.S. are at risk for gypsy moth invasion.[3] To manage such a pest, it is important to know the order in which events happen throughout the course of a year. The transition cycle that I am using to optimize management decisions is explained in Figure 1.

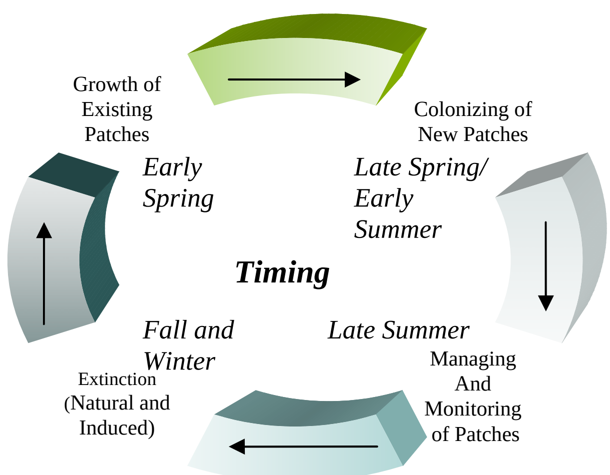


*Figure 1: Gypsy moth population transition cycle.*

## Master's Thesis Research

The gypsy moth population is growing in two distinct ways—both as a wavelike front from the main population and as several dispersing "island" populations that may eventually merge with the slow-moving main population.[4] This type of movement is called "stratified-diffusion."[5] In my research, I assume that the gypsy moth population behaves like a mainland-island metapopulation, i.e., "a population of populations"[6] consisting of a mainland population and several smaller dispersed island populations. The best management solution may be a mixed strategy involving intervention on both the small dispersed island populations and the main population front.[7] By examining the gypsy moth population as a metapopulation, we can focus mainly on the dynamics of the small patches but also assume that the source of dispersal is from the main wavelike large population front. My research is aimed at developing a useful mathematical tool to optimize the plan of attack for the control of this invasive species.

**Stochastic Dynamic Programming as a Management Tool**

Stochastic Dynamic Programming (SDP) is an ideal management tool in the case of invasive species control because it can be used to generate solutions to problems of optimal decision-making. SDP requires the assumption that the state of the system is dynamic and therefore can change, but in order to use it we must define a discrete state space. To further limit the changes in the state of the system, constraints must be imposed on the system and finally the optimization criterion must be outlined. Because the dimensions of the state space can become overwhelmingly large, SDP models are typically solved numerically.[8,9]

After receiving widespread attention in behavioral ecology,[8] SDP has emerged as a valuable problem-solving tool in studies of biological control, agroecology, and conservation.[10] For example, SDP was used to find the strategy that maximizes the number of successful releases of a biological control agent.[11] In problems of fire management, SDP helped determine the optimal fire management strategy where threatened species were concerned.[12] SDP was also used to examine the optimal management of Saiga antelope, with climate as the main parameter.[13] For weed control, SDP helped researchers examine herbicide recommendations for wheat crops[14] and also to examine optimal economic crop rotation for wheat.[15] Methods of invasive species management are extremely costly and time-intensive. Mathematical models such as SDP in conjunction with research could contribute to a more cost-efficient and practical method of investigating and recommending management decisions for invasive species.

**Model Outline**

In my research, I have begun to outline and define the necessary assumptions and parameters to successfully construct an appropriate SDP for gypsy moth management. I plan to build the initial model based on the outline here, then continue my research by 1) adding to the initial model to create a more general model of invasive species management, and 2) exploring other mathematical tools to answer similar questions.

The SDP algorithm will be the set of strategies that will result in the "least invasive" state of the system within a defined time frame.[10] In order to reach the least invasive state, the probability of transition between states (based on the state of the system at the previous time step) will be determined for each point in time.

The state space of the system can be defined by five transitions with patches moving between three states: empty, medium, and large (Figure 2). The model assumes 1) a finite number of patches, 2) identical patches, 3) each patch as being in one of three states depending on how much of the patch is populated by the invasive species, and 4) no "small" patches. The final assumption of no small patches was made for two reasons. First, detecting small patches of isolated populations is very difficult and expensive, so most populations are not detected until they are slightly larger. Secondly, Allee effects contribute to the natural death of small populations.[16]

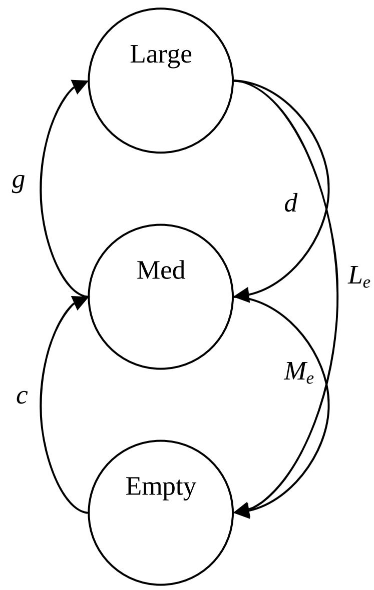


*Figure 2: State space model of gypsy moth dynamics.*

The five parameters can be broken down into three processes—growth, colonization, and extinction—that will shape the population transition matrix of the final model. Growth includes the probability of growth, *g*, from a medium patch to a large patch. Colonization includes the probability, *c*, of individuals from the large main population front colonizing an empty patch. Here, the assumption is made that only the main front generates new patches. Finally, extinction includes the probability of a large patch going extinct, $L_e$; the probability of a medium patch going extinct, $M_e$; and the probability of a large patch declining to a medium patch, *d*. The large, main wavelike front, or "mainland," is considered only in terms of colonizing new, empty patches.

Five strategies will be applied to optimize management based on how many large, medium, and empty patches are present (see Table 1). With the exception of the "do nothing" strategy, which incurs no cost, each management strategy has an equal cost. Costs were made equivalent by varying the number of patches affected by each strategy. Strategies are all based on pesticide application, since it is the most common management practice for gypsy moth infestations.[3] In that sense, "containing" would mean applying pesticide to the edge of a population or spraying with a lower pesticide application rate so that extinction might not be likely, but the population would be unable to grow and might actually decrease in size and impact. "Spraying" would encompass applying pesticide with the motivation of complete patch extinction. "Do nothing" would allow the system to continue without intervention.

*Table 1: Five management strategies to be considered for model optimization.*

| Management Strategy | Impact on Dynamics |
|---|---|
| Contain main population front | Decrease $c$ |
| Contain 4 large sites | Increase $d$ |
| Spray 2 large sites | Increase $L_e$ |
| Spray 4 medium sites | Increase $M_e$, and indirectly decrease $g$ |
| Do nothing | No impact |

Each of the parameters will be tested for sensitivity. Values for colonization, growth, and extinction probabilities will be based on up-to-date knowledge of biological tendencies, and determined in consultation with USDA gypsy moth researcher Dr. Andrew Liebhold.

At any time, we assign a value or reward to a particular state. The reward value is defined by the function:

$$f(l,m) = \frac{l + \frac{m}{4}}{P} \qquad where: l + m \leq P$$

where $l$ is the number of large patches, $m$ is the number of medium patches, and $P$ is a constant value describing the total number of patches in the system. Thus, in order to determine the optimal decision at any given point, we select the strategy that yields the minimum reward value. Assuming that a large patch is less desirable than a medium patch, the worst possible state of the system is when there are $P$ large and 0 medium or empty patches, yielding the maximum value of 1. On the other hand, the best possible state occurs when there are 0 large and 0 medium patches, yielding the minimum value of 0.

The reward function will be revisited in order to examine the effects of altering the weight placed on large versus medium patches. The assumption that large patches are less desirable than medium patches will be relaxed in order to determine how the management strategy changes according to the perception of large and medium patches.

**Future Research Considerations**

The initial mathematical model of management will yield answers to fundamental questions of management based on strategies of pesticide application to control gypsy moths. Other areas I plan to further explore as part of my master's research are i) the effect of monitoring on the management strategy, ii) the possibility for biological control, and iii) the impact of a different strain of gypsy moth on management decisions.

i) Monitoring gypsy moth population levels through the use of pheromone traps is common practice across the U.S.[3] Incorporating monitoring into the management strategies described above and altering the costs of those strategies would add another element of reality and may change the optimal decision. Increased monitoring incurs a cost, but may allow for future savings through the detection of smaller patches that are less costly to eliminate, making it worthwhile to explore the interplay of management and monitoring strategies.

ii) Using the fungal pathogen *Entomophaga maimaiga*—an effective natural enemy of the gypsy moth capable of preventing outbreaks—as a biological control agent may be a viable management strategy in the near future. Current research is being conducted to further explore the dynamics of the fungus and its role in controlling gypsy moth populations.[17] SDP would be useful in determining optimal release strategies of the fungus.[11]

iii) Finally, to anticipate the invasion of the Asian strain of the gypsy moth (AGM), it may be important to consider how we would manage this strain should it become established in the United States. A few cases of the AGM have been found but not established in North America, first in 1991 and a second time in 1993. Eradication efforts were successful in both cases, but incredibly costly.[3] In one year, $25 million was spent in the northwestern U.S. to eradicate the AGM; $9 million was spent in the Carolinas for the same purpose.[18,19]

The AGM is characterized by female flight and an even broader range of hosts. Compared to the current North American strain with little population variability and flightless females, the AGM, once established, would spread much faster and leave a more devastating path through forests and other treed areas of the U.S. and Canada. Females of the AGM can travel more than 18 miles to deposit eggs, whereas females of the North American strain rarely move far from their birthplace to lay eggs.[3] Because of the flight capabilities of females of the AGM, the transition cycle would need to be altered to account for the timing of events in the model. Different dispersal abilities may affect the optimal management strategy.

Ultimately I plan to expand upon the gypsy moth system to make the model applicable to other invasive species. Species-specific modifications will have to be made, but the general SDP will help in the process of developing a framework for applied problems of invasive species management.

**Academic Career and Future Outlook**

Vital questions such as those involving invasive species management are often too costly or difficult to conduct experimentally but can be tackled mathematically. My undergraduate background in mathematics and applied analysis along with my interest in biology provides me with a unique foundation as an ecologist. By pursuing graduate work at Mythic University, I will be able to expand my biological and ecological background and integrate that with my mathematical abilities, laying the foundation for a successful career in mathematical ecology. Following the completion of my master’s degree in Ecology in the spring of 20xx, I plan to pursue a research career in the field of ecology through a Ph.D. degree, focusing on experimental and mathematical work in the areas of biological invasion and conservation biology.

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