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Carbon-Storing Trees and Particulate Matter Reduction in Los Angeles, California

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Abstract

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MS, East Carolina University, 2012

BS, California State University Los Angeles, 2003

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Air pollution is a major concern in heavily populated cities such as Los-Angeles, California. Particulate Matter (PM) pollution in Hispanic and Black American neighborhoods in Los Angeles tends to be higher than adjacent non-minority areas. Research has indicated that certain carbon-storing trees can be used to reduce PM pollution. The purpose of this qualitative, interview research project was to determine the feasibility of using carbon-storing trees to reduce PM pollution in Hispanic and Black American neighborhoods in Los Angeles. Using an ecological theoretical framework, 10 subject matter experts were interviewed about their knowledge of carbon-storing properties and the feasibility of planting 10 different types of trees to reduce PM in the target neighborhoods. The results indicated that oak and pine trees are the most feasible in accomplishing PM reduction within the target areas based on factors like leaf structure, size, and adaptation to Southern California climate and soil. The least feasible trees included California sycamore, Fremont cottonwood, ox horn bamboos, American sweetgum, and yellow poplar. Public health officials may use this study's findings to bring social change to communities by encouraging the development and implementation of tree planting plans that may reduce PM pollution for all populations across the United States. The responsibility of implementing a tree planting strategy would be up to city planners and public health officials (stakeholders) in affected communities. To accomplish this, stakeholders would need to determine the financial costs and specific locations for planting oak and pine trees.

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Chapter 1: Introduction to the Study

Introduction

Air pollution results from natural processes including volcanic activity and human activities like fossil fuel burning for electricity and emissions from automobiles. Air pollution ranges from fine particles, to ground level ozone, to indoor dust and mold. In the United States, air pollution is a significant problem in major cities like Houston, Texas and Los Angeles, California (Anderson, Thundiyil & Stolbach, 2012).

In Los Angeles, the large numbers of vehicles on the roadways causes an increase in greenhouse gases (GHG) emissions of carbon dioxide (CO_2) and sulfur dioxide (SO_2), which can contain particulate matter (PM) pollutants (Houston, Li & Wu, 2014). Air pollution in Los Angeles is particularly prevalent in minority communities, which tend to be located near heavily trafficked freeways, as compared to White-American communities (Hajat et al., 2013). Air pollution causes asthma attacks and lung diseases that are problematic in minority neighborhoods in Southern California (Kershaw, Gower, Rinner & Campbell, 2013).

Recent studies have shown that various trees have carbon-storing capabilities which may help reduce PM pollution. Trees such as American sweetgum can sequester carbon from the atmosphere (Mullaney, Lucke & Trueman, 2015), and a 2010 study in Fairfax County, Virginia conducted by the U.S. Forestry Service (USFS) showed that red maple, American beech, and tulip trees aided in reducing 4,670 tons of carbon pollution from the atmosphere (Fairfax County, 2010). Furthermore, research conducted by the Environmental Protection Agency (EPA, 2015) showed that the planting of black tupelo and white oak trees in urban areas was helpful in reducing PM pollutants in Baltimore, Maryland. Due to the higher air pollution rates in minority communities, use of carbon-storing trees may be particularly beneficial in reducing air pollution in those communities (Hajat, Diez-Roux, Adar, Auchincloss, Lovasi, O'Neill, & Kaufman, 2013). The purpose of this study was to determine the feasibility of using various types of carbon-storing trees to reduce PM pollution in minority communities in Los Angeles, based on the opinion and knowledge of subject-matter experts (SME). These SME have a background in carbon storage trees and air pollution. Community stakeholders could use the results as evidence to encourage public health officials to use various carbon-storing trees to reduce PM pollutions in minority communities in Los Angeles. Chapter 1 of this study includes discussion of the study's background, problem, purpose, nature, theoretical framework, scope, limitations, and significance. Chapter 2 includes an in-depth literature review and Chapters 3 includes a discussion of my research methodology. Chapter 4 includes a discussion of the data analysis, and Chapter 5 contains interpretations and recommendations.

Background

Understanding Particulate Matter

According to the Intergovernmental Panel on Climate Change (IPCC), industrial operations and vehicle tailpipes release greenhouse gasses (GHGs) like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the atmosphere (Pachauri, Allen, Barros, Broome, Cramer, Christ & Dubash, 2014). In major cities like Los Angeles and Mexico City, air pollution is quite common due to the high levels of GHG emissions resulting from power plants and transportation sources. These released GHGs contain liquid droplets and solid particles of PM (Hasheminassab, Daher, Ostro & Sioutas, 2014). PM pollution includes extremely small and breathable particles with diameters smaller than 10 micrometers (µgm) and larger than 2.5 micrometers. Figure 1 below shows the comparison between human hair and $PM_{2.5}$ and PM_{10}.

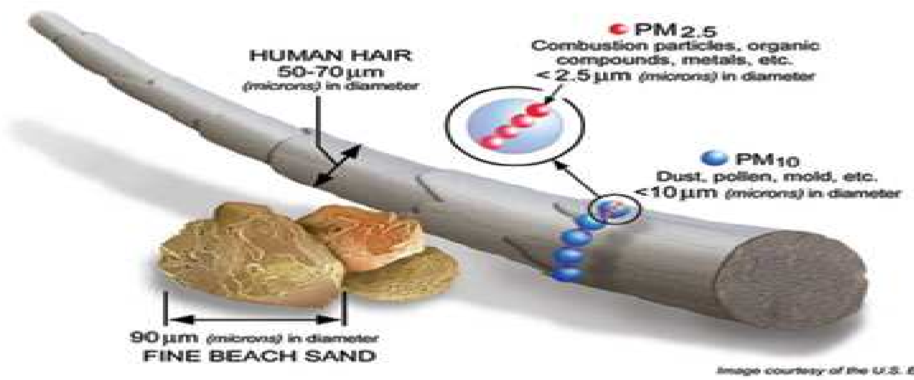

Figure 1. How big is particle pollution? Adapted from "Particulate Matter (PM)," by the Environmental Protection Agency, 2016 (http://www3.epa.gov/pm/basic.html).

As shown in Figure 1, the average human hair has a diameter of approximately 70 micrometers, which is about 30 times larger than the largest PM. In addition to GHG emissions, PM is found in other mediums such as dust, buildings, construction sites, and roadways (EPA, 2016a). In the United States, the EPA regulates particulate matter, both coarse and fine particles. Particles greater than 10 micrometers like dust and sand are not EPA regulated mainly because they do not have the same toxicity that PM from GHGs possess, which can lead to human health problems (EPA, 2016b).

Because of its small size, PM can pass from human lungs into the bloodstream and can damage lung tissues or cause cancer, cardiovascular diseases, and death

(Anderson, Thundiyil & Stolbach, 2012). Recent research has shown that there has been a 20% increase in deaths related to heart disease because of chronic exposure to PM (Anderson, Thundiyil & Stolbach, 2012). Additionally, respiratory diseases such as asthma and COPD, heart failure, and atherosclerosis have also been attributed to PM exposure (Garshick (2014), Hajat, Diez-Roux, Adar, Auchincloss, Lovasi, O'Neill, & Kaufman, 2013).

In 2013, more than 7 million respiratory disease-related deaths have been linked to air pollution worldwide (Hoek et al., 2013). The EPA has reported that PM found in air polluting gasses is a major contributor to breathing problems and premature death, especially amongst vulnerable populations like the elderly, children, and those living in the low-income areas (EPA, 2016a).

In countries like China and India, air pollution is a continuous public health problem. In India, PM levels have surpassed levels in Mexico and China. According to Pant et al. (2015), in 2011 New Delhi, India had a PM level of 128 micrograms per cubic meter (µg/m³), in comparison to Beijing, China which was at 81 µg/m³ and Washington D.C.'s 12 µg/m³. Furthermore, Pant et al. contended that the high PM levels in Indian cities such as New Delhi resulted in approximately 570,000 premature deaths in 2011. The most affected communities were those in areas with heavy traffic congestion and areas close to airports and power plants (Pant et al., 2015).

PM in Los Angeles

In Los Angeles, managing air pollution can be challenging. Conditions like weather, topography, and population influence the level of pollution. Also, the Los

Angeles Basin is largely surrounded by mountains, which sometimes makes it difficult for air to circulate out of its metropolitan areas, especially given the high volume of vehicles on roadways (Hasheminassab, Daher, Ostro, & Sioutas, 2014).

The amount of air pollution in the Los Angeles area tends to vary based on population density. In areas that have a higher population, there tends to be a higher level of $PM_{2.5}$ and PM_{10} pollution. Additionally, socioeconomic status plays a role because minority populations tend to live in lower-priced housing complexes that are located close to air pollution sources like heavily trafficked freeways and power plants (Su, Jerrett, Morello-Frosch, Jesdale, & Kyle, 2012).

According to Su, Jerrett, Morello-Frosch, Jesdale, and Kyle, (2012), Hispanic-majority areas in major U.S. cities like New York and Los Angeles have 1.5 more times air pollutants than in White-majority areas. In areas like the South Bronx, which has a high Puerto Rican and Black American population, about 40% of the residents are at the poverty line (Maroko, Riley, Reed, & Malcolm, 2014). In South Los Angeles, Black people live in areas that have the worst levels of PM pollution and ground-level ozone. Likewise, Hispanics who live in low-income communities such as East Los Angeles also experience a high level of PM pollution ailments (Su et al., 2012).

Mitigation of PM Pollution

The EPA has designated certain areas in the United States as “nonattainment areas” because of high levels of pollution. According to EPA, a nonattainment area is “any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant" (EPA, 2016b). The Los Angeles South Basin has been designated as a nonattainment area since 2012. The nonattainment status in Los Angeles is based on five major air pollutants, which include $PM_{2.5}$, PM_{10}, lead, Nox, and ozone. Other areas in Southern California such as Imperial County and the southern part of the Central California Valley have also been designated as attainment areas. As in most nonattainment areas in California, the common factors include mountainous areas, high populations, and increased number of power plants and vehicles alongside major freeways (Houston, Li, & Wu, 2014).

To address PM pollution, the EPA uses the National Ambient Air Quality Standards (NAAQS) to limit air pollutants like $PM_{2.5}$ and PM_{10} that are harmful to the environment and public health. The primary NAAQS standards focus on public health protection, while secondary standards focus on environmental protection. The current standards for air pollutants like $PM_{2.5}$ and PM_{10} are measured in parts per million (ppm), parts per billion (ppb), and micrograms per cubic meter ($\mu g/m^3$) of air (EPA, 2016a). The current primary NAAQS annual limit for $PM_{2.5}$ is $12.0\mu g/m^3$ and $150\mu g/m^3$ daily for PM_{10} (EPA, 2016). In the Los Angeles South Coast Air Basin, the $PM_{2.5}$ and PM_{10} annual levels average$14.48\mu g/m^3$ and $136\mu g/m^3$, respectively (South Coast Air Quality Management District [SCAQMD], 2016).

Similarly, the California Ambient Air Quality Standards (CAAQS) also sets legal limits on outdoor air pollution that are designed to protect the health and welfare of Californians. These standards are similar to the NAAQS and are enforced by the California Air Resources Board (CARB) on both private and public entities. Currently, there are some counties (including Los Angeles County) that are at or above CAAQS PM limits (CARB, 2016).

In addition to NAAQS, there are other strategies used to address the problem of air pollution in polluted areas. The use of alternative energy like solar, wind, nuclear, biofuels, and hydroelectricity combined with stringent environmental regulations is prevalent, particularly in developed nations (Moriarty & Honnery, 2012). Use of alternative energy sources such as solar and wind reduces the amount of air pollutants that would normally be released by fossil fuel burning. However, the underlying problem of using these alternative sources is that they are too costly or cannot meet the energy demands of a large and growing population (Moriarty & Honnery, 2012). Moreover, it is less likely that these alternative energy sources will be widely adopted in low-income minority communities because of the limited capacity of minority communities to absorb those costs.

Using Carbon-Storing Trees

Public health officials have not fully explored the use of carbon storage in trees in minority urban areas. The EPA has indicated that carbon-storing trees may reduce particulate pollution to NAAQS limits (EPA, 2016b). However, there is a gap in research concerning the feasibility of using various carbon-storing trees for PM pollution reduction in minority communities in Los Angeles. The purpose of this study was to determine the feasibility of using various types of carbon-storing trees to reduce PM pollution in minority communities in Los Angeles, based on the opinion and knowledge of SME. I collected qualitative data using in-depth interviews (in form of open-ended questions) with SME, including plant biologists and air pollution professionals.

Problem Statement

Air pollution is a modern day problem that has been on the rise worldwide. In Los Angeles, California, air pollution is a significant issue, primarily because of car emissions from traffic on roadways (Hasheminassab et al., 2014). According to the Centers for Disease Control and Prevention (CDC, 2013), "traffic-related air pollution is the main contributor to unhealthy ambient air quality, particularly in urban areas with high traffic volumes" (CDC, 2013). Furthermore, the CDC has reported that minority populations have a higher exposure to traffic-related air pollution than do non-minority populations, since minority communities tend to live closer to high traffic areas in comparison to non-minority communities (CDC, 2013). The primary pollutants include N_2O and sulfur dioxide from industrial facilities and CO_2 from automobile tailpipe emissions (Amster, Haim, Dubnov & Broday, 2014).

Because of large populations and high numbers of vehicles on the roadways, the problem of PM pollution is prevalent in many large cities around the world (Hasheminassab et al., 2014). PM pollution refers to the contamination of ambient air by particles that are harmful to the environment and include GHG emissions, polycyclic aromatic hydrocarbons (PAH), dust particles, ground-level ozone or smog, and volatile organic compound (VOC) emissions.

Rowangould (2013) found that minority communities overall have poorer air quality than non-minority communities because of the tendency of minority populations to live in more polluted areas like heavily trafficked freeways. Furthermore, the EPA has found that several minority communities across the United States are plagued with various types of air pollutants like $PM_{2.5}$ and PM_{10}.

Researchers have found that planting of trees may reduce $PM_{2.5}$ and PM_{10} pollution in suburban areas outside of New York City (Nowak, Greenfield, Hoehn, & Lapoint, 2013). However, in large metropolitan areas like Los Angeles, researchers have not fully explored the use of carbon-storing trees to reduce PM pollution in minority communities. Moreover, in comparison to less populated areas in suburban New York, the Los Angeles area has a larger population, higher PM pollution rates, and a different topography.

Therefore, it is necessary to determine the feasibility of using carbon-storing trees to reduce PM pollution in Los Angeles minority neighborhoods. To do so, I collected qualitative data from interviews with SMEsubject matter experts, such as plant biologists and air pollution professionals, to determine the feasibility of using various types of trees to reduce PM pollution in Black and Hispanic communities in Los Angeles.

Purpose

The purpose of the qualitative study was to determine the feasibility of using carbon-storing trees to reduce PM pollution to NAAQS limits in Hispanic and Black American neighborhoods (target population) in Los Angeles, California. I conducted interviews with SME on the types of carbon-storing trees needed for PM pollution and also obtained information regarding $PM_{2.5}$ and PM_{10} pollution rates for the target population from various sources such as the University of California Los Angeles Center for Clean Air, the SCAQMD, and the CARB. I gathered additional information regarding carbon-storing trees from sources like the USFS and the California Department of Forestry and Fire Protection's Urban Forestry Program.

Research Question

To what extent, if any, is it feasible to use carbon-storing trees to reduce PM pollution within minority communities in Los Angeles, California?

Conceptual Framework

I used the ecological model as the conceptual framework for this study (see Augusiak, Van den Brink, & Grimm, 2014). This model treats the interaction between factors at the varying levels equally and helps in identifying intervention strategies based on the ecological level in which the factors act. Furthermore, this model focuses on multilevel interventions using various environmental subsystems including communities, the environment, and economics (Augusiak, Van den Brink & Grimm, 2014). This model may involve the implementation of various processes and strategies that increase the likelihood that healthy programs and policies will be adopted and maintained, especially by government entities in various communities (Augusiak, Van den Brink & Grimm, 2014).

In this study, my intention was to determine the feasibility of using carbon-storing trees in reducing PM pollution in minority communities in Los Angeles to NAAQS limits. Since the ecological approach model involves observing interactions amongst variables as well as identifying intervention techniques, the results of this study may provide information to local public health officials and organizations to develop a tree planting strategy in minority areas in Los Angeles with the intention of reducing PM pollution. An example of an organization's use of the ecological model is the U.S. Department of Health and Human Services' *Healthy People 2020* initiative, which is a national disease prevention and health promotion program that seeks to improve the health of all Americans. With this initiative, public policies that can influence communities to prevent and/or mitigate health ailments are examined (U.S. Department of Health and Human Services, 2011). For instance, *Healthy People 2020* discusses what strategies can be employed to reduce childhood obesity within public schools across the United States.

Nature of the Study

Study Design

I used a qualitative interview study design, to gather opinions from SME to determine the feasibility of using carbon-storing trees to reduce PM pollution to NAAQS limits in the target population. I used semi-structured interviews with a pre-determined set of open questions to give me the opportunity to explore particular themes or receive expansive responses from research participants (see Lewis, 2015). The semi-structured approach is effective in collecting information from a variety of participants of with the aim of answering the research question (Lewis, 2015). The semi-structured model was useful in collecting substantial information from the SME.

To ensure an in-depth analysis, I interviewed participants using open-ended questions and follow-up questions to determine their viewpoints. The interviews were conducted in a face-to-face or telephone format and were no more than one hour long.

because of the specificity of the subject matter under studied, I conducted a limited number of interviews.

Participant Selection Criteria

I conducted semi-structured interviews with 10 participants to gather information relating to PM pollution reduction and carbon-storing trees. Using this format, I asked a list of questions and then followed up with additional questions as needed. To achieve saturation, participants were interviewed until a similarity between answers was achieved (see Elo, Kääriäinen, Kanste, Pölkki, Utriainen & Kyngäs, 2014).

The interview process with each SME lasted for about 1 hour with about time of 10 minutes for each question. The selection time for each question was to ensure that each participant had a sufficient amount of time to fully answer each question. The participants exited the study through follow-up questions. Participants were contacted at a later date for any clarifications to questions previously posed via a transcript.

I selected 10 participants after extensively reviewing numerous scholarly journals making 30 email queries to botanists on the subject matter.I found that there were a limited number of SME with expertise on PM pollution reduction and carbon-storing trees. These subject matter experts included university professors and a USFS employee.

Since the study related to air pollution and environmental concerns, it was logical to use personnel who have firsthand experience dealing with air pollution, community development, urban planning, and silviculture. The selected participants included plant biologists and air pollution professionals. I initially contacted participants via email and then conducted a follow-up in-person interview. Selection of these participants was not based on race, gender, age, or ethnic origin, and several of those selected had written scholarly articles on carbon storage trees and PM pollution.

Justification for the Qualitative Approach

The objective of this study was to interview experts for opinions on the feasibility of using carbon-storing trees to reduce PM pollution within the target population. Public health officials in Los Angeles and in other cities may use the results of this study to develop carbon-storing tree planting initiatives targeting minority neighborhoods. Qualitative research is exploratory, and qualitative researchers use underlying reasons, opinions, and perceptions to develop a conclusion (Yilmaz, 2013). I used SME opinions on the feasibility of using various types of carbon-storing trees to reduce PM pollution to gather usable information for public health officials.

Nature of Data Collected

Primary data collection consisted of semi-structured interviews (using open-ended questions) of SME regarding the feasibility of using various types of trees to reduce PM pollution in the target population. The subject matter experts included individuals who have firsthand experience dealing with air pollution, urban planning, and silviculture. I treated each research participant with respect, protected their identities, and promised to maintain confidentiality. Participants were not pressured in any way to provide answers that favored the research.

Definitions

California Code of Regulations Titles 13 and 17 for the California Air Resources Board- These regulations govern motor vehicle emissions as well as public health (CARB, 2016).

Carbon-storing trees- Perennial plants that have the ability to sequester significantly large amounts of atmospheric carbon in their wood. Examples include black tupelo and American sweetgum (Nowak, Greenfield, Hoehn & Lapoint, 2013).

Community Multi-Scale Air Quality (CMAQ)- This is an EPA tool used for air quality management. The tool can provide detailed information about air pollutant concentrations in any given area for any specified emission or climate scenario (EPA, 2016).

Minority (target) population- Black and Hispanic American residents of Los Angeles California who are affected by PM pollution from various nearby sources.

Nonattainment Areas-"Any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant" (EPA, 2016).

Particulate Matter- "Particulate matter, also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles" (EPA, 2016).

Socioeconomic status: The social class or standing of a group or an individual within a society that is usually based on income and educational levels (National Center for Health Statistics, 2012). For this study, the population was primarily people of a lower socioeconomic status in Los Angeles.

Assumptions

In this study, I assumed that SME would provide honest and factual answers during the interview process. To ensure the accuracy of answers, I assured participants' confidentiality. Additionally, I assumed that the selected participants would be able to provide some insight on carbon-storing trees and PM pollution reduction.

Scope and Delimitations

The scope of the research involved interviews with SME on the feasibility of using carbon-storing trees to reduce PM pollution in Los Angeles, California. The final sample size was 10 SME. SME were limited to botanists.

According to Nishimura et al. (2013), the incidence of air pollution in minority communities tends to be higher than in non-minority areas. The authors attribute this to the reality that minority neighborhoods tend to be located close to air pollution sources such as freeways and power plants in comparison to non-minority areas, which tend to have better air quality. Hence, I delimited this study to the specific problem of PM pollution in Los Angeles minority areas.

Limitations

Limitations are elements the researcher cannot control and result in restricting the methodology and conclusions (Yilmaz, 2013). The limitations of this study resulted from the research design in terms of potential response biases and a small sample size. Specifically, interviews are subject to participants' recall bias. To address the potential for recall bias, I used semi-structured interviews and specific questions for data acquisition. Furthermore, I allotted additional time as needed for each. SME during the interview process to ensure that the information obtained was credible and based on the SME expertise. Because this was a qualitative research, obtaining and confirming SME responses was important and necessary. In any research, credibility derives from the believability of the results (Cope, 2014). In this study, I gathered data from SME with a comprehensive knowledge of trees.

Another potential limitation of the study was whether the same results would be obtained from interviews of all SME. The dependability of the study relied on the consistency and similarity in answers that each participant provided regarding which carbon-storing trees could reduce PM pollution rates in the target population. Based on the results obtained, I noted the most and least feasible trees.

In addition to response biases and the nature of the data collected, there were a limited number of SME available. Englander contended that small sample sizes may limit the generalizability study findings (Englander, 2012). Using SME with experience and knowledge and conducting a comprehensive semi-structured interview with pertinent questions may have helped reduce this limitation.

Significance

Non-minority areas tend to have less air pollution when compared to minority areas (Nishimura et al., 2013). According to Bell and Ebisu (2012), there is a relation between minority communities residing close to major PM pollution sources and the prevalence of asthma and other respiratory ailments (Bell & Ebisu, 2012). Therefore, it is important to address the issue of air pollution in minority communities. The results of this study may be relevant in bringing social change to communities that are plagued with air pollution problems by providing public health officials information on using trees for PM reduction. This might, in turn, encourage public health officials to implement tree planting plans that may reduce PM pollution in all populations across the United States. In addition to including useful information for tree planting strategies, this study may also be to increase awareness and understanding of the problem of PM pollution in different communities.

Summary

As with many urban areas, air pollution in Los Angeles is commonplace. In Los Angeles, the problem of air pollution has been attributed to smog and respiratory ailments. In Southern California, the main pollution sources include trains and vehicles that release harmful CO_2 along with other GHGs containing PM. This PM has been attributed to various respiratory ailments inclusive of lung cancer and asthma, especially in minority populations who tend to live near freeways and other highly polluted areas. Prior research has indicated that the use of carbon-storing trees may reduce PM pollution in urban minority communities. For the study's framework, I used an ecological perspective because it involved collecting and analyzing qualitative data from the SME interviews. With this framework, researchers can consider a problem on multiple levels including the environment, economics, and populations (Augusiak, Van den Brink, & Grimm, 2014). Furthermore, Nowak et al. (2013) contend that using the ecological approach was helpful in determining the impact of tree planting on PM pollution reduction.

To elaborate further on the feasibility of using carbon-storing trees in PM pollution reduction in minority communities, I conducted an exhaustive literature review. Chapter 2 includes a review of the available literature on PM pollution and use of carbon-storing trees to reduce PM pollution. In the next chapter, I also discuss the ecological model and my literature review strategy.

Chapter 2: Literature Review

Introduction

In large cities, the problem of PM pollution is common because of the number of vehicles on the roadways, power plant emissions, and commercial and residential sources. In populated states like California, PM pollution reduction can be costly. According to Delamater, Finley, and Banerjee (2012), the costs of reducing PM pollution through various means like alternative energy use and carbon sequestration technologies can total over $28 billion annually. The CARB (2016) reported that between 2000 and 2014, approximately 4500 cancer deaths in California resulted from PM pollution from vehicles with many of the deaths linked to heavily trafficked roadways that are polluted. The CARB also reported that children, the elderly, and people with heart or lung disease are at increased a health risk from continuous PM exposure (CARB, 2016).

In Los Angeles, more cars on the freeways lead to increased exposure to PM pollution and adversely affect the health of at-risk populations. Populations that fall in a lower socio-economic status (SES) are especially susceptible to PM pollution. Minority communities tend to have less financial resources, low education, and mostly single parent households (Krieger, Waterman, Gryparis, & Coull, 2014). This in turn may result in fewer employment opportunities and lower wages when compared to non-minority communities (Krieger, Waterman, Gryparis, & Coull, 2014). Furthermore, in most parts of Los Angeles and the United States, the overall cost of living closer to polluted and noisy freeways is less than living away from freeways (Hu et al., 2012). As a result, minority communities live closer to freeways and thus are more susceptible to PM pollution than non-minority communities. The purpose of this qualitative research was to determine the feasibility of using carbon-storing trees to reduce PM pollution rates in Hispanic and Black American neighborhoods in Los Angeles, California. I used the study to examine the feasibility of tree planting strategies in minority Los Angeles communities based on factors such as topography and climatic conditions.

To further examine the phenomenon of PM pollution and how it affects minority communities, I have included an analysis of the problem of PM pollution and the types of trees that may be helpful in reducing PM pollution in minority communities in Los Angeles. In addition, I discuss the databases and search engines I used to gather peer reviewed literature. Furthermore, I discuss the theoretical framework and key principles I used to address PM pollution reduction. The chapter concludes with a summary.

Literature Search Strategy

I used a qualitative research design for this study. The qualitative design is an exploratory approach researchers use to explore underlying reasons, opinions, and perceptions to come up with a conclusion about a given topic or problem (Lewis, 2015). In addition, qualitative research can provide insights into the problem and can help develop hypotheses or ideas that researchers can use as tools that can benefit the outcome of the study. The results of a qualitative research approach tend to be more descriptive and less predictive in comparison to quantitative research (Lewis, 2015). The qualitative research approach was optimal for this study because it was based on expert opinions about the use of trees to reduce PM pollution in Los Angeles's minority communities, and it led to results that public policymakers can used to implement pollution reduction initiatives.

In comparison to quantitative research, qualitative research does not use frequencies and trends to develop a conclusion. Qualitative research has a broader approach in terms of data collection through the use of various instruments inclusive of open-ended questions, opinion surveys, and observations (Berger, 2015). Furthermore, qualitative research seeks to understand natural phenomena with an emphasis on viewpoints and experiences of participants. In terms of health-related research may benefit from using quantitative data to better explain results from a public health study (Berger, 2015). Since the study is based on the feasibility of using carbon-storing trees in PM pollution reduction within Los Angeles, California, the qualitative approach was a good choice since it involved subject matter expert opinions. The results of this study may be helpful in providing information to public health officials in possibly implementing a tree planting strategy within the target population to reduce PM pollution.

This review includes journal articles, books, and reports that I retrieved from various search engines including Education Resources Information Center (ERIC), EBSCOhost, ProQuest, and Google Scholar, and from governmental resources such as the EPA, the CARB, and the SCAQMD. My searches of the database and websites included the keywords *Senate Bill 656, California air resources, PM pollution in Los Angeles, carbon-storing trees, NAAQS*, and *CAAQS*. To ensure up-to-date information for the study, I limited the search to materials published between 2010 and 2016. Of the governmental sources, the CARB site was particularly useful because it has a multitude of air pollution data for Los Angeles. In addition, the CARB website provides information on using trees to offset carbon pollution.

The literature review for this study included a matrix (Table 1) which includes a number of books, scholarly journals, and other resources that I examined and the sources that I used for the research. This matrix shows the scope of sources that I accessed, but but did not necessarily use.

Table 1

Literature Research Matrix

Key terms searched	Books	Scholarly journals	Secondary sources	Reviewed	Used
California air resources	30	20	3	10	6
Carbon-storing trees	80	1415	155	160	12
CAAQS	5	20	10	6	3
CARB	10	8	7	8	3
California Code of Regulations Titles 13 and 17	2	108	20	12	5
Community action model	4	5	6	2	1
Ecological approach model	10	15	4	15	3
EPA	15	10	5	4	3
Health belief model	1	20	5	6	2
Minority population	8	1000	633	40	6
NAAQS	15	1930	570	100	5
Nonattainment areas	5	1863	50	150	17
Particulate matter	4	1490	48	78	4
PM in Los Angeles	7	1360	72	88	16
SCAQMD	15	33	5	3	1
Senate Bill 656	2	280	40	17	2
Social cognitive theory	5	5	5	10	4
Socioeconomic status	10	1720	101	77	5
Subject matter experts	12	1000	55	68	4
Transtheoretical model	5	5	5	5	1
Total	235	12307	1799	859	103

Theoretical Foundation

The ecological model served as the theoretical basis for this study (Augusiak et al., 2014). This framework treats the interaction between factors at varying levels equally, and it helps in identifying intervention strategies based on the ecological level in which they act.

The ecological model focuses on multilevel interventions using various environmental subsystems including communities, the environment, and economics (Augusiak, Van den Brink & Grimm, 2014). In this study, my intention was to determine the feasibility of using carbon-storing trees to reduce PM pollution in Los Angeles, California. Since the ecological model is based on observing interactions amongst variables and identifying intervention techniques (Augusiak, Van den Brink & Grimm, 2014), it can be used to assist local public health officials and organizations in adopting a tree planting strategy in minority areas in Los Angeles with the intention of reducing PM pollution.

The ecological framework uses multilevel interventions and includes a relation between communities, economics, and the environment (Augusiak, Van den Brink & Grimm, 2014). This model is appropriate for this research because it involves effective strategies that may increase the likelihood that formal organizations will adopt and maintain health programs and policies. The ecological model may focus on the interaction between the environment and a population at the varying levels. For example, the amount of PM pollution can be related to the rates of respiratory ailments amongst minority populations in Los Angeles. The ecological framework can help explain the interaction of individuals and their environment, and it can be used to identify intervention strategies that can be useful in addressing a community-environmental problem (Reyers et al., 2013).

The American College Health Association (ACHA) has used the ecological approach to implement the Healthy Campus 2020 initiative. This initiative focuses on both individual-level and population-level determinants of health and interventions in college and university settings (ACHA, 2016). In this instance, the ecological approach is used to determine multiple factors including public policy, community, institutional, interpersonal, and intrapersonal that may be involved in developing an appropriate health programs for a college or university.

The ecological framework can aid public health officials in adopting a tree planting strategy that would reduce PM pollution in minority populations in Los Angeles. A historical example of the ecological approach model is the EPA Community Multi-Scale Air Quality (CMAQ) Modeling System for Air Quality Management (EPA 2015). Through this program, the EPA determines which air quality management procedures are adequate for reducing PM pollution in the target population. This program can assist public health managers in Los Angeles to get involved in the decision-making process with the goal of developing innovative strategies (like tree planting) that can be used to reduce or eliminate the PM pollution in minority neighborhoods in Los Angeles.

In California, several entities such as the California Environmental Protection Agency (CALEPA), the CARB, and the SCAQMD are involved in reducing harmful air pollutants like $PM_{2.5}$ and PM_{10} in many communities including minority areas. The

SCAQMD is responsible for regulating stationary air pollution sources in Southern California, which includes Los Angeles, Orange, San Bernadino, Imperial, Riverside, San Diego, and Santa Barbara Counties. Through the CARB, the CAAQS are designed to reduce the emission of air pollutants inclusive of $PM_{2.5}$, PM_{10}, SO_2, and NO_2. Similarly, the SCAQMD and the CALEPA require annual emissions inspections for all fossil fuel vehicles, and they place restrictions on the purchase of certain products that have volatile organic compounds (Pang, Fuentes, & Rieger 2014). Although legislation, alternative energy, and carbon sequestration techniques are useful strategies to deal with air pollution, research has indicated that carbon-storing trees in specific geographic locations may aid in PM pollution sequestration and is less costly than the aforementioned strategies. Though it is unconventional, tree planting can be employed as a means to control $PM_{2.5}$ and PM_{10}. Knowing which tree species to plant is the first step to implementing this approach. An estimate of carbon pollution sequestration by urban trees in the United States is between 350 and 750 million tonnes per annum (Nowak & Greenfield, 2013).

Approaches in Research

Phenomenological Approach

The focus of phenomenological research is to determine the experience of people with a phenomenon. This approach seeks to comprehend people's viewpoints regarding a specific situation (Finlay, 2012). For a study regarding PM pollution, the phenomenological approach may be useful within a community in determining a person's experience in dealing with PM pollution. However, since this study is more focused on expert opinions regarding PM pollution storing trees within the target population, the phenomenological approach would be less effective than a survey questionnaire approach which focuses on subject matter expert opinions. Furthermore, the phenomenological approach may also be disadvantageous because:

1. There is no reliability or validity of results
2. Research bias may not be detected
3. Samples tend to be very small and therefore collected data is not generalizable
4. Acquiring qualified participants may be difficult (Finlay, 2012).

Ethnography

The ethnographical approach involves studies of people within their own environment by utilizing methods like face-to-face interviews and community observation. This approach tries to understand how people live their lives. For the present study, the ethnographic approach would be helpful if the focus was on individuals living within the target population in regards to taking personal action to reduce or eliminate their exposure to PM pollution. Since this research is based on subject matter expert opinions rather than people's behaviors within their environments, the ethnographic approach would not appropriate for use (MacLeod, 2016).

Semi-Structured Study Approach

Semi-structured studies usually narrow down research topics for researchers within a variety of fields including anthropology and public health (Cronin, 2014). The use of the semi-structured approach is effective in collecting information from various participants of this study with the aim of answering the research question (Lewis, 2015). For this research, the semi-structured model may be useful in collecting substantial information from subject matter experts regarding PM pollution reduction and carbon-storing trees. This study approach is appropriate for this research because it involves a pre-determined set of open questions (questions that prompt discussion) with the opportunity for the interviewer to explore particular themes or receive expansive responses from research participants (Lewis, 2015). Additionally, the semi-structured method may focus on specific research topics for researchers within a variety of fields including anthropology and public health (Ansolabehere & Schaffner, 2014). The use of the semi-structured approach is effective in collecting information from various participants of this study with the aim of answering the research question (Lewis, 2015). For this research, the semi-structured model may be useful in collecting substantial information from subject matter experts regarding the feasibility of using carbon-storing trees in reducing PM pollution within minority Los Angeles communities.

Literature Review Related to Key Variables

Particulate Matter

Particulate matter is a mixture of inorganic and organic compounds. PM is mostly found within urban settings and comprises of 2 main groups inclusive of fine and coarse particles. Coarse particles differ in size from 1 micrometer to 2.5 micrometers from fine particles and tend to be larger. For measurement purposes, PM is measured as 2.5 micrometers and 10 micrometers, hence $PM_{2.5}$ and PM_{10}. PM is primarily found in aerosol compounds as well as organic vapors, dust and greenhouse gases that are emitted from power plants and motor vehicles.

Due to its size, PM is small enough to pass from through human lungs into the bloodstream which can in turn damage lung tissue as well as lead to cancer, cardiovascular diseases and even death (Anderson, Thundiyil & Stolbach, 2012). Recent research has shown that there has been a 20% increase in deaths related to heart disease as a result of chronic exposure to particulate matter (Anderson, Thundiyil & Stolbach, 2012). Additionally, respiratory diseases, heart failure, and atherosclerosis have also been attributed to PM exposure (Hajat, Diez-Roux, Adar, Auchincloss, Lovasi, O'Neill, & Kaufman, 2013).

According to author Garshick (2014), PM pollution found in CO_2 and other GHG emissions may also cause chronic obstructive pulmonary disease (COPD) and asthma. On a global scale, over the last decade, about 7 million respiratory disease-related deaths have been linked to air pollution (Hoek, Krishnan, Beelen, Peters, Ostro, Brunekreef & Kaufman, 2013). The EPA states that PM found in air polluting gases is a major contributor to breathing problems and premature death especially amongst vulnerable populations like the elderly, children and low-income areas (EPA, 2016). The primary PMs found in GHGs include particulate matter 10 (PM_{10}) and particulate matter 2.5 ($PM_{2.5}$). On a global scale, in countries like China, India and Nigeria PM pollution is a continuous public health problem.

PM on a Global Scale

PM in China. Beijing, China has a high rate of PM pollution mainly due to the fact of population density which results in many vehicles on the roadways. In China, the yearly PM 2.5 concentration ranges from 39 to 75 $\mu g/m^3$ which exceeds China's NAAQS of 35 $\mu g/m^3$ and the World Health Organization (WHO) air quality standard of 10 $\mu g/m^3$ (Liu, Baumgartner, Zhang & Schauer, 2016). In northern China, the PM pollution rates tend to be higher than in southern China. This is attributed to topography where southern cities like Hong Kong are closer to waterways which brings in air circulation. Whereas northern cities like Beijing are landlocked and in some cases surrounded by mountains and hills (Liu et al., 2016).

Furthermore, southern cities have warmer weather than in northern areas tends to be more stagnant and colder which facilitates PM pollutant accumulation. In arid cities located in China's interior, the high amount of dust particles also contribute to the PM pollution rates since dust particles tend to carry particulate matter (Liu et al., 2016).

PM pollution may also fluctuate based on the season and the time of the day. In Beijing and Guangzhou, the daily $PM_{2.5}$ variation concentration happens found during the fall and winter, with the lowest levels in the afternoon hours, which results from cloud coverage and less air circulation. In the winter evening hours, the $PM_{2.5}$ rates are higher than in the fall since many people utilize heating equipment (i.e. GHG emissions) to stay warm (Wang et al., 2013).

Overall, approximately 9% of China's population resides in areas that have an annual $PM_{2.5}$ less than China's NAAQS standards of 35 μg/m^3. However, in most metropolitan areas the PM 2.5 rates exceed the WHO Air Quality Guideline of 10 μg/m^3. From a public health perspective, the PM pollution rates in China's cities has been attributed to various respiratory ailments such as asthma and lung cancer (Wang et al., 2013). Cities in the northern region have the highest levels of $PM_{2.5}$ concentrations that exceeds 70% of the total population of China. Hoek et al. (2013) estimated that within the next decade, there will be an increase of 10 μg/m^3 in terms of long-term $PM_{2.5}$ rates in northern China and about a 6.2% increase in $PM_{2.5}$ rates in central and arid regions in China. In areas within the Gobi Desert northern China, the rates are expected to surpass southern cities like Hong Kong over the next 10 years (Wang et al., 2013).

In examining the $PM_{2.5}$ rates in northern China, the high risk of health ailments from $PM_{2.5}$ pollution can be problematic especially for the growing population that tends to live in major cities. As such, it would be necessary for China to develop effective policies that can reduce PM 2.5 within large cities. The Ministry of Environmental Protection and the legislative branch in China is the primary authority on air pollution. In the last 20 years, Chinese legislators have created laws to deal with air pollution. In 2014, the Standing Committee of National People's Congress amended Air Pollution Control Law which focuses on reducing smog within urban areas (Wang et al., 2013). With this law, government authorities may arrest and charge company executives for up to 2 weeks if they do not comply with environmental impact assessments as well as knowingly neglect to prevent excessive air emissions. Some have criticized this policy as very stringent; however, the success rates of this policy's implementation have been praised by many within the government and industry (Wang et al., 2013). In addition to strict laws, the Ministry of Environmental Protection also monitors the amount of major air pollutants like nitrous oxides, sulfur dioxide, ozone and carbon monoxide within households and small businesses. The Ministry also gives high citations to violators of that exceed the PM pollution rates (Wang et al., 2013).

In China today, even with legislation and enforcement, the challenge of conducting PM 2.5 assessments within urban areas may be difficult due to the sheer size and populations of its main cities like Beijing and Shanghai. The Chinese government has consulted with U.S. and other western nations to develop an air sampling strategy with regard to PM 2.5 pollution. Interestingly enough, China is a member state of the Kyoto Protocol (which sought to reduce carbon dioxide and other GHG emission rates) and has urged the U.S. to join. However, the Bush Administration refused to join the pact, on the basis that it does not hold developing nations as accountable as developed countries. China has the second highest carbon dioxide rates in the world and is to pass the U.S. between 2025 and 2030 as the largest carbon dioxide emitter (Wang et al., 2013).

PM in India

In India, PM levels are higher than those of countries like China and Mexico. Pant et al., (2013), state that cities like New Delhi and Mumbai PM levels exceeded 100 $\mu g/m^3$, when compared to Beijing, China which was at 81 $\mu g/m^3$ in a 2011 study. Pant et al., further stated that high PM levels New Delhi caused the deaths of over half a million premature deaths in India amongst children and the elderly. The majority of communities affected primarily lived close to freeways, power plants and airports (Pant et al., 2015).

Over the past five years, PM 2.5 rates have been on a steady increase in New Delhi which is due to the constant population increase and vehicles on the roadways. It is estimated that during peak traffic hours, there are over 200 thousand cars and rickshaws on the freeways in India’s capital city (Pant et al., 2015). In essence, over half of the city’s population inhales unhealthy air that is high in PM as well as other carcinogenic pollutants. The WHO has declared that outdoor air pollution in New Delhi is the number 1 cause of lung cancer amongst its population. PM pollution in New Delhi has also been attributed to heart diseases (Pant et al., 2015).

Like China, PM pollution is dependent of topography as well as climatic conditions. Areas in the north which a landlocked, mountainous, heavily populated, cooler and semi-arid tend to have higher PM pollution levels than warmer southern areas that are coastal. The PM levels in New Delhi are higher than in Panaji, which is the capital of the southern Indian state of Goa. Moreover, Panaji is coastal and has year-round warm weather since it is located in the tropics. In warm summer New Delhi months, the PM levels tend to drop and wind circulation is more consistent. On the other hand, the colder months see an increase in PM rates. Since most people do not use air conditioning in the summer and burn wood in the winter to stay warm, New Delhi PM pollution rates are higher in January, February and March (Pant et al., 2015).

Unlike China, the enforcement of stricter air pollution laws in India do not seem to be a priority and there is less of the likelihood of an air pollution control authority that would effectively. India in the long run may need to adopt U.S. air pollution regulations in order to minimize their pollution problem.

PM in Nigeria

Large Nigerian cities like Abuja and Lagos have high PM annual levels. The WHO states that the average PM level in Lagos was 120µg/m^3. In arid northern Nigerian cities like Sokoto and Maiduguri have higher concentrations of PM10 than southern cities of Calabar and Owerri. Similar to China and India, warmer areas in the south tend to be coastal and have better air circulation than northern cities that are drier and slightly cooler overall. However, although Lagos is coastal, the large amounts of vehicles on the road as well as a multitude of industrial areas, the PM levels can exceed 140µg/m^3 in comparison to less populated northern cities (Yusuf, et al., 2013).

Within most rural Nigerian areas, the average PM 10 levels per annum do not exceed 58µg/m^3. The figures do however change in the dry season between December and February where the mean ambient PM 10 levels range between 133µg/m^3 in January to 135µg/m^3 in March. The average PM 10 levels in the rainy season months of June to September ranged from 128 µg/m^3 to 131µg/m^3 (Yusuf, et al., 2013).

High PM 10 levels in Nigeria's urban areas have led to significant health implications for the city residents. In fact, PM 10 has been attributed to various airborne ailments inclusive of nasal airway clogging, chronic bronchitis, cough, asthma, heart disease, skin diseases and asthma. To deal with air pollution in cities like Lagos and Abuja, the National Environmental Standards and Regulations Enforcement Agency (NESREA) implements various initiatives to deal with air pollution problems within the nation. These initiatives include;

- Increased pricing for automobiles that have high air emission rates.
- Improvements in public transportation services which include a fleet of compressed natural gas buses and trains.
- The construction of more freeways to prevent traffic congestion
- Banning the import of cars and motorbikes that are more than five years old due to their high pollution rates.
- The reduction of outdoor incineration of garbage which releases particulates into the atmosphere (Yusuf, Oluwole, Abdusalam, Adewusi, 2013).

Ultimately, the effectiveness of these initiatives would depend on how well the Nigerian government is in implementing them.

PM in Mexico

Within Mexico, the rates of PM pollution may vary from one region to another. Like other heavily populated areas, cities that are in valleys or have colder weather tend to have higher PM pollution rates than coastal and warmer areas. For instance, the PM levels in Mexico City, which seats in a valley, tend to be higher than in coastal Cancun. Since Mexico City is the nation’s capital, various standards have been introduced into the legislation. On interesting rule relates to the manner in which individuals drive on a weekly basis. On some days, people with even number license plate numbers are allowed to drive on certain weekdays. The same is true for people with odd number license plate numbers (Shields, Cavallari, Hunt, Lazo, Molina & Holguin, 2013).

Furthermore, the Mexican government also requires vehicle inspections on an annual basis. The objective of these vehicle inspections is to reduce ozone levels and carbon dioxide emissions from vehicle tailpipes. Additionally, public transportation including buses, trains, and subway transportation are being converted into compressed natural gas transportation mechanisms (Shields, Cavallari, Hunt, Lazo, Molina & Holguin, 2013).

PM in California

In the United States, the state of California has one of the highest pollution rates which is attributed to population density particularly in cities like San Francisco, Los Angeles, and San Diego. The amount of air pollution within the Los Angeles area tends to vary based on population density. In areas that have a higher population, there tends to be a higher level of PM-2.5 and PM-10 pollution. Additionally, socioeconomic status also plays a role in air pollution as minority populations tend live within lower priced housing complexes that are located close to air pollution sources like heavily trafficked freeways and power plants (Su, Jerrett, Morello-Frosch, Jesdale & Kyle, 2012).

According to Rachel Morello-Frosch, Hispanic populations in major U.S. cities like New York and Los Angeles have 1.5 more times air pollutants than in White American populations. In areas like the South Bronx, which has a high Puerto Rican and Black American population, about 40% of the residents are at the poverty line (Maroko, Riley, Reed & Malcolm, 2014). As a result, the population turns to live low-income communities which tend to be in heavily polluted areas like freeways and industrial sites where fine particle air pollution exceeds EPA pollution regulations. Within South Los Angeles, black people live in areas that have the worst levels of PM pollution and ground-level ozone. Likewise, Hispanics that live in low-income communities such as East Los Angeles, also experience a high level of PM pollution ailments (Su, Jerrett, Morello-Frosch, Jesdale & Kyle, 2012).

To deal with air pollution problems, the California Environmental Protection Agency (CALEPA) has been instrumental in enforcing legislation that deals with air pollution reduction. An example of enforcement is the vehicle emissions inspection requirement that mandates all vehicle owners to have their vehicles tested for air pollutants before their vehicle can be registered (Parrish, Xu, Croes & Shao, 2016). Other legislation that has been brought forward by the state legislature is monitoring volatile organic compounds (VOCs) emissions from paint products. Paint consumers within occupational settings have to meet various air quality standards with regards to VOCs in the workplace. In Los Angeles area, the South Coast Air Quality Management District is responsible for enforcing these paint regulations (Parrish, Xu, Croes & Shao, 2016).

Within many local and state transportation agencies, the use of CNG buses has become the norm since these types of vehicles have fewer air pollutants than conventional public transportation which uses fossil fuels. Other initiatives that have been introduced by State authorities include;

- The diesel particulate filter (DPF) program which prevents and/or captures PM 2.5 emissions into the environment from vehicular exhaust systems.
- Scrubber system or flue gas desulfurization- This system captures sulfur dioxide emissions from various manufacturing processes, especially via the combustion of oil and coal for electricity generation. A benefit to this system is the reduction of soot in the atmosphere. Tax credit for using alternative energy- This program in conjunction with the Federal tax credit program, allows consumers to claim alternative energy use on their taxes. Businesses and individuals that use alternative energy are eligible for a tax break which means more money in their pockets during tax season.
- The California State Implementation Plan (SIP)- Through the California Air Resource Board (CARB), complies a list of submitted plans, programs (including permitting and monitoring), control strategies and fuel regulations to deal with air pollution. The SIP mandates that local air quality management districts prepare initiatives that focus on air pollution reduction to the CARB. The CARB in turn submits these plans to the EPA for final approval and publication in the Federal Register. Some of these initiatives include smog check improvements as well as standards for maintaining off-road equipment like heavy duty trucks.
- Seaport and Container Yard Inspections- The poor air quality in the Ports of Los Angeles and Long Beach are a constant air pollution problem that plagues Southern California. Since these ports are one of the busiest ports in the world, the PM pollution levels are larger than most other seaports within the United States

and the world as a whole. Besides vessels that come into port, there are also trucks and railway trains that pass through these ports delivering and picking up goods. As a result, the CALEPA along with various local agencies (like the SCAQMD and CARB) conduct air quality monitoring activities to determine PM levels (Bedsworth & Hanak, 2013).

With these different initiatives, it is possible that areas in California may be able to achieve cleaner air and reduce harmful air pollutants. However, with respiratory ailments on the rise, it will be necessary to use additional air pollution reduction techniques to limit pollutants like carbon monoxide and particulate matter. Recent studies have shown that using certain trees aid in sequestering air pollutants (Nowak et al., 2013).

PM Storage in Trees and L.A. Minority Populations

On average, one acre of a new forest can sequester over 2.5 tons of PM and greenhouse gases per year (Fairfax County, 2010). New trees can absorb carbon pollutants at a rate of about 13 pounds for each tree each per annum. Many trees typically reach their most productive stage of carbon pollutants storage within a decade. At the 10 year mark, trees can absorb about 50 pounds of PM and CO_2 annually and while simultaneously releasing enough oxygen back into the atmosphere to support human life (Vos, Maiheu, Vankerkom & Janssen, 2013). According to Pincetl, Gillespie, Pataki, Saatchi & Saphores (2013), planting a hundred million trees like American Sweetgum and black tupelo may remove about 19 million tons of CO_2 per year which may save U.S. energy users over $4 billion each year on electric bills.

In addition to sequestering PM and CO_2, trees can also provide shade to office buildings and residences. As a result of the shading from the hot rays of the sun, trees may essentially reduce the usage of air conditioners by more than 30% and this would in turn the amount of fossil fuels burnt to produce electricity. From an economic standpoint, research has indicated that tree planting is the more preferred method of sequestering CO_2 and PM because it does not cost a lot of money to plant trees in comparison to the using more expensive carbon sequestration technologies or using of alternative energy sources like solar power or wind energy (Demuzere, Orru, Heidrich, Olazabal, Geneletti, Orru & Faehnle, 2014). Moreover, trees can sequester 20-45% more PM than scrubber systems which are typically used by power plants to remove some particulates and/or gases from industrial exhaust systems (Demuzere, Orru, Heidrich, Olazabal, Geneletti, Orru & Faehnle, 2014).

According to the U.S. Forest Service, U.S. forests sequestered about 309 million tons of carbon pollutants and PM each year between the 2000 and 2014 which reduced the amount of carbon air pollution by about 25% from the previous 14 years (Oswalt, Smith, Miles & Pugh, 2014). Furthermore, Oswalt et al., contend that U.S. forests can offset approximately 13% of U.S. emissions from the burning of fossil fuels via power plants as well as car exhaust systems Canham, Rogers & Buchholz, (2013) state that in 2011, within the state of New Hampshire, about 10% to 20% of air emissions from various sources were sequestered due to the presence of trees within major urban and suburban areas. Canham, et al also contend that a fully grown tree has the capacity of absorbing as much as 48 pounds of carbon pollutants on an annual basis and can, sequester a ton of carbon dioxide by the time it reaches 40 years old. Table 2 on the next page illustrates PM storage in trees. Within the U.S., the more populated Northeastern U.S. has the highest amount of PM and carbon storage by trees in comparison to the Pacific Southwest.

City	Total (t/year)	Range (t/year)	Value (USD$/year)	Effect[z] (g)	($)	ΔC[y] (μg/m³)	AQ[x] (%)
Atlanta, GA	64.5	(8.5-140.4)	9,170,000	0.36	0.05	0.030	0.24
Baltimore, MD	14.0	(1.8-29.5)	7,780,000	0.24	0.13	0.010	0.09
Boston, MA	12.7	(2.0-35.6)	9,360,000	0.32	0.23	0.020	0.19
Chicago, IL	27.7	(4.0-68.1)	25,860,000	0.26	0.24	0.011	0.09
Los Angeles, CA	32.2	(4.2-70.3)	23,650,000	0.13	0.09	0.009	0.07
Minneapolis, MN	12.0	(1.6-28.2)	2,610,000	0.23	0.05	0.010	0.08
New York City, NY	37.4	(5.1-97.2)	60,130,000	0.24	0.38	0.010	0.09
Philadelphia, PA	12.3	(1.6-28.1)	9,880,000	0.17	0.14	0.006	0.08
San Francisco, CA	5.5	(0.8-14.4)	4,720,000	0.29	0.25	0.006	0.05
Syracuse, NY	4.7	(0.6-10.8)	1,100,000	0.27	0.06	0.009	0.10

[z] Average effects (grams or dollars) per square meter of tree cover per year.
[y] Average annual reduction in hourly concentration.
[x] Average percent air quality improvement.

Figure 2. 2013 PM Storage in Trees by the U.S. Forest Service, 2016 (https://www.fs.fed.us/nrs/pubs/jrnl/2013/nrs_2013_nowak_001.pdf).

Further studies have shown that trees in urban parks can remove about 50 pounds of particulate matter, 1 pound of CO, 6 pounds of SO_2, 9 pounds of NO_2 and 100 pounds of CO_2 on a daily basis. In addition to black tupelo, sugar maple trees can remove PM pollutants from the atmosphere. One mature sugar maple tree that is along a roadway may remove 50 pounds of PM from the atmosphere over a course of one year (Gessler &

Treydte, 2016). In some U.S. states, the use of trees along with other methods to sequester PM and greenhouse gases is gaining momentum.

Since PM pollution can run rampant in various communities within a city (especially spillover pollution from one area to another), it may be important to know how feasible it is to utilize various types of trees to reducing PM pollution within Los Angeles minority communities. Additional factors such as time to grow trees as well as funding for a trees planting strategy would also need to be explored. Bowman, Brienen, Gloor, Phillips & Prior (2013) state that trees can take a large amount of time to mature and so as to be able to sequester PM pollution and this might be problematic for communities that have a high PM pollution rate. Furthermore, the funding for growing trees in minority Los Angeles communities might not be as economically feasible as growing trees in more affluent neighborhoods. Bowman et al. state that a large tree 14 to 20 feet tall can cost $2423 to plant and grow. These costs include the following;

- Site preparation- setting up an area for tree growth which can include preventing roots from growing into underground power lines or phone lines
- Taxes and permits needed to grow the tree- growing trees will typically require a permit by a county or city authority
- Labor- the manpower that would be needed to grow the tree as well as the maintenance.
- Equipment used to grow the tree (Brienen, Gloor, Phillips & Prior, 2013).

To address costs, Shibuya, Koizumi & Torita (2014) suggest that some trees can be uprooted and replanted in urban areas. This would also eliminate the factor of having to wait several years for a tree to mature to aid in absorbing PM from carbon sources. This may also reduce the costs associated with planting and maintaining a new tree.

Within urban areas in Southern California like Los Angeles and Long Beach, tree coverage is estimated at about 35% in comparison to tree coverage in Boston, Massachusetts where tree coverage is about 62% (Nowak & Greenfield, 2013). Therefore, implementing a tree planting strategy in minority communities might be helpful in reducing PM pollution. In terms of spillover pollution from other communities, the SCAQMD states that there are areas in Los Angeles that tend to have less air pollution rates than others. In Los Angeles County, municipalities with similar geographic layouts and pollution sources (i.e. cars and industrial operations) tend to have differing pollution rates (SCAQMD, 2015). Cities with a lot of greenery like Beverly Hills and Santa Monica tend to have less air pollution than areas with fewer trees and more buildings like Downtown Los Angeles (SCAQMD, 2015). As such, the issue of spillover pollution may not be a major factor considering the fact that the affluent areas have more trees to reduce PM pollution. Given the growing expanse of Los Angeles, the presence of trees can surely sequester substantial amounts of PM-2.5 and PM-10 within minority communities. In any event, further research to determine the feasibility of using various carbon-storing trees particularly in minority areas in Los Angeles so as to reduce PM pollution.

According to the U.S. Forest Service's Center for Urban Forest, silver maple trees are one of the most useful trees to absorb PM. In fact, these types of trees can absorb about 25,000 pounds of PM over a half-century period in comparison to other common trees (USDA, 2016). In addition, the U.S. Forest Service state that growing PM absorbing trees like silver maple are pest and disease resistant and can be good for varying climates which will be essential for the Mediterranean climate in Los Angeles. Research has indicated that trees like American basswood and eastern white pine can aid in reducing PM pollution (Nowak, Robert, Bodine, Crane, Dwyer, Bonnewell & Watson, 2013).

In a study done by the Davey Institute in Syracuse, New York, the U.S. Forest Service and the State University of New York College of Environmental Science and Forestry, researchers stated that approximately 225 tons of PM-2.5 per annum can be removed from the air using various types of trees within urban areas like New York and Los Angeles. The research estimated that the PM removal can save cities like Chicago over $24 million per year in terms of health benefits (Nowak, Hirabayashi, Bodine, Hoehn, 2013). Ultimately, there will still need to be additional research done to determine the feasibility of how these various types of trees can be utilized in minority communities across Los Angeles.

Summary and Conclusion

Within many major urban areas, PM pollution is commonplace. Within Los Angeles, the problem of PM pollution is prevalent within minority communities and it can be problematic in terms of respiratory ailments such as asthma and lung cancer. In Southern California, the major pollution sources are from vehicles and power plants that release harmful CO_2 and other GHGs which contain PM. To remedy this PM pollution, prior research has shown that using carbon-storing trees may reduce PM pollution within urban communities. However, little is known about the feasibility of using carbon-storing trees to reduce PM pollution within Los Angeles minority areas because the amount of time it would take to grow a tree is quite long. Also, not all carbon-storing trees are viable in every climatic or geographic location. Furthermore, there is also the fact that growing such trees may cost a significant amount of money which minority communities may not have. Moreover, the process of PM sequestration is a new science and using trees within minority communities in Los Angeles has not been fully explored. As such, consulting subject matter experts on trees and PM pollution in the form of comprehensive interviews was necessary.

From a framework perspective, the ecological theory is the most logical approach for this study because it focuses on multilevel interventions using various environmental subsystems including communities, the environment, and economics (Augusiak, Van den Brink & Grimm, 2014). The ecological approach can be useful in this study by assisting public health officials and organizations in adopting a tree planting strategy that would be used to reduce PM pollution within the target population. The next chapter of this research includes the methods by which information was collected from subject matter experts on the feasibility of using certain carbon-storing trees to reduce PM pollution within the target population. In addition, the issue of trustworthiness (credibility, confirmability, transferability & dependability) was explored in chapter 3.

Chapter 3: Methodology

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Introduction

The purpose of the qualitative, interview research was to determine the types of carbon-storing trees needed to reduce PM pollution in Hispanic and Black American neighborhoods in Los Angeles, California. The research involved conducting interviews with SME on carbon-storing trees needed for PM pollution reduction in the target population. These SME include plant biologists from universities in California with knowledge on carbon-storing trees and an employee from the USFS.

In this chapter, I discuss the research design and rationale for this study on PM pollution and the need for carbon-storing trees in minority communities in Los Angeles. Additionally, I outline my role as researcher, review the participant selection process, discuss data collection methods and validity, and conclude with a summary.

Research Design and Methodology

The research question for this study was: To what extent, if any, is it feasible to use carbon-storing trees to reduce PM pollution within minority communities in Los Angeles, California?

The nature of the study warranted a qualitative approach. The primary reason researchers use this approach is because it enables them to use a broader range of data collection instruments including open-ended questions, opinion surveys, and observations (Berger, 2015). This approach may, in turn, allow for further analysis of a problem thereby enabling a researcher to decipher the causative factors and potential solutions to the problem.

Furthermore, qualitative research can provide a researcher with details about behavior and personality characteristics that quantitative studies cannot. In general, quantitative research is limited to statistical data, while qualitative research allows for flexibility, which can provide a more comprehensive outlook on a research topic. Data collection in qualitative research allows researchers to identify trends, which can allow them to formulate accurate conclusions on their research topics (Lewis, 2015). In this study, I used semi-structured interviews to explore the opinions of SME with regards to reducing PM in minority communities in Los Angeles

Participant and Interview Format

Target and Study Population

The affected populations for this study were Black and Hispanic American residents of Los Angeles, California who are affected by PM pollution from various nearby roadway and power plant sources. These are the affected communities of interest that have high PM pollution rates. Although Southeast Asian communities are also minority communities affected by PM pollutions in this area, I focused primarily on Black and Latino areas because research has indicated these communities have higher levels of PM pollution in comparison to Caucasian and Southeast Asian areas in Los Angeles (Paulson & Winer, 2013). The study population for this research included 10 SME who I interviewed on the feasibility of using certain trees best suited for reducing PM pollution in the affected population.

Sampling Strategy for Study Population

I used judgmental sampling as the sampling strategy for this study. Judgmental sampling is a non-probability sampling technique whereby the researcher selects subjects for a research based their professional expertise and knowledge (Ishak & Bakar, 2014). Judgmental sampling design is used when there is a limited number of individuals who possess the necessary knowledge or experience needed for the study (Ishak & Bakar, 2014). Etikan, Musa, and Alkassim (2016) have contended that judgmental sampling allows the researcher to choose only the participants who are appropriate and relevant for the study. It is typically used when there are a limited number of SME or when the research is limited to a very specific topic. Based on my extensive review of numerous scholarly journals and 30 email queries made to botanists and on the subject matter, I determined that there were a limited number of SME with expertise on PM pollution reduction and carbon-storing trees. Therefore, using this sampling strategy was appropriate because it enabled me to recruit only relevant participants who were deeply familiar with the topic. In addition, judgmental sampling is usually fast and inexpensive, which can be beneficial to the researcher. Other advantages of judgmental sampling include (a) obtaining accurate data regarding the study without the complications that may occur when using random sampling strategies, and (b) helping a researcher determine relationships between different phenomena (Ishak & Bakar, 2014).

Types of Participants

I interviewed a total of 10 experts from California universities and an employee of the USFS to collect their opinions on using carbon-storing trees to reduce PM pollution in minority populations. As a result of my extensive research by contacting many individuals in the field of air pollution and silviculture, I found that only 10 individuals were very knowledgeable on the subject matter; therefore, I used only 10 individuals for the study.

Data Saturation

Mason, (2010) contend that data saturation is based on sample size as well as frequent patterns in research. To achieve data saturation, the researcher can introduce additional interviewees until a similarity between answers is achieved (Shaw, 2013). In this study, I determined that I had achieved data saturation when I found a consistency in SME responses to the interview questions. In essence, when the same answers were given by each participant over and over again, then data saturation was achieved. If data saturation had not been achieved with the 10 selected participants, I would have identified and enlisted additional SME.

Selection Criteria

I recruited participant experts who have significant experience dealing with air pollution and plants. The selected participants included 9 plant biologists from universities in California with knowledge on air pollution, and a USFS employee. The use of California plant biologists was logical because these participants have practical and firsthand experience in dealing with the air pollution rates in California. I recruited participants by randomly emailing several plant biologists in California. After initial contact via email, I set up times to interview those who agreed to participate, either via phone or in person. The selection of these participants was not based on race, gender, age, or ethnic origin, and some of those selected had written several scholarly articles on carbon storage trees and PM pollution. I asked the participants five open-ended questions that focused on PM pollution reduction and carbon-storing trees, and I collected the interview results using both a voice recorder and shorthand transcription of their responses.

Instrumentation

Participants

SME included 10 tree experts who have familiarity with Los Angeles air pollution rates and comprehensive knowledge of carbon-storing trees. By using local Los Angeles-based experts and professionals, I was able to gather more accurate information regarding PM pollution reduction, and the feasibility of using certain types of trees in the Southern California climate.

Interview Questions and Data Instruments

This study involved the use of open-ended interview questions to gather the data I needed to answer the research question. Open-ended questions can do the following:

- Increase the possibility of answers and questions. With open-ended questions, an interviewer or researcher can ask as many questions as possible since one simple question can lead to many more questions and answers. Asking a participant about the feasibility of using certain trees to reduce PM pollution allowed the respondents to elaborate on their answers rather than only give a yes or no response. In essence, open-ended questions mean that a participant is not placing any limits on a response.

- Facilitate collection of more detail. Open-ended questions allow respondents to provide as much detail to an answer as possible. This can be advantageous to the researcher because it may provide useful information that can be used for their research. In addition, it may allow for information to be revealed that the researcher may not have been able to get from a closed-ended question.
- Encourage creative answers. Open-ended questions allow respondents to express themselves freely on a question or subject matter. For this study, the guarantee of confidentiality in response to posed questions may have further allowed for more freedom of expression by each participant.
- Help clarify the thought process of participants. Through open-ended questions, researchers can better understand the thought process of their participants, which may help researchers tailor follow-up questions that maximize their information gathering.
- Provide sufficient data for secondary analysis. Open-ended questions may allow other researches to conduct a secondary analysis that closed-ended surveys cannot provide. In other words, open-answered questions can be further analyzed by future researchers (Popping, 2015).

In order to answer the research question, I posed the following interview and follow up questions to each participant.

1. What is your knowledge in regards to carbon-storing trees and PM pollution?

2. Based on existing literature on carbon-storing trees, of the following trees, do you think that it would be feasible to use any of them for particulate matter reduction or capture from the atmosphere and why?
    - Yellow poplar
    - Silver maple
    - Oak
    - Horse chestnut
    - Red mulberry
    - London plane
    - American sweetgum
    - Dogwood
    - Blue spruce
    - Pines
3. Of the following Southern California native trees, do you think that it would be feasible to use any of them for particulate matter reduction in the Southern California climatic region and why?
    - Big Leaf Maple
    - Oak trees
    - Pines
    - Redwood trees (McDonald, Kroeger, Boucher, Longzhu and Salem, 2016).

4. Research indicates that to aid in PM pollution reduction, trees selected should have long lifespan, compete with other trees for sunlight/resources and also be preferably pest and disease resistant (Song, Y., Maher, B. A., Li, F., Wang, X., Sun, X., & Zhang, H. (2015). Which trees from the list in Question 3 or Question 4 do you think would be able to meet these requirements and why?

Rationale for Interview Questions

The interview questions were developed based on scholarly articles from cited sources regarding the feasibility of various types of trees being used for PM reduction. A pilot study was not conducted because pilot studies can be financially costly and time-consuming and the results for this study can be obtained directly without doing a pre-study. In addition, since there are not many SME for this specific research topic, it would be difficult to conduct a pilot study. The interview questions are open-ended and allow the participants wide latitude to give feedback about the subject matter. Since the interviews were semi-structured, the interview questions were expansive in terms probing the participants for additional explanations regarding their answers. At the time the study commences, participants had been initially contacted with information on the nature of the study and confirmed their credentials and understanding of this issue of PM pollution and carbon-storing trees. With this initial feedback, research questions were developed. For Question 1, in order to know the feasibility of using certain trees for reducing PM pollution by using carbon-storing trees, SME had to have an extensive knowledge of trees that can store PM. This may in turn provide credible information for the research particularly in answering the research question. Question 2's objective was simply to determine the types of trees that can reduce PM pollution. For Question 3, researcher had to determine the types of trees that are needed for the target population based on climate and geography since not all carbon-storing trees may thrive in the Southern California environment. Question 4 focused on PM pollution. Since this study is based on trees reducing PM pollutants from the atmosphere, it was necessary to see if these trees have the longevity to serve continuously as PM capturing mechanisms.

Follow-up Questions

For semi-structured interviews, follow up questions are needed to get a general consensus of how each participant feels about the interview and the interviewer. As a result, follow-up questions were posed to each participant. These questions are as follows;

- Do you feel that this interview was conducted in a non-biased manner?
- Did the interviewer provide a summary of statements you made during the interview?
- Is there any important question that was not asked regarding capturing PM pollution?

Procedures for Recruitment & Data Collection Methods

Sources of Data Collection and Data Recording

Initially, 10 individuals were contacted for interviews. Using university websites for biology professors as explained in the selection criteria section, each participant was initially contacted by email and then followed by a phone call to setup up an in-person interview. Interviews were arranged and conducted in an office space as most of the SME are college professors and this would be the most convenient and appropriate setting. During each interview, both shorthand writing format as well as a voice recorder was used when gathering responses from participants. These responses and their analysis are discussed in Chapters 4 and 5. The interview questions were developed to answer the research question and each participant selected will provide a clear and substantive answer to each question posed. Information that is obtained from the voice recordings was also included in Chapter 4.

Obtaining Sufficient Responses

Open-ended questions were asked to allow respondents to have a freedom of expression which may provide substantial information for the study. To ensure that participants are cooperative and their responses are reliable and accurate, it was necessary to treat each research participants with respect and courtesy. Furthermore, focusing only on the selected interview questions was employed to prevent participants from deviating from providing the appropriate answers. Finally, a promise of confidentiality was issued to each participant so as to guarantee that information which will guarantee that information obtained will be used for the research only.

Data Collection Frequency and Duration

An initial round of 10 participants was selected for the study and up to 20 interviews may be done based on availability and expertise of SME. Each participant was allotted as much time as needed to answer each question, however, each interview lasted less than 90 minutes.

Member Checking

In general, member checking allows the researcher to check the data obtained and data interpretation with the original respondents (Thomas, & Magilvy, 2011). The participants exited the study through follow up questions and member checking. In this study, through member checking, participants were provided with detailed notes or a transcript of the interview discussion (as needed) at a later date to ensure that accurate information was obtained from them. This took place at the end of research in the form of a transcript to confirm that SME responses are full, complete and consistent with the interviews conducted.

Follow-Up Plan if Initial Recruitment had Failed

Since there were no guarantees that each participant was readily available and was able to provide the necessary answers to the interview questions, other participants could have been identified and selected if initial recruitment plan yielded an insufficient number of participants. Additional participants could have included SME on carbon-storing trees and air pollution and included personnel from various universities in California inclusive of;

- The California State University Northridge Ecology & Evolution Department, faculty member (botany expert)
- The University of California Los Angeles Department of Ecology and Evolutionary Biology, faculty member (botany expert), and

- The California State University Los Angeles Ecology & Evolution Department.

These follow-up participants would have been recruited in the same manner as the initial participants through emailing and phone calls. This study did not use a follow-up plan as it was not needed.

Data Analysis Plan

The purpose of analyzing data is to gather useful information. The data analysis for this qualitative study included:

- A description and summary of the information obtained from participant interviews.
- Data analysis (based on the data collected from the SME interviews) that would be used to draw conclusions of the study.

To analyze the data obtained, I listened to each recorded interview and extracted information that answered each interview question. For example, in question 1, I collected information on the SME education credentials as well as their experience working in plant biology as it relates to air pollution. This included scholarly articles they have written on the subject matter as well as years of practical experience working as a plant biologist. Considering that the interviews lasted over one hour, it was necessary to extrapolate only relevant information that answers each of the 5 questions posed. This relevant information was in the form of a transcript used for member checking.

Information obtained from the recorded interviews was initially handwritten and then later transcribed. Each recording was reviewed more than once to ensure that accurate information was captured and not overlooked. In addition to data collection, the transcript that was developed included an analysis of each interview that was conducted. The expectation is that after the interview process is completed, each SME was able to provide a list of trees that they feel were able to reduce or remove PM pollution within the target population. A further analysis of the data obtained was discussed in more detail in Chapter 4.

In terms of data coding, Baskarada (2014), states that within qualitative studies, it is important for the researcher to be able to categorize or classify data that is collected. This in turn facilitates the analysis process for the researcher in terms of an ease of access to information for the research analysis. Furthermore, Baskarada notes that looking for major themes is integral in coding data as a repetition of a concept during the data collection process indicates a pattern which may then be used to devise an adequate conclusion. Since linking carbon-storing trees to PM pollution reduction by interviewing SME was the prime focus of this study, it was necessary to focus on repeating themes. These themes were based on the responses given to each question and were categorized and kept in a separate *MS WORD* Document (i.e. if/when I see a repeating theme I will make note of it in a separate document and use it later for analysis. For question 1, (1.What is your knowledge in regards to carbon-storing trees and PM pollution?)- This established SME credibility. *Very knowledgeable* and *Knowledgeable* will be used as codes to determine SME credibility on carbon-storing trees and PM pollution reduction.

If a SME provided a substantial amount of information on concepts regarding the research topic, then they were considered as being very knowledgeable and if they are not as well versed as very knowledgeable then they were labeled as knowledgeable. The term substantial amount of knowledge is based on how detailed the response to the question by the SME which will more than likely be based on occupational (field) experience and/or scholarly work that has been published or presentations they have made as it relates to the research topic.

For question 2 and 3 (the feasibility of using certain trees for particulate matter reduction or capture from the atmosphere in Los Angeles and why)- The purpose of these questions was to find out the feasibility of using certain trees that SME believe would reduce PM pollution as a whole and in the Los Angeles area. As a result, the coding used involved categorizing which trees can remove PM on a scale of 1-3, with 1 meaning very feasible to 3 being the most feasible. The trees that are seen as the most feasible to use for particulate matter reduction within the target area by SME were given a 3 and the ones that are seen as less feasible to use were given a 1. Trees that are rated as more feasible to use than 1s but less feasible to use than 3s were given a 2 (moderately feasible). The reason for each trees feasibility is based on the SME interview and was included as part of the data coding & collection process. This would then aid in the analysis of the data in terms of stating and discussing which trees are feasible to use for PM pollution reduction within the target areas.

For question 4 (Which trees from the list in question 2 or question 3 do you think would be able to last long so as to continuously provide PM pollution reduction)- the coding used involved categorizing tree lifespan on a scale of 1-3, with 1 being short lifespan trees to 3 being long lifespan trees. For the purpose of this study, a tree with a long lifespan is a tree that can last over 50 years.

The collection and coding of the specific data can then be used to devise a comprehensive analysis of which trees are best suited to remove PM pollution from the target population. The coding provided useful information on tree longevity, viability and also knowledge level of SME who are the sources for the research.

Issues of Trustworthiness

Credibility

In any research, credibility establishes that the results obtained from the research are believable (Cope, 2014). For any study, it is important that participant data collected via interviews are from credible sources. Hence, selecting SME with a comprehensive knowledge on trees adds credibility to the study. Furthermore, any previous and relevant scholarly work that a participant has written may be reviewed to further establish subject matter credibility.

Transferability

Transferability refers to the manner in which results of qualitative research can be transferred to other contexts. From a qualitative perspective, the researcher may enhance transferability by ensuring that their research can be applied to similar studies (Yilmaz, 2013). Transferability in research is utilized by the readers of study. Unlike generalizability, transferability does not include broad claims, and instead promotes readers of a research to devise their own conclusions based on an association of elements within the study (Robinson, 2014). In relation to this study, if this research is published in scholarly journals and made available to various public health entities, there is a possibility that this study may invoke change in terms of aiding public health officials in adopting a tree planting strategy that would reduce PM pollution within minority populations in Los Angeles. Furthermore, transferability may determine if the use of carbon-storing trees in Los Angeles may be helpful in removing PM pollution in areas with similar geographical and demographical settings.

Dependability

Dependability in qualitative research focuses on whether the same results would be obtained from repeated experiments (Yilmaz, 2013). To determine the dependability of a qualitative study, the researcher has to ensure that no there are no errors in data collection, reporting & interpreting results or concept development (Yilmaz, 2013). Furthermore, dependability emphasizes the necessity for the researcher to take all content into consideration when doing research (Yilmaz, 2013). In this study, the dependability was to rely on the consistency and similarity if any, in answers that each participant provides regarding carbon-storing trees reducing PM pollution rates within the target population.

Confirmability

Qualitative research assumes that every research is uniquely different from other studies. Through confirmability, results obtained in a study may be confirmed or corroborated through peer review. To enhance confirmability, a researcher may document the procedures for data collection particularly any assumptions that may be made or any biases that either the researcher or research participants may have (Cope, 2014). Confirmability can allow the researcher to review and check actively for any negative factors that may contradict previous observations.

Ethical Procedures

Participant Protection

Participants from various organizations were interviewed to answer the research question. The main objective of the research in regards to ethics includes the protection of any human participants. There were ten participants in the study who were interviewed on the feasibility of using certain carbon-storing trees on PM pollution reduction. Each participant was required to give their consent in participating in this research and was provided confidentiality. This also mitigated participants from withdrawing from the study since no persons outside the study would be aware of the answers they give based on the interviews. To ensure that ethical procedures are followed, the Walden University Institutional Review Board reviewed and approved the proposal prior to any conducting interviews.

Data Protection

In terms of protecting data collected, each participant was ensured that their interview was confidential and only I had access to the data. Informed consent forms from each participant were obtained. Since the interview data were recorded and then later typed/saved in a MS WORD document, all interview data were password protected in a detachable USB drive that is dedicated to this study. Informed consent forms once signed, were scanned and then stored in the same detachable USB drive where the interview data is stored. All information collected is kept for a period of 5 years and then the USB drive that contains all information will be destroyed. Data was only be used to provide an analysis of results as needed for the study.

Summary

As with any qualitative study, the method in which the data is collected is very important as it can determine the type of information that is collected. This could in turn affect the results, analyis, and conclusion of the study. SME interviews were conducted to determine the types of carbon-storing trees needed in reducing PM pollution to NAAQS limits within the target population. To accomplish this, subjective information was used in addition to the exploration of new areas of research that examine various facets of the research subject. The next chapter of this research includes the results section. This section further explored the methods used in conducting this research inclusive of data collection and demographics of participants. Chapter 4 also includes a detailed analysis of the data collected as well as provides evidence of trustworthiness in the research methodology. The evidence of trustworthiness examines the credibility, transferability, confirmability, and dependability. Samples of data collected of SME are included in Chapter 4.

Chapter 4: Findings

Introduction

As with many heavily populated areas, air pollution is a major concern in Los Angeles. In Southern California, PM pollution in Hispanic and Black American neighborhoods tends to be higher than adjacent areas. Research has indicated that certain carbon-storing trees can be used to reduce PM pollution in various communities (Yang, Chang & Yan, 2015). The SME I interviewed for this research contended that oak and pine trees are the most feasible for accomplishing PM reduction in the target areas based on various factors like leaf stucture and size, and adaptation to Southern California climate and soil. To gather SME knowledge, I used a qualitative approach to allow for broader data collection. I conducted this study with the goal of gathering data that could be used by public health officials by identifying most feasible trees for PM pollution reduction within target areas.

The SME enlisted for the research included plant biologists from California universities and an employee of the USFS with knowledge of carbon-storing trees. I interviewed 10 participants using a semi-structured interview format to gather information as it relates to PM pollution reduction and carbon-storing trees. Chapter 4 includes the findings, an analysis of data collected, evidence of trustworthiness, and an overall summary of the data.

Setting and Demographics

I conducted this qualitative interview study using 10 participants who provided information on PM pollution reduction and carbon-storing trees. All interviews were conducted in the offices of the participants and lasted an average of 52 minutes. I asked each participant four interview questions, and recorded each answer using a voice recorder shorthand notes. The information collected by shorthand was later transcribed into a Word document to facilitate inclusion in this chapter. In addition, I provided the participants a consent form prior to the interview and also gave each a written summary (transcript) of their interview within 36 hours of its completion. The following discussion includes a summary of each participant's level of experience in the field of plant ecology and their current occupation.

Participants in the Research

Participant 1 was a 60-year-old male California university professor who has extensive knowledge on plant and climate relationships. Participant 1 has also written many publications on crop ecology and sustainability in farming systems. He is a resident of Walnut, California.

Participant 2 was a 48-year-old male California university professor who is chair of the biology department with experience in plant anatomy, plant physiological ecology, and eco-morphology. Participant 2 has scholarly experience in the architecture of trees and other woody plants. He currently resides in Pomona, California.

Participant 3 was a 52-year-old male California university professor with experience in ecology and environmental biology and has written over 35 articles on geographic variation of plants. He lives in Whittier, California.

Participant 4 was a 46-year-old female California university professor whose experience involves the ecology and evolution of plants in extreme environments.

Participant 4 has published research on plant population genetics and reproductive ecology of steppe vegetation. She lives in Los Angeles, California.

Participant 5 was a 51-year-old male California university professor who currently serves as an associate professor of biology. His experience involves plant decomposition and the cycling of carbon and nutrients in the environment. Participant 5 resides in Pasadena, California.

Participant 6 was a 58-year-old male California university professor whose research includes tropical tree species distribution and remnant habitat patches in Los Angeles County. He lives in Los Angeles, California.

Participant 7 was a 50-year-old female California university professor who instructs students in the plant systematics and plant conservation fields. Participant 7 concurrently works at a botanical garden and resides in Claremont, California.

Participant 8 was a 44-year-old female California university professor whose research focuses on plant physiology and morphology in non-vascular plants. She lives in Los Angeles, California.

Participant 9 was a 52-year old male California university professor with expertise in evolutionary biology and botany. Participant 9 also works at a botanical garden as a plant advisor and has over 15 years of classroom instruction in plant ecology. He lives in La Habra, California.

Participant 10 was a 48-year old female USFS employee with experience on global climate change, systems ecology, biosphere-atmosphere interaction, and plant eco-physiology. She lives in Los Angeles, California.

Data Collection

I conducted 10 individual interviews regarding PM pollution and carbon-storing trees between July 11th and July 21st, 2017 in Los Angeles County cities in California. Initially, 22 experts had agreed to participate, but by the time the interviews were scheduled on July 6th 2017, only 10 individuals had responded and were available for an interview. During the interview process, all 10 participants were able to provide information needed to conduct the research and were fully willing to participate in the interview.

I asked each participant follow up questions regarding the fairness and accuracy of the data collected during the interview process. The final sample of 10 completed interviews represented 45% of the initial respondents of 22 from September 2016. Some of the potential participants I had initially contacted later informed me that they would not be able to provide adequate information needed for the research. Other non-responsive individuals were college professors who were on sabbatical and were either unable or unwilling to do an interview.

Face-to-face interviews were conducted in the offices of the nine participants at the universities where they were employed. I conducted the interview for Participant 10 at her workplace at the USFS office. I developed the interview questions were developed to answer the research question, and each participant selected provided a clear and substantive answer to each question posed.

Nature of Questions

I used open-ended questions when interviewing participants to ensure that the participant could provide as much information as possible for the research. Participant answers were kept confidential and only used for the research, and I provided a consent form that outlined the confidentiality of the data to each participant.

Duration of Interviews

Interviews ranged in duration from 49 to 55 minutes, with an average time of 52 minutes. Each of the participants was interviewed once, and a transcript (summary) of the interview was emailed to them within 36 hours to ensure the accuracy of the information collected from the participants. I asked each participant a series of four questions (as listed in Chapter 3) that related to their experience and their knowledge on carbon storage trees and PM pollution in the Southern California. In the next section, I highlight the responses each participant gave to each of the interview questions.

Participant Responses

In regards to which trees are feasible to use for PM reduction or capture within the target areas Participant 1 indicated that silver birch trees are most feasible for PM reduction since they have biophysical characteristics inclusive of plant density, total leaf surface area, phenology, and spatial arrangement that allow them to absorb $PM_{2.5}$ and PM_{10}. In addition, Participant 1 indicated that London plane, honey locust, horse chestnut, silver maple, and red mulberry trees have fine textures, dense canopies and thick and large leaves that facilitate the absorption of $PM_{2.5}$ and can easily adapt to urban environments. However, Participant 1 stated that silver maple trees may not grow as tall as the other aforementioned trees which would make it difficult for sunlight absorption and hence limit viability. As such, Participant 1 classifies this tree as moderately feasible.

According to Participant 1, honey locust and horse chestnut grows to about 80-98 feet in height and can survive for a century. He reported that red mulberry and horse chestnut leaves with complicated structures and rough, sticky, or waxy surfaces can capture and retain $PM_{2.5}$ more efficiently. Participant 1 stated that California native trees like big leaf maple, oak trees, and pine redwood also have a lifespan of over 100 years. In addition, maple, oak, and pine trees grow at a faster rate than most trees, with an estimated 36 inches to 48 inches per year. Furthermore, these native trees do not have to compete for sunlight with other trees since they grow up to 115 meters in height once they reach maturity.

For less feasible trees, Participant 1 stated that yellow poplar was the least feasible for PM pollution reduction because of their lack of thick and lengthy leaves to absorb $PM_{2.5}$ and PM_{10} Participant 1 claimed that the more a tree has thick and lengthy leaves the better it would be at capturing pollutants including $PM_{2.5}$ and PM_{10}. He concluded that a tree planting strategy for oak and pine trees in minority communities could be beneficial in terms of PM capture.

Participant 2 is an expert on plant anatomy, plant physiological ecology, and eco-morphology. Participant 2 also has scholarly experience in the architecture of trees and other woody plants. In terms of which trees are feasible to use for PM reduction within the target areas, he indicated that dogwood trees are the most feasible for PM reduction because of their large canopies as well as their rapid growth habits and leaf characteristics, which are conducive to absorbing particulate matter.

In addition to dogwood trees, Participant 2 stated that oak and pine trees also have large leaf surface areas that can assist in $PM_{2.5}$ removal efficiency. He indicated that dogwood trees also have long branches that allow for a substantial amount of leaves on them in comparison to smaller trees. Participant 2 reported that dogwood leaves with complicated structures and rough, sticky, or waxy surfaces can capture and retain $PM_{2.5}$ more efficiently. He concluded that dogwood, pine, and oak trees are the most feasible to use for PM reduction within the target areas. Dogwood trees have a lifespan of about 80 years and can grow up to 40 feet. Like pine and oak trees, dogwood are also native to Southern California. In terms of least feasible, Participant 2 indicated that ox horn bamboo trees are the least feasible since they have little to no leaves and they also do not grow high enough to compete (about 33 feet) for sunlight compared to dogwoods and other carbon-storing trees like silver maple.

Furthermore, ox horn bamboos only live for about 35 years and would likely not survive in Southern California's Mediterranean climate that can have temperatures below 40°F between November and April when people use more fossil energy for residential activities (heating and cooling) and transportation. Ox horn bamboos will also not grow in the soils of Southern California, which tend to be composed of sand, granite, or clay. Participant 2 also stated that yellow poplar would be the least likely to absorb PM because of leaf distribution, small leaf size, and thin leaf structure.

Participant 3 has experience in ecology and environmental biology, and has written over 35 articles on geographic variation of plants. In terms of which trees are feasible to use for PM reduction or capture from the atmosphere, Participant 3 indicated that oak and pine trees are the most feasible for PM reduction since their leaves are wide and thick which facilitate the uptake of $PM_{2.5}$ via their leaf stomata. Once inside an oak or pine tree leaf, PM pollutants diffuse into intercellular spaces and are absorbed by water films inside the tree. Additionally, oak and pines have faster growth rates than many other trees and are suitable for the Mediterranean-like varying temperatures in Southern California that can range from 30°F to 110°F.

Participant 3 indicated that for polluted Los Angeles minority neighborhoods such as Watts and East Los Angeles, oak and pine trees would be the most appropriate types of trees for PM reduction. Participant 3 further stated that trees such as horse chestnut and silver maple trees have very large leaf surface (2.5 to 4 inches) areas which allow for better $PM_{2.5}$ removal efficiency especially within heavily polluted areas like the target population. Participant 3 also stated that horse chestnut trees are viable within urban environments and can tolerate various biotic and abiotic stresses like waterlogging, droughts, pests and diseases, compacted soil and volatile organic compounds.

Horse chestnut trees can also last up to 3 centuries and can grow up to 100 feet while silver maple trees can last 130 years at a height of 85 feet. American sweetgum on the other hand, can live up to 150 years but within urban street tree conditions, the lifespan can be reduced to 7 years, depending on the growing and seasonal conditions.

Additionally, American sweetgum may only grow up to 30 feet in height. Consequently, Participant 3 concluded that oak and pine trees as well as horse chestnut trees are the most feasible for PM reduction within the Los Angeles inclusive of minority communities. Participant 3 stated that American sweetgum and yellow poplar would also be the least likely to absorb PM due to leaf distribution and small leaf size as well as thin leaf structure. Yellow Polar also have flat leaves and is deciduous.

Participant 4 is a California university professor whose experience involves the ecology and evolution of plants in extreme environments. Participant 4's publications include the topics of plant population genetics and reproductive ecology of steppe vegetation. In terms of which trees are feasible to use for PM reduction or capture from the atmosphere, Participant 4 indicated that oak, pine and dogwood trees are the most feasible for PM reduction and can reduce the concentration at street level of NO_2 by about 40% and PM by approximately 60%.

Furthermore, Participant 4 stated that urban pine and oak leaves have hairy leaf surfaces that can trap metallic particles as well as particulate matter pollutants. Participant 4 stated that implementing a tree planting strategy of oak and pine might be very beneficial for reducing PM pollution within minority communities in Los Angeles primarily because these types of trees have a longer lifespan in comparison to other trees like blue spruce that lasts up to 40 years and a maximum height of 50 feet. Participant 4 affirmed that Blue Spruce trees have fairly large & thick leaves adequate to absorb PM pollution within urban areas.

Furthermore, oak and pine trees are already native to Southern California and tend to grow very tall (47-57 meters) so that there is little to no competition for sunlight which enables the process of photosynthesis and consequently, the viability of the tree. Participant 4 stated that considering the fact that other trees are likely to grow within an area, planting taller trees (for PM reduction) may be optimum for sunlight absorption. In terms of least feasible, Participant 4 indicated that even though they can grow up to 170 feet and last 100 years, yellow poplar would be the least likely to absorb PM due to leaf distribution and small leaf size as well as thin leaf structure.

Participant 5 indicated that his expertise is on plant decomposition and the cycling of carbon and nutrients within the environment and also stated that he had written many publications on plant physiology and photosynthesis of Mediterranean plants. In terms of which trees are feasible to use for PM reduction or capture from the atmosphere, Participant 5 indicated that oak and pine trees tree are the most feasible for PM reduction since they have leaf density and a large leaf surface area that allows these types of trees to absorb $PM_{2.5}$ and PM_{10}. In addition, Participant 5 indicated that silver maple trees have thick canopies that facilitate PM_{10} absorption. Participant 5 further indicated that Dogwood trees such as the blue dogwood trees and white dogwood trees, were considered the most feasible in $PM_{2.5}$ reduction within the target population by as they are resilient plants in terms of adaptation to weathering of soil as well as drastic temperature changes. Since Los Angeles weather may vary from day to day, particularly in the winter, these types of trees are definitely a preferred option for PM reduction within the target population. Dogwood trees can grow up to 80 feet and can survive for

80 years. Dogwood trees also have a rapid growth rate of 1 meter per year. On the other hand, despite a long lifespan of about 150-250 years, Participant 5 stated that trees such as yellow poplar, California sycamore, and the Fremont cottonwood are the least feasible in PM reduction primarily due to their thin and small leaf size and limited height of only 30 feet of sycamores and cottonwoods at maturity. These types of trees also tend to have a scarcity of leaves on their branches that can make it difficult to absorb a reasonable amount of particulate matter pollutants.

Participant 6 is a California university professor whose research includes research tropical tree species distribution, and remnant habitat patches in the Los Angeles County. Participant 6 indicated that red mulberry is the most feasible type of tree for PM pollution reduction within the target population. Participant 6 contended that red mulberry leaves are perfect for PM absorption due to their rough and thick nature. From an ecological perspective, Participant 6 stated that these types of trees have fruits are very attractive to birds, provide shade from the sun to reptiles and they can tolerate both drought and air pollution. Red mulberry can also flourish in all for seasons and can grow up to 70 feet with a lifespan average of 55 years. Participant 6 also viewed oak and pine trees as feasible for PM reduction as they have similar leaf absorption capabilities as mulberry trees and they are also native to the region. In terms of least feasible to use for PM reduction, Participant 6 indicated that yellow poplar trees possess the characteristics since they do not flourish in dry, low humidity climates such as Los Angeles. Furthermore, yellow poplar trees require a significant amount of water for sustenance. Considering that the precipitation rates in Los Angeles are amongst the lowest within large U.S.

metropolitan areas, the yellow poplar variety would not be a preferred choice to use within the target population.

Participant 7 was a California university plant systematics and plant conservation instructor and concurrently works at a botanical garden. Participant 7 indicated that London plane and horse chestnut trees are the most feasible for PM reduction within the target population. Participant 7 contended that London plane have thick and large leaves (3-7 cm) as well as the appropriate leaf spatial arrangement that allows them to absorb 10%-25% of $PM_{2.5}$ and PM_{10} from the atmosphere. Participant 7 also stated that horse chestnut has rough and waxy leaves and can grow 80 feet and last 100 years similarly to London plane trees which can also grow up to 80 feet and last 100 years. Furthermore, Participant 7 also stated that blue spruce, along with pine and oak tree varieties were also suited for PM pollution reduction since they had large leaves and trunks that not only absorb CO_2 and PM, but also absorb other harmful air pollutants like VOCs, SO_2 and NO_2 which can contribute to health ailments and acid rain. According to Participant 7, oak and pine trees are also very suitable for Southern California soils that tend to be well drained and dry due to the low precipitation rates within the region. Participant 7 indicated that yellow poplar may not be ideal for California dry climate and would therefore not be feasible for PM reduction.

Participant 8 was a California university professor whose research focuses on plant physiology and morphology within non-vascular plants. Participant 8 indicated that yellow poplar and American sweetgum trees are the least feasible for PM reduction within the target population. Participant 8 contended that these types of trees are not ideal for hot weather and since they are deciduous, they lose their leaves in the winter and would therefore not be able to capture PM. Furthermore, neither Sweetgum nor yellow poplar has rough leaves to filter in PM. In terms of feasible trees, Participant 8 indicated that coast live oak, California pine, deodar cedar, chitalpa are the most feasible. Deodar cedar may last up to a millennium and grow up to 70 feet while chitalpa may last 50 years and grow as high as 50 feet. Furthermore, California pine has thick & rough leaves as well as the good leaf spatial arrangement that allows them to absorb PM pollution. Deodar cedar and chitalpa have thick & long leaves that make it good to absorb PM pollution. Participant 8 stated that silver maple, London plane, horse chestnut, blue spruce, red mulberry and dogwood trees can also be feasible in capturing PM, however, Participant 8 stated that these trees are not street trees since they grow haphazardly and occupy a lot of space that can shade out other trees as well as block pedestrian walkways. Participant 8 classified these trees as moderately feasible.

Participant 9 was a 52-year-old male California university professor with an expertise in evolutionary biology and botany. Participant 9 also works at a botanical garden as a plant advisor and has over 15 years of classroom instruction in plant ecology. Participant 9 contended that oak and pine trees are the most feasible for PM reduction within highly polluted areas. Participant 9 stated that the rough and thick leaves of these types of trees can be very effective when it comes to PM capture. In addition, oak and pine trees are also very suitable for Southern California soils that tend to be well drained and dry due to the low precipitation rates within the region. Furthermore, Participant 9 stated that dogwood trees would also be good for PM pollution due to their height and longevity in terms of lifespan. Participant 9 indicated that yellow poplar would be the least likely to absorb PM due to leaf distribution and small leaf size as well as thin leaf structure. Participant 9 stated that yellow poplar cannot flourish in that these types of trees are not ideal for hot weather and would therefore not be effective in the summer months. Participant 9 recommended a tree planting strategy for oak and pine trees within the target population.

Participant 10 was a USFS employee with experience on global climate change, systems ecology, biosphere-atmosphere interaction and plant eco-physiology. Participant 10 indicated that pine and oak trees as well as red mulberry and big leaf maple were the best choices for PM pollution mainly due to their durability, leaf size and structure as well as adaptability to semi-arid regions. Participant 10 contends that silver maple, big leaf maple and red mulberry leaves in particular, are perfect for PM absorption due to their adhesive leaf nature and large leaves. Red mulberry can also flourish in all for seasons and can grow up to 70-80 feet with a lifespan of over half a century. Participant 10 stated that moderately feasible trees included blue spruce and horse chestnut but indicated that their main shortcoming is because they are deciduous trees and would shed leaves in the autumn and therefore not absorb PM in colder weather. For least feasible trees, Participant 10 indicated that yellow poplar trees cannot flourish in dry weather areas such as Los Angeles and would need an excessive amount of water to grow. Considering the fact that California faces a drought crisis on occasion, Participant 10 concluded that yellow poplar would not be ideal.

Data Analysis

To analyze the data, codes were developed to determine the most feasible and least feasible trees for PM reduction within the target population. Question 1 established the participants' knowledge on carbon-storing trees as they relate to reducing particulate matter pollutants. Questions 2 and 3 of the interview focused on the feasibility of using certain trees for particulate matter reduction or capture from the atmosphere in Los Angeles based on tree physical characteristics (such as leaf texture and tree height) and adaptability to local climate. As a result, coding was used to categorize which trees can reduce PM on a scale of 1-3, with 1 meaning very feasible to 3 being the most feasible. Trees that were identified as the most feasible to use for particulate matter reduction within the target population by SME were given a code of 3 and trees that are seen as less feasible were given a 1. Trees rated as more feasible to use than 1s but less feasible to use than 3s were given a 2 or considered moderately feasible. Question 4 examined the longevity of trees listed in question 2 and 3.

Kenzo, Inoue, Yoshimura, Yamashita, Tanaka-Oda & Ichie (2015) contended that trees that can survive for at least half a century and grow to a height of 12 meters or higher would be suitable for absorption of solar energy and consequently, will thrive over trees that do not meet these specifications. Therefore, for the purposes of this study, a tree with a long lifespan is a tree that can live over 50 years, and a tall tree was considered a tree above 40 feet. The age factor is based on how long a tree can be used within a community to be beneficial in terms of PM reduction. The height factor is also based on a tree's ability to compete effectively with other trees for sunlight which is needed for the photosynthesis process to occur. Furthermore, authors Singh, Kumar and Ra (2006) when taller trees are present, trees shorter than 40 feet are in a more difficult position to absorb sunlight so as to facilitate the process of plant nutrition (i.e. photosynthesis). Since other trees are likely to grow within an area, planting taller trees (for PM reduction) may be optimum for sunlight absorption.

The data collected from each participant varied based on the SME experience and knowledge. Some trees classified as most feasible (like chitalpa and deodar cedar) by SME were not on the original interview questionnaire. Likewise, some trees that were classified as least feasible (California sycamore, Ox Horn Bamboo and Fremont cottonwood) by SME were not on the original interview questionnaire. In terms of data trends, each tree was coded as a 3, 2 or 1 based on their leaf length, leaf structure, tree height, adaptability to climatic conditions and lifespan. The following trees were classified as the most or moderately feasible (3s or 2s) according to each participant response:

- Participant 1- Big Leaf Maple, Oak, Pine, Silver Birch, London Plane, Red Mulberry, Silver Maple, Horse Chestnut and Honey Locust.
- Participant 2- Dogwood, Silver Maple, Oak and Pine.
- Participant 3- Oak, Pine, Horse Chestnut and Silver Maple.
- Participant 4- Oak, Dogwood, Blue Spruce and Pine.
- Participant 5- Oak, Pine, Silver Maple and Dogwood.
- Participant 6- Red Mulberry, Oak and Pine.
- Participant 7- London Plane, Horse Chestnut, Blue Spruce, Oak and Pine.

- Participant 8- Chitalpa, Deodar Cedar, Horse Chestnut, Oak, Pine, Blue Spruce, Red Mulberry, Dogwood, London Plane and Silver Maple.
- Participant 9- Oak, Pine and Dogwood
- Participant 10- Silver Maple, Big Leaf Maple, Red Mulberry, Blue Spruce, Horse Chestnut, Oak and Pine.

The trees that were coded as 2 included; silver birch, London plane, red mulberry, big leaf maple, silver maple, blue Spruce, horse chestnut and honey locust, dogwood, red mulberry and blue spruce. These trees only appeared in about 10-44% of the participant interviews (in comparison to oak and pine that were unanimously classified as most feasible) and hence were categorized as 2s.

In examining the data based on SME ratings, oak and pine trees were identified in participant reviews as most feasible for PM reduction within the target population. The primary factors that made these trees the most feasible included their leaf ability to absorb PM pollutants, their growth rates, the fact that some are native species to the Southern California area and their lengthy lifespans that could be beneficial for the target population in terms of long-term pollution absorption. Oak and pine trees also have a long lifespan of 70 to 150 years and tend to grow at about 4 feet per year from prematurity to maturity. In addition, oak and pine trees are also very suitable for Southern California soils that tend to be well drained and dry due to the low precipitation rates within the region.

There were some slightly conflicting opinions in terms of which trees were the most feasible for PM reduction. Participant 3 initially indicated the American Sweetgum that normally lasts for 150 years, was a good choice for PM reduction but then later stated that this tree would not last beyond 7 years within an urban setting due to urban pollution from a multitude of sources included vehicles and power plants. As a result, I did not consider American Sweetgum as feasible for PM removal within target population particularly since this population is within an urban environment.

In further analyzing data trends, some trees were seen as the least feasible based on their leaf length, leaf structure, tree height, adaptability to climatic conditions and lifespan. Trees that SME indicated as least feasible were coded as 1. The following trees were seen as the least feasible (1s) according to each participant:

- Participant 1- Yellow Poplar.
- Participant 2- Ox Horn Bamboos and Yellow Poplar
- Participant 3- American Sweetgum and Yellow Poplar
- Participant 4- Yellow Poplar
- Participant 5- California Sycamore, Fremont Cottonwood and Yellow Poplar
- Participant 6- Yellow Poplar
- Participant 7- Yellow Poplar
- Participant 8- Yellow Poplar and American Sweetgum
- Participant 9- Yellow Poplar
- Participant 10- Yellow Poplar

In examining the data based on SME perspectives, 100% of SME indicated that Yellow Poplar as the least feasible for PM reduction within the target population. In addition, even though previous information from Chapter 1 indicated that planting a hundred million trees like American Sweetgum (Pincetl, Gillespie, Pataki, Saatchi & Saphores, 2013) may remove about 19 million tons of CO_2 per year, this variety of tree was not seen as feasible for PM pollution reduction. American Sweetgum was categorized as least feasible by Participant 3 due to height limitations as well as its ability to grow within urban environments like Los Angeles. Furthermore, ox horn bamboo trees were classified as the least feasible since they have little to no leaves and they also do not grow high enough to compete for sunlight compared to other trees. Ox horn bamboos would also not likely survive in Southern California's Mediterranean climate which can experience temperatures below 40°F between November and April when people use more fossil energy for residential activities (heating & cooling) and transportation. As far as native trees are concerned, California sycamore and the Fremont cottonwood were classified as least feasible in PM reduction primarily due to their leaf size and height at maturity. These types of trees also tend to have a scarcity of leaves on their branches which can make it difficult to absorb a reasonable amount of particulate matter pollutants.

Overall, the data collected provided insights on the perspectives of SME regarding PM pollution reduction within the target population and the use of carbon-storing trees. Repeating patterns (data saturation) for the research based on SME interviews indicated that the most feasible trees were oak and pine. The primary factors that made these trees the most feasible included their leaf ability to absorb PM pollutants, their growth rates, their nativity to the Southern California area and their lengthy lifespans that could be beneficial for the target population in terms of long-term pollution absorption. Oak and pine trees also have a long lifespan of 70 to 150 years and tend to grow at about 4 feet per year from prematurity to maturity. As a result, these types of trees are the preferred choice for implementing a tree planting strategy within the target area. An outline of data collected and an explanation is shown in a table format within the results section of this chapter.

Evidence of Trustworthiness

Credibility

In any research, credibility establishes that the results obtained from the research are believable (Cope, 2014). In this study, the data collected were from SME that have knowledge on trees as well as air pollutants. All participants are professional botanists and were able to provide adequate amounts of information to conduct the research. Furthermore, previous and relevant scholarly work that a participant had written was presented during the data collection process and was reviewed to further establish subject matter credibility. For this study, the credibility relied on the consistency and similarity in answers that each participant provided regarding carbon-storing trees reducing PM pollution rates within the target population. Participants 1, 2, 3, 5, 8 and 10 contended that silver maple trees were feasible for PM reduction within the target population as a result of their very large leaf surface (2.5 to 4 inches) area which allows for better $PM_{2.5}$ capture within heavily polluted areas like Los Angeles. However, even though Participants 4, 7 and 9 did not indicate silver maple trees were effective in PM pollution reduction, Yang, Chang & Yan (2015) indicated that silver maple trees can be very useful in PM pollution reduction. Moreover, Participants 4, 7 and 9 responses were based on their knowledge of each specific tree and so they were not able to provide information on silver maple trees. Furthermore, the participants that selected silver maple trees all had expertise in these types of trees, therefore, their knowledge was seen as credible.

Transferability

Unlike generalizability, transferability does not include broad claims and instead promotes readers of a research to devise their own conclusions based on an association of elements within the study (Robinson, 2014). Transferability refers to the manner in which results of qualitative research results can be transferred to other contexts. From a qualitative perspective, the researcher may enhance transferability by ensuring that their research can be applicable to similar studies (Yilmaz, 2013). The results of this study can be used by public health officials and urban planners to develop a tree planting strategy to reduce PM pollution with communities that have a high rate of harmful particulate matter. Furthermore, there is a possibility that this study may invoke social change in terms of aiding public health officials in adopting a tree planting strategy that would reduce PM pollution within minority populations in Los Angeles and in areas with similar geographical and demographical settings.

Dependability

Dependability in qualitative research focuses on whether the same results would be obtained over repeated experiments (Yilmaz, 2013). To determine the dependability of this qualitative study, by using a voice recorder and member checking, I ensured that there were no errors in data collection, reporting and interpreting results. The member checking process allowed the SME and me to confirm that all the information collected from them during the interview was accurate and concise and that there were no errors in the data collection process. Since this study conducted in an interview format, the dependability relied on the consistency and similarity of answers that each participant provided regarding carbon-storing trees reducing PM pollution rates within the target population.

Confirmability

Through confirmability the results of a research can be confirmed or corroborated by others, in this case the SME (Cope, 2014). To enhance confirmability, the researcher can document the procedures for checking and rechecking data collected during the study (Cope, 2014). This allows the researcher to determine any information that contradicts prior observations. Once the study is completed, the researcher can conduct a data audit (member checking) which reviews the data collected in order to determine the potential for bias (Cope, 2014). Through confirmability, results obtained in this study were confirmed and corroborated through initial scholarly review (Chapter 2) that carbon-storing trees reduce PM pollution within urban settings. In addition, using the member checking method, the participants were given a consent form prior to the interview, and were also given a written summary (transcript) of the interview within 36 hours post interview. At the end of the study, all information collected was verified to be accurate by each SME interview and no errors were noted.

Table 2

Results

Tree Name	Leaf Characteristics (Size & Structure)	Tree Height and Lifespan	Good Absorption of PM Based on # of Participant Interviews	Most or Moderately Feasible for PM reduction in Target Population (Ranking)	Least Feasible for PM reduction in Target Population (Ranking)
American Sweetgum	Thin leaves and small in size	30 feet/7 years	0	No	Yes (1)
Big Leaf Maple	Thick Leaves and large	380 feet/100 years	2	Yes (2)	No
Blue Spruce	Thick Leaves and large	50 Feet/ 40 Years	3	Yes (2)	No
California Sycamore	Thin Leaves and small in size	30 Feet/ 150-250 years	0	No	Yes (1)
Chitalpa	Thick leaves and long	50 feet/ 50 years	1	Yes (2)	No
Deodar Cedar	Rough leaves and long	70 feet/1000 years	1	Yes (2)	No
Dogwood	Thick Leaves and large	40 feet/80 years	2	Yes (2)	No
Fremont Cottonwood	Thin Leaves and small in size	30 Feet/ 150-250 years	0	No	Yes (1)
Honey Locust	Rough, sticky and waxy surfaces and large in size	80 feet/100 years	1	Yes (2)	No
Horse Chestnut	Rough, sticky and waxy surfaces and large in size	80-100 feet/100-300 years	5	Yes (2)	No
London Plane	Thick Leaves and large in size	80 Feet/100Years	2	Yes (2)	No
Ox Horn Bamboo	Thin Leaves and small in size	3 feet/35 years	0	No	Yes (1)
Oak	Thick Leaves and large in size	380 feet/100 years	10	Yes (3)	No
Pine	Thick Leaves and large in size	380 feet/100 years	10	Yes (3)	No
Red Mulberry	Rough, sticky, or waxy	70 feet/ 55 years	3	Yes (2)	No
Silver Maple	Thick Leaves and large in size	85 feet/130 years	6	Yes (2)	No
Yellow Poplar	Thin Leaves and small in size	170 Feet/ 100 years	0	No (10)	Yes (1)

The results table on the previous page illustrates the determining factors that categorized each tree as most feasible, moderately feasible and least feasible. The table was organized according to six major factors which included: tree name, leaf size and structure, tree height & age, good absorption of PM based on number of participant interviews, most, moderately & least feasible for PM reduction in target population. The first three columns are based on physical characteristics of the selected trees as well as their lifespan. The column on the absorption of PM lists the number of SME that selected each tree as feasible/not feasible for PM absorbing. The fifth column ranks trees based on their feasibility to absorb PM with 1 being the least, 2 moderately and 3 most feasible. In addition, a yes meant that it was feasible (either a 2 or 3) and least (as 1). Oak and pine trees showed up in 100% of participant interview as most feasible for PM reduction. Oak and pine trees feasibility resulted from their leaf ability to absorb PM pollutants, their growth rates, their long lifespan, their tall height and their suitability for Southern California soils. The trees that were coded as 2 included silver birch, London plane, red mulberry, chialpa, deodar cedar, big leaf maple, silver maple, blue spruce, horse chestnut and honey locust, dogwood, red mulberry and blue spruce. The least feasible trees included American sweetgum, yellow poplar and ox horn bamboo with 100% of participants viewing yellow poplar as lease feasible. As with trees coded 3 and 2, least feasible trees were categorized based on their leaf structure and size as well as tree height, lifespan and the number of participants that rated them accordingly.

Summary

As with many urban areas, air pollution is commonplace. Within minority communities in Los Angeles, the problem of air pollution has been attributed to smog and respiratory ailments. In Southern California, the main pollution sources include trains and vehicles which release harmful PM. The implementation of an oak and pine tree planting strategy might be beneficial in PM absorption in the target population. The results of my research indicated that other trees beside oaks and pines could be used for PM reduction based on various factors like leaf structure & size and adaptation to Southern California climate and soil.

In terms of observed consistencies, trees with rough and thick leaves that were tall and had long lifespans were classified as the most feasible while trees with smooth leaves and short heights were the least feasible. Other findings for this chapter that are consistent with the literature, was the information obtained on silver maple trees. According to the U.S. Forest Service's Center for Urban Forest, silver maple trees are one of the most useful trees to absorb about 25,000 pounds of PM over a half-century period in comparison to other common trees (USDA, 2016). Participant 10, who is employed by the U.S. Forest Service, confirmed this during their interview.

The inconsistencies I found in the study related to American sweetgum may remove about 19 million tons of CO_2 per year. Contrary to previous information from Chapter 1 indicating that planting 100 million trees like American Sweetgum (Pincetl, Gillespie, Pataki, Saatchi & Saphores, 2013), this variety of tree was not seen as feasible for PM pollution reduction. American Sweetgum was categorized as least feasible by 2 SME because of height limitations as well as its ability to grow within urban environments like Los Angeles.

Overall, the results discussed in chapter 4 were quite informative and presented information that highlighted the types of trees that are most and least feasible to reduce PM pollution within the target population. The trends that were observed during the interview process were that oak and pine trees would be the most feasible with yellow poplar and American sweetgum being the least and all other trees as being moderately feasible. Consequently, based on expert opinions, oak and pine trees would be the most suitable types of trees for PM reduction within the target population. The next chapter (Chapter 5) includes the research credibility, limitations; interpretations and implications of the research results; recommendations based on collected data and study conclusions.

Chapter 5: Summary and Conclusion

Introduction

The purpose of this qualitative, interview research was to determine the types of carbon-storing trees needed to reduce PM pollution in Hispanic and Black American neighborhoods in Los Angeles, California. To this end, I conducted interviews with SME on carbon-storing trees needed for PM pollution reduction within target areas. These SME included plant biologists with knowledge on carbon-storing trees from universities within the State of California as well as an employee of the U.S. Forest Service. A qualitative approach to allow for broader data collection using various instruments inclusive of open-ended questions, opinion surveys and observations was used in this study. I conducted in depth analysis of the data to identify possible solutions to the research problem.

The results of my research indicated that oaks and pine trees were the most feasible for reducing PM in the target areas based on various factors like leaf structure and size, and adaptation to Southern California climate and soil. American sweetgum and yellow poplar were seen as the least feasible because of their height limitations and their inability to grow in urban environments like Los Angeles. In the following sections I discuss (a) the findings and interpretations; (b) limitations of the study; (c) recommendations for future research and for practitioners in education, policymaking, and leadership; (d) and implications. The chapter closes with a conclusion.

Findings and Interpretations

The data I collected from each participant varied based on the SME experience and knowledge. The most feasible trees included pine and oak, while moderately feasible trees included big leaf maple, silver birch, London plane, red mulberry, silver maple, horse chestnut, honey locust, dogwood, blue spruce, chitalpa, and deodar cedar. The least feasible trees included Fremont cottonwood, American sweetgum, yellow poplar, California sycamore, and ox horn bamboo. I coded trees that participants unanimously acknowledged as most feasible as 3. Trees that SME indicated as least feasible were coded as 1. Trees' relative feasiblity was categorized based on their leaf length, leaf structure, height, adaptability to climatic conditions, and lifespans. In the literature review, I found that like silver maple trees are one of the most useful trees in absorbing PM and can absorb about 25,000 pounds of PM over a 50-year period (USDA, 2016). In addition, the USFS reported that PM absorbing trees like silver maple are pest and disease resistant and could flourish in varying climates, which is essential for the Mediterranean climate in Los Angeles (USDA, 2016). Results showed that 100% of the SME interviewed believed that pine trees were the most feasible for PM pollution reduction within the target areas. The primary factors that made these trees the most feasible included their leaf ability to absorb PM pollutants, their growth rates, their nativity to the Southern California area, and their lengthy lifespans that could be beneficial for the target population in terms of long-term pollution absorption. Oak and pine trees also have a long lifespan of 70 to 150 years and tend to grow at about 4 feet per year from prematurity to maturity. Participant 3 indicated that American sweetgum, which normally lasts for 150 years, was not a good choice for PM reduction because of its height limitations and its inability to grow in semi-arid urban environments like Los Angeles.

One point that was similar between my research and the findings of Kim et al. (2012) was that Participant 3 indicated via member checking that these types of trees would not last beyond 7 years in an urban setting due to excessive pollution from a multitude of sources including vehicles and power plants.

I used the ecological model (Augusiak, et al., 2014) for this study. Since the ecological approach model is based on observing interactions amongst variables as well as identifying intervention techniques (Augusiak, et al., 2014), it can be used to assist local public health officials and organizations to adopt a tree planting strategy within minority areas in Los Angeles with the intention of reducing PM pollution. Given the results of this research, the ecological approach proved to be effective in terms of identifying intervention techniques for a pine and oak tree planting strategy to alleviate PM pollution in heavily polluted areas.

Overall, the data collected provided an insight to SME perspectives on reducing PM pollution in target areas by using of carbon-storing trees. Data saturation was achieved for the research when participants unanimously identified oak and pine as the most feasible trees. As a result, these types of trees should be public officials' preferred choice when implementing a tree planting strategy in the target area. Economically speaking, studies have indicated that tree planting is the preferred method of capturing PM because it does not cost a lot of money in comparison to the more expensive carbon sequestration technologies or the use of alternative energy sources like solar power or wind energy (Demuzere et al., 2014). Moreover, trees can sequester 20-45% more PM than scrubber systems, which are typically used by power plants to remove some particulates and/or gases from industrial exhaust systems (Demuzere, et al., 2014).

When examining the results from SME input, I found that implementing a tree planting strategy using the most feasible trees (oak and pine) might be useful for reducing PM pollution in minority communities in Los Angeles. The goal of public health authorities and city planners would be to determine the financial costs and the benefits to the public before implementing a tree planting strategy. The recommendations section of this chapter includes an outline of the best practices that would facilitate this process.

Limitations of Study

Limitations involve what the researcher cannot control and restrict the study's methodology and conclusions (Yilmaz, 2013). The limitations of this study are based on the research design in terms of interview bias and small sample size of SME. One limitation is that the use of interviews is subject to recall bias. To deal with the potential recall bias, I masked the intent of questions by using structured interviews and specific questions for data acquisition. I also allowed for additional time as needed for each SME during the interview process to ensure that the information obtained was credible and based on the SME's expertise. As this was a qualitative research, obtaining and confirming SME responses is important and necessary. In any research, credibility establishes that the results obtained from the research are believable (Cope, 2014). In this study, participant data collected via interviews were from SME with a comprehensive knowledge on trees adds credibility to the study.

Another limitation of the study was whether the same results would be obtained from interviews of all SME. In this study, the dependability relied on the consistency and similarity in answers that each participant provided regarding carbon-storing trees reducing PM pollution rates within the target population. Based on the results obtained on the most and least feasible trees were noted.

In addition to response biases and data collected, there were a limited number of SME used. Englander contended that small sample sizes can limit the ability to generalize study findings (Englander, 2012). Using SME with experience and knowledge as well as conducting a comprehensive and detailed semi-structured interview with pertinent questions, may have helped reduce this limitation. The use of 10 SME was a delimitation for the study and I could have used more participants, however, it would have made the study more difficult to conduct since there are a limited number of people that who would be able to provide substantial information on the topic. Moreover, it was challenging to find qualified experts, and there was a limited time to conduct the research.

Recommendations

Based on the findings of this study, I recommend that public health officials implement a tree planting strategy for pine and oak trees to reduce PM pollution in minority communities in Los Angeles. The primary responsibility for public health professionals and city planners would be to ensure that the optimal types of trees that can thrive in the Los Angeles area in terms of PM pollution reduction are used. Bowman et al. (2013) reported that trees can take a long time to mature so as to be able to sequester PM pollution, which might be problematic for communities that currently have a high PM pollution rate. Furthermore, it may not be easy to secure funding for planting and growing trees in minority communities because of budget constraints of various municipalities. Bowman et al. state that a large tree 14 to 20 feet tall can cost $2423 to plant and grow. These costs include site preparation, taxes and permits needed to grow the tree, labor, and equipment.

To address these costs, Shibuya, Koizumi and Torita (2014) suggested that some trees can be uprooted and replanted in urban areas. This would also eliminate the factor of having to wait several years for a tree to mature to aid in absorbing PM from carbon sources. This may also reduce the costs associated with planting and maintaining a new pine and oak trees. In addition to pine and oak trees, public health officials and city planners may also use silver birch and horse chestnut trees as a means to reduce or capture PM pollution since these were considered feasible by six experts in this study. As with oak and pine trees, determining the costs as well as the location of planting would be important to determine.

Implications

Non-minority areas tend to have less air pollution when compared to minority areas (Nishimura et al., 2013). According to Bell & Ebisu (2012), there is a relation between minority communities residing close to major PM pollution sources and the prevalence of asthma and other respiratory ailments (Bell & Ebisu, 2012). Therefore, it is important to address the issue of air pollution in minority communities. The results of this research are relevant in bringing social change to communities that are plagued with PM pollution problems by using tree varieties identified as most feasible by SME. This may, in turn bring social change by encouraging public health officials to develop and implement tree planting plans that may reduce PM pollution within all populations across the United States. In addition to tree planting strategies, the significance of this study may also increase awareness and understanding of the problem of PM pollution in all communities.

In any research, the factor of transferability refers to the manner by which results of qualitative research can be transferred to other contexts. From a qualitative perspective, I enhanced transferability by ensuring that this research can be applicable to similar studies. Transferability in research is utilized by the readers of study. With the publication in scholarly journals of this research, there is a possibility results of this study may lead to social change in terms by aiding public health officials in adopting a tree planting strategy. This in term may reduce PM pollution within minority populations in Los Angeles. Furthermore, the results of this study may help city planners and public health officials to determine if the use of oak and pine trees in Los Angeles may be helpful in removing PM pollution in areas with similar geographical and demographical settings such as New Delhi, India and Mexico City, Mexico.

Overall, the results of my research indicated that other trees besides oaks and pines can be used for PM reduction based on various factors like leaf structure and size and adaptation to Southern California climate and soil. Trees with rough and thick leaves that were tall and had long lifespans were classified as the most feasible while trees with smooth leaves and short heights were the least feasible. Furthermore, the results discussed in chapter 4 were quite informative and presented information that highlighted the types of trees that are most and least feasible to reduce PM pollution within the target population.

Conclusion

The purpose of this qualitative interview research was to determine the types of carbon-storing trees needed in reducing PM pollution, specifically within Hispanic and Black American neighborhoods (the target population) in Los Angeles, California. To accomplish this purpose, interviews were conducted with SME on carbon-storing trees needed for PM pollution reduction within the target population. In examining the data based on SME input, implementing a tree planting strategy by using oak and pine trees could be useful in PM pollution within the target population. The responsibility of implementing a tree planting strategy would be up to city planners and public health officials (stakeholders) within Los Angeles County. To accomplish this, stakeholders would need to determine the financial costs as well as determining the specific locations within the target population for planting oak and pine trees.

Overall, the results of this research were quite informative and presented information that highlighted the types of trees that are most and least as well as moderately feasible to reduce PM pollution within the target population. The trends that were observed during the interview process were that oak and pine trees would be the most feasible with Yellow Poplar and American Sweetgum being the least and all other trees as being moderately. As a result, it would be important for public health officials and city planners to develop and implement tree planting plans that may reduce PM pollution within the target population as well as all populations across the United States and even globally.

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