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California Drought: A Need for Agricultural Revolution in the Golden State

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California Drought:
A Need for Agricultural Revolution in the Golden State

Abstract:

California is in a drought State of Emergency, which is fueling negative social and economic consequences. After multiple years of below average rainfall, California has arrived at one of the most severe droughts in recorded history. Climate change is upon the Golden State, and the ugly consequences need to encourage citizens to spur green movements combating environmental destruction. The agriculture industry is in need of drastic change in order to secure a future that includes clean water, and fresh food for a growing population. Currently, the agricultural techniques practiced are far from sustainable. Adopting a new ideal on what it means to grow food is key if California's citizens wish to continue living in an aesthetically pleasing state.

To address this problem I will implement the disciplines of ecology, environmental history, public health, environmental economics, environmental policy, and environmental design. Basic ecological principles will be the backbone for understanding how to improve agricultural techniques to deal with drought. Public health will be addressed, as it pertains to quality and availability for water and food. I will use economic and political disciplines to gain a better understanding of why the problems associated with drought exist, and the pragmatic solutions they can offer to those problems. Concepts in environmental design will be crucial for proving that we have available technologies that can change the way we farm. In the end, I hope to offer a clear path for how California agriculture should revolutionize in the wake of severe drought.

Introduction:

California's current Drought State of Emergency is the environmental problem I chose to focus on. The first chapter describes the current drought, and its relation to climate change. Environmental consequences associated with droughts are covered, and the chapter addresses the number of public health concerns that stem from droughts. Chapter 2 applies ecological principles to our current agricultural techniques. Basic ecological principles are the cornerstone behind my desired agricultural change. The second half of Chapter 2 details California's agricultural history, and attempts to gain a better understanding for modern day problems associated with the state's water and food system. Chapter 3 focuses on the economic burdens associated with California's drought, and the economic impact it has on the state's agricultural industry. The second half of the chapter 3 details the political ramifications taking place to stem the problem. Chapter 4 introduces farming within the urban environment, and the exciting new concept of vertical farming. The final chapter argues that use of ecological design with advanced technology is the ultimate solution for lowering water use during an extended drought, without letting a growing population go hungry. The paper concludes that traditional farming cannot continue, and that the drought in California will force citizens to adopt new urban farming techniques this century.

Chapter 1: Understanding California's Drought & Public Health Concerns

According to the National Climatic Data Center, droughts historically are the most detrimental weather circumstances with their relation to environmental and economic damage. A drought can be described as the following, "In simple terms, a

drought is a period of unusually dry weather that persists long enough to cause environmental or economic problems, such as crop damage and water supply shortages. But because dry conditions develop gradually and impact different regions differently, there's no agreed upon way to pinpoint when a drought begins or ends, or to objectively assess its severity.”¹ The fundamental cause of droughts is abnormally low rainfall, but scientists are now looking to what extent temperature has played in California’s current drought. Dr. Tom Painter at NASA Jet Propulsion lab said this of historic droughts, “going back a thousand years there are mega droughts in the paleo record, droughts of 30, to 50, to 80 years.. so the possibility is there, that we could be going into a 30, to 50, to 80 year drought.” A five-year drought would have irreversible changes on California citizens, so the possibility of droughts extending decades is truly frightening. Dr. Painter continues to say, “the warming that we are going to be experiencing from the increased greenhouse gasses is going to really amplify that climate variability...we think the magnitude of these extremes, and that climate variation, are going to hit us harder and harder.”² To put it simply, greenhouse gasses and CO2 are fanning a flame, making natural climate change events more extreme. The pacific decadal oscillation has been warming waters in the upper Pacific Ocean. This has created a strong high-pressure system, which has pushed the jet stream north. This is effectively steering California rainfalls and snowpack north into Canada, and even Alaska. This high-pressure system is so extreme that scientists have nicknamed it the triple R, meaning ridiculously resilient

¹ Natalie Wolchover, “What is a Drought? ,” Jul. 9, 2012, <http://www.livescience.com/21469-drought-definition.html>

² Tom Painter, “Climate Denial Crock of the Week”, Mar. 13, 2012, <http://climatecrocks.com/2014/03/13/new-video-california-drought-natural-man-made-or-both/>

ridge of high pressure.³ The triple R builds pressure in the upper atmosphere, and allows cold air to surge to the mid-west and northeast. Therefore, there is a line to be drawn between California's drought, and the polar vortex experienced on the other side of the country.

Extreme weather is occurring all over the world, and not just in the form of droughts. This past winter, New York City and much of the North Eastern Coast were victims of a polar vortex. A polar vortex is when pockets of freezing air sit and churn over the North, or South poles. The cold churning air increases temperature differences between the equator and the poles. This difference causes jet stream winds that act as a barrier for the poles to keep warm air out.⁴ These jet stream winds protect the poles, but leave citizens from the mid-west to the northeast in nearly unbearable conditions.

Professors working at the Utah Climate Center recently announced their studies have lead them to believe the California drought and the polar vortex are direct consequences of climate change. Leading the scientific investigation was assistant Professor Simon Wang at Utah State University. He said the following regarding current weather patterns, "Global effect is there that amplifies weather patterns...And those weather patterns of extreme weather cause us more and more in terms in life, property and money."⁵

Professor Wang and his associates were not the first scientists to observe connections between the western drought, and the extremely cold temperatures in the east.

³ Painter, "Climate Denial Crock of the Week"

⁴ Latasha Alvaro, "Global Warming and the Polar Vortex, Apr. 27, 2014, <http://guardianlv.com/2014/04/global-warming-and-the-polar-vortex/>

⁵ Morgan Pratt, "Climate Researchers link Climate Change, California Drought, and Polar Vortex," Apr. 24, 2014, <http://upr.org/post/climate-researchers-link-climate-change-california-drought-and-polar-vortex>

Scientists are contemplating whether massive losses of arctic sea ice, due to global warming, are causing change in the cycles responsible for weather variations. Ten years ago, Dr. Jacob Sewell investigated what effects declining arctic sea ice would have on global precipitation. He published his findings under the title; *Disappearing Arctic sea ice reduces available water in the American West*. Using an array of powerful computers, Jacob Sewell examined a normal atmospheric model, but took away some of the arctic sea ice. While holding everything the same in the model, he was able to draw conclusions on what the melted ice would specifically do to climate change, in absence of any other events. In the model, arctic sea ice loss produced a pattern strikingly similar to this last winter's triple R high-pressure system. In a recent interview Dr. Sewell talked about the cause of the current drought, and his experiments a decade ago, "Where the sea ice is reduced, heat transfer from the ocean warms the atmosphere, resulting in a rising column of relatively warm air...The shift in storm tracks over North America was linked to the formation of these columns of warmer air over areas of reduced sea ice...both the pattern and even the magnitude of the anomaly looks very similar to what the models predicted in the 2005 study."⁶ He does recognize that his model did not include other things happening in the climate system, which eliminates the possibility of blaming certain climate events on anything specific. He knows that climate patterns are reactionary to a countless systems intertwined in a complicated web of weather. However, he believes that the research he conducted 10 years ago is being validated by current drought in California. In his opinion, the evidence presenting a relatively stable

⁶ Joe Romm, "Climatologist Who Predicted California Drought 10 Years Ago Says It May Soon Be 'Even More Dire'," Mar. 7, 2014, <http://thinkprogress.org/climate/2014/03/07/3370481/california-drought/>

pattern of melted polar ice caps to western drought cannot be ignored. Unfortunately, some scientists believe that these changes to our oscillation systems will have major consequences on weather and climate, and will differ from incremental climate change the earth has experienced in the past. Rather than the changes being slow and over a period of years, the quickly changing oscillation systems will bring about swift climate change.

Consequences of drought will include economic and social problems for California citizens. The environment will deliver consequences in the forms of fire and flooding. Hot and dry temperatures experienced through drought provide dangerous conditions for forest fires. Dry and warm conditions are native to California, and are partially the reason why people enjoy California's climate. However, the current drought is sucking moisture from the earth and vegetation through the process of evaporation. Dry and dead trees are scattered across California wildlife, and are setting the stage for an especially dangerous wildfire season this summer. The summer months are always a danger for California wildfires, as the strong and dry Santa Ana winds help fan flames. This summer will be especially dangerous, as every part of the state is experiencing some sort of drought for the first time in 15 years.⁷ To put it bluntly, California is prime for a big burn. The National Climatic Data Center recently released new drought data on the regions of California. The data shows that 76.6% of the state is experiencing "extreme" drought, while 24.7% of the state has reached the top level with "exceptional" drought.⁸ The snowpack levels in the Sierra Nevada Mountains are far below par, and were

⁷ Jason Wells, "Drought Covers 100% of California for first time in 15 Years," Apr. 25, 2014, <http://www.latimes.com/local/lanow/la-me-ln-drought-covers-california-15-years-20140425-story.html>

⁸ Jason Wells, "Drought Covers 100% of California for first time in 15 Years,"

measured in early May at only 18 percent of normal snowpack.⁹ The annual Sierra Nevada snowpack melts in the spring to provide water for vegetation, as well as water for California citizens. Without significant snowpack, nature's system is disrupted. Plants and trees have not had access to enough water in the past few years, which has led to a lack of green life. Green vegetation helps plant and tree life maintain water, which helps to prevent fire. Additionally, green vegetation collects carbon dioxide from our atmosphere, helping reverse the greenhouse gas effect. An excessive amount of dead and drying branches, trees, and leaves covering the forest floors provide the perfect setting for large forest fires. When forest fires leave hills lifeless, it increases the potential for flooding. Trees and plant life that would normally soak up rainfall are not there to do so. This scenario leaves people in danger of flash floods and mudslides when there is heavy rainfall after forest fires. When California experienced heavy rainstorms at the end of February, more than 1,200 homes received mandatory evacuation notices because of these dangers. The *Geophysical Research Letters* produced a study in April that showed significant increases in large forest fires in the West from 1984 to 2011. The increase included 7 large forest fires per year with the acres burned increasing to 90,000 acres per year within the 27-year gap. The authors attributed the fire increases to climate change, and made predictions for further fire increases within the next century.¹⁰

The California drought poses a number of public health issues. These issues are well documented in the publication, *When Every Drop Counts*, which is meant to be a guide

⁹ Jonathon Lloyd, "Final Measurement of Snow Shows CA Snowpack at 18 Percent of Average," May 1, 2014, <http://www.nbclosangeles.com/news/local/Sierra-Nevada-Snowpack-California-Drought-257500871.html>

¹⁰ Bryan Walsh, "Southern California Blaze Kicks off What could be Especially Dangerous Wildfire Season," May 2, 2014, <http://time.com/84851/southern-california-blaze-kicks-off-what-could-be-especially-dangerous-wildfire-season/>

for public health officials. The publication is the combined work of several organizations wishing to organize information about public health issues regarding drought. The Centers for Disease Control (CDC), the U.S. Environmental Protection Agency (EPA), the American Water Works Association (AWWA), and the National Oceanic and Atmospheric Administration (NOAA) all took part in the publication. The first public health issue the publication touches upon was “compromised quantity and quality of potable water.”¹¹ They note that Lake Mead, a southwestern lake that sits on the border between Arizona and Nevada, has lost half of its water storage since 1999. This is just one example of surface water reduction, but the lake is key for Colorado River water resources. Decreased stream and river flow throughout the southwest causes concern for stagnation and pollution. Droughts increase forest fires, and runoff from acres of burnt landscape is a pollution threat to all surface water, and aquatic wildlife can die due to the decreased oxygen levels from the runoff. The publication also notes that current filtration systems may not be ready to handle runoff from extraordinary wildfires that a drought can cause. Groundwater resources have been reporting decreased levels throughout the Southwest, and many already shallow wells have run dry. Coastal drought raises concern for saltwater intrusion into groundwater supply, which is a result of groundwater not being replenished from rain and surface water.

“Compromised food and nutrition” is the second public health concern noted for drought.¹² Lack of rainfall results in decreased or limited growing seasons, and generates

¹¹Center For Disease Control and Prevention, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Agency, and American Water Works Association, “When Every Drop Counts,” 2010, Atlanta, US Department of Health and Human Services

¹² “When Every Drop Counts”

environments that facilitate disease, and insect infestation. Decreased food production leads to price increases in what little food there is available. People of low income feel the price increases the most, and malnutrition suddenly becomes a concern. In modern American society it has actually become cheaper to eat unhealthy. Fresh fruit and vegetables are already overpriced in comparison to a readily available hamburger from McDonalds for the price of one dollar. If healthy food prices continue to rise, then it will become almost financially impossible for the lower class to eat healthy, and malnutrition among the poor becomes a concern. The journal records negative mental and behavioral consequences, like depression and anxiety, as being other side effects from drought caused economic hardship. Food being infected by pathogens, like toxin-producing E. coli and Salmonella, are also concerns. Feeding livestock food grown under drought concerns is also a problem. Toxin-producing fungi can grow within crops in drought conditions, and eventually find their way to our animals, or our citizens. Aside from agricultural concerns, food supplies in our freshwater river, lakes, and streams also feel the squeeze from drought. Low levels of water affects water quality by being more susceptible to toxins, which in turn affect the health of animals living in the water. This affects us because there is less wildlife to eat from the water, and the fish still available could carry concentrated levels of toxins harmful for human health.

“Diminished living conditions” is a third consequence the study suggests will come about from a drought.¹³ Energy produced through hydroelectric generators is a major source of power in the United States, but is subject to the water levels of rivers and lakes. Water is also used to cool and heat our built environment, such as housing, or

¹³ “When Every Drop Counts”

industrial buildings. Water scarcity can cause impairment of machinery meant to regulate our homes and businesses. Drought induced wildfires create concern for air quality, and increased fungal activity also creates concern for air quality. Negative consequences related to our sanitation and hygiene is considered as consequences of drought. However, the publication notes that sanitation and hygiene should be given top priority among water conserving citizens. The surface water during droughts is not always safe for swimming because of contamination. Therefore, recreational activities once enjoyed in our natural water parks will not be available during extreme droughts. Everyone feels the economic burdens associated with drought, however the journal lists immediate impact for the following professions: “farmers and other agriculture-related professionals, ranchers, landscapers, horticulturalists, nursery and garden supply owners and employees, and recreational facility operators.” Suicide rates are also noted to increase within rural areas during drought. Farmers, who pride themselves on crop production, are at risk for negative mental health issues commonly affiliated with droughts. The last main topic the journal covers as a negative consequence of drought is “increased disease incidence.”¹⁴ Infectious and chronic diseases are associated with droughts for a number of reasons, but water quality is the main reason for increased concern for disease. Infectious diseases are introduced to humans primarily through ingestion or inhalation. This can come from water sources themselves, or from infected plants and animals consumed. One scary disease the journal mentions is threatening during a drought is the West Nile virus. This virus is transmitted to humans by mosquitos, and mosquito populations thrive in stagnant waters that droughts often

¹⁴ “When Every Drop Counts”

produce. The journal goes so far as to claim that the risk of wildlife and human interaction, a result of wildlife searching for water in our backyards, will result in increased exposure to vector borne and zoonotic diseases.

The journal presents many problems many would not have considered could come from a serious drought. Increased disease incidence, diminished living conditions, compromised food and nutrition, and compromised quality and quantity of potable water are all sincere concerns for the current drought in California. Many of the dangerous conditions presented, like increased suicide rates or West Nile virus, have not begun to appear. However, citizens who rely on the well being of the agricultural industry for their main source of income will likely suffer economic losses for the next few years to come.

Chapter 2: Applying Ecological Principles & California's Agricultural History

Humans transitioned from hunter-gatherer societies to agricultural societies, thus forever changing the world around us. 15,000 years ago there was not a single farm on the planet. However, around ten to twelve thousand years ago, our species discovered the advantages to be had through farming.¹⁵ Fast-forward to 2014, and it is clear that farming was the key to unlocking a future where our species dominates the Earth. Farming enabled our species the privilege of having a dependable food source. Not having to worry about where the next meal would come from allowed humans to develop in other ways. Time not spent hunting and gathering could be spent on developing culture. It is no surprise that the development of written language, mathematics, music,

¹⁵ Dickson Despommier, *The Vertical Farm*, Majora Carter, 2010, pg. 1

and other building blocks of society soon followed the development of the farm.¹⁶

However, the most important reaction to farming was that of the city. Having sedentary farms gave our species the ability to build sedentary homes, and with it came our modern day conception of an urban environment.

Currently, the world uses landmass the size of South America for farming, and that does not include grazing land.¹⁷ This is an extraordinary figure, and one that would leave your average citizen very surprised. It should be extremely concerning when considering the fact that our species population is growing. Our world boasts a human population of over seven billion people. The World Health Organization and the Population Council estimates that by the year 2050, we will have a population of 8.6 billion people.¹⁸ This begs the question, how are we going to be able to feed everybody? The answer to that question cannot be found in our current agricultural system. If we did continue to use our current system, we would have to add cropland the size of Brazil to meet our needs. The United Nations Food and Agriculture Organization estimated that nearly 870 million people suffer from chronic undernourishment on a daily basis.¹⁹ This figure was taken from 2010-2012, and has likely increased since. If we add three billion people to our current population over the next forty years without making major agricultural changes, then we are certainly facing a future involving mass-starvation in pockets of the world. Having enough food and repairing the environment do not have to be mutually exclusive goals, however we must change the way we farm.

¹⁶ Dickson Despommier, *The Vertical Farm*, pg. 1

¹⁷ Dickson Despommier, *The Vertical Farm*, pg. 1

¹⁸ Dickson Despommier, *The Vertical Farm*, pg. 37

¹⁹ Food and Agriculture Organization of the United Nations,
<http://www.fao.org/news/story/en/item/161819/icode/>

Understanding what life was like before we began to farm the natural world is key if we are to reverse the negative effects we have caused. Before we started building cities, roads, shopping malls, and mini-malls, there existed an environment that was completely self-sustaining. This self-sustaining environment still exists, however we continue to disrupt it with our growing urban environments. In order to build a sustainable environment, we must do our best to mimic what nature teaches us through the free flowing assemblage of life seen in ecosystems. Most scholars agree that in order to slow down climate change and reverse its negative affects, we must redesign our cities to “reflect the integration of functions equivalent to that of an ecosystem.”²⁰ Living within our means is necessary if we wish to live in an environment that reflects the behavior of an ecosystem. From an ecological perspective, our built urban environments do not at all reflect that of the natural world. William McDonough describes this built environment as the “technosphere”, and contrasts them to natural ecosystems because they have no limits to their growth. This “technosphere” disrupts the natural ecosystems by fragmenting them with cities, suburbs, but most importantly farmlands.²¹

Recycling of energy, food, and water is a fundamental part of sustainable living. Additionally, waste management will be integral in solving environmental problems. Waste produced from cities is staggering and is not only visually unappealing, but leads to sickness and disease. Agricultural runoff is particularly destructive, and is a major source of pollution in the world. Pesticides, silt, herbicides, and nitrogen fertilizers have been pouring into natural estuaries. The results of which have lead to nearly lifeless

²⁰ Dickson Despommier, *The Vertical Farm*, pg. 16

²¹ Dickson Despommier, *The Vertical Farm*, pg. 20-21

estuaries that were once highly productive aquatic ecosystems.²² Everything about a modern day city does not reflect that of a healthy ecosystem because they reach beyond their limits for energy, food, and water. Thus, I believe that the first step to changing our cities is to change our agriculture.

The history of California agriculture should be considered so that we can fully grasp the region's modern day agricultural situation. When settlers first arrived in California, there will little to no native crops. Again, before European settlers touched ground in the California region, there will little to no native crops. The Native Americans who inhabited this part of the west survived on seeds, fruits, roots, insects, and animals caught through hunting and fishing.²³ The Native Americans of California were forced to live a hunter-gatherer lifestyle, as the climate does not easily allow for sufficient farming without proper irrigation. Alas, the Spanish, Mexican, Japanese, Chinese, and American settlers from the east began to migrate to California, and the region's agriculture revolution began. The Spanish Missionaries were the first to cultivate crops. They began gardens surrounding their Missionary settlements, and successfully started growing wheat, fruit, and nuts. To facilitate these gardens, the Spanish began construction of aqueducts and other forms of irrigation as early as 1797.²⁴ Gardens and Missions growing together adds more evidence to the idea that cities and agriculture are linked in growth, as many of California's largest cities today are products of Missions founded over 200 years ago.

²² Dickson Desmpommier, *The Vertical Farm*, pg. 8

²³ Library of the University of California, Berkeley, "California History of Agriculture," <http://harvest.mannlib.cornell.edu/node/11>

²⁴ Library of the University of California, Berkeley, "California History of Agriculture"

Gold was discovered in 1848, and the legendary California gold rush was on. Regions that were predominantly occupied by Native Americans and Spanish settlers were bombarded by an influx of people. The people were predominantly Yankees seeking riches, however peoples from around the world migrated to California in search of gold. The population boom that took place was incredible, and was facilitated by the completion of the transcontinental railroad in 1869.²⁵ Traveling across the west by horse and buggy was both difficult and dangerous. The railroad provided fast and comfortable passage across the country, and unquestionably served as a catalyst for industrial and agricultural revolution in the west.

Many of the 49'ers, a name given to gold prospectors that arrived during the rush, did not find fortune. However, they did realize that they had arrived in an environment conducive for growing wheat, and by the mid 1850s the regions wheat output exceeded local consumption.²⁶ The region was good for growing wheat because of it's wet winters, dry summers, fertile soil, and flat valleys. This is a pivotal moment in California agricultural history. The ability to grow vast amounts of wheat contrasted with the traditional farms of the American North, which included a farmer caring for a few animals, and a couple fields of crop. The wheat farming at the end of the 19th century in California changed agriculture. California set the standard for large scale farming operations, and was able to do so for a number of reasons. The Mexican government had been granting individuals giant pieces of land to establish "ranchos". These expansive ranchos were used for raising cattle and sheep, and were meant to mimic the land gentry

²⁵ Alan L. Olmstead & Paul W. Rhode, *California Agriculture: Dimensions and Issues*, pg. 6

²⁶ Alan L. Olmstead & Paul W. Rhode, *California Agriculture: Dimensions and Issues*, pg. 2

of Spain.²⁷ Droughts and floods in the 1860s were destructive to the cattle industry. However, in the aftermath sheep herding continued to be a force, and by 1889 California was leading wool producer in the United States. The ranchos established by the Mexicans set the stage for the State's future agricultural layout of having very large farms. The adoption of new technologies such as the gangplows, large headers, and combined harvesters revolutionized large-scale farming. However, there was still a need for laborers to tend to these expansive fields of wheat. Migrant workers seeking employment were hired by farmers, and were given cheap wages. Native Americans worked the fields in the 1850s through the 1860s, but were eventually run out by an influx of Chinese, Japanese, Hindustanis, Filipinos, and Mexicans. Due to their ethnicity, these workers were not granted admission to the American Federation of Labor. This made it possible to pay them very low wages, and to run 16-hour workdays.²⁸ The crooked trend of paying migrant workers little money for labor-intensive work stretched throughout the 20th century, and in some ways can still be seen today.

From 1880s through the 1890s, most of the regions grain growers adopted the new technologies, and were able to increase production tenfold. Thus, California wheat farmers were able to export their grain around the world to start what is now a world-renowned agricultural economy. However, California's success with growing wheat did not last. This is essentially a result of the regions wheat farmers getting lazy, and not understanding the need to develop new biological species of wheat. Sonora and Club wheat species were the grains of choice, and differed from northeastern strains of winter-

²⁷ Library of the University of California, Berkeley, "California History of Agriculture"

²⁸ Joshua Paddison, "1866-1920: Rapid Population Growth, Large Scale Agriculture, and Integration into the United States,"
<http://www.calisphere.universityofcalifornia.edu/calcultures/eras/era5.html>

habit wheat. In fact, many farmers who immigrated from the East were forced to relearn how to grow the crop. The success with the Sonora and Club wheat did not see the 20th century, as decades of weak seed stocking and lack of new varietal species introduction proved to be dismal to the industry. Farmers were producing low-yields, and reports of weeds resulted from lack of crop rotation and monocrop farming methods.²⁹ Farmers abandoned their cash crop, and once again the agriculture of the region was in flux.

At the turn of the century, California agriculture transformed from a large-scale wheat farms to small-scale fruit farms. California emerged as a leading producer of citrus, grapes, and other deciduous fruits. The growth of the fruit industry was facilitated by the growth of industries dedicated to moving California produce around the world. Industries that facilitated the growth were the packing, canning, food machinery, and transportation services. By 1919, California had a stronghold on America's fruit market.³⁰ California's fruit market interrupted the Mediterranean fruit exportation as well. While taking away the Mediterranean's market in Eastern States, they slipped behind the Mediterranean and started to impact Northern Europe's fruit market. The success of the fruit boom could largely be attributed to the farmers whom over the years were able to learn how to breed new species of fruit conducive to the climate. Farmers learned how to distinguish good and bad soils of the region, and through trial and error learned where to plant specific strains of fruit. A community of farmers alike was built from the horticulture, and publications on fruit growing were released in journals like the *Southern California Horticulturist* and the *California Citrograph*.

²⁹ Alan L. Olmstead & Paul W. Rhode, *California Agriculture: Dimensions and Issues*, pg. 3

³⁰ Alan L. Olmstead & Paul W. Rhode, *California Agriculture: Dimensions and Issues*, pg. 4

The second transformation of California agriculture took place with the introduction vegetables, rice, cotton, and sugar beets. These crops differed from the others because they are row crops, which need significant amounts of water and interrow tillage to survive. Efforts to grow cotton had been taking place for decades, but farmers were never able to produce strong yield. However, during World War 1 farmers were encouraged to try to grow the crop, and were finally able to find success. California offered more land space, and used new technology to overcome competing cotton growing regions. For example, the acreage in average California cotton farms was five times larger than southern cotton farms from the 1920s through the 1950s. Additionally, a California farm was almost 20 times more likely to own a tractor than a farm in Mississippi in 1929. New technologies for harvesting cotton, like spindle picking machines, were also developed. Around 50 percent of California's cotton was picked mechanically by 1951, which contrasted with the national average of only 10 percent. All of these developments lead to California becoming a major player in just 40 years. In 1919, California was second to last in cotton producing states, but was the second leading cotton-producing state in America by 1959.³¹

This agricultural boom would not have taken place without one essential resource needed for all of life. The essential resource is of course water, and without it, nothing grows. The debate over water has been raging since the first settlers entered the California region, and will likely continue to rage through this century. To quote Mark

³¹ Alan L. Olmstead & Paul W. Rhode, *California Agriculture: Dimensions and Issues*, pg. 8

Twain, “Whiskey is for drinkin’, water is for fightin’ over.”³² This rings true in California, especially now that the State is in extreme drought.

The California irrigation system is complex myriad of dams, levees, canals, aqueducts, and reservoirs. In fact, the California irrigation system is so grandiose that is the only other man-made venture, other than the Great Wall of China, that can be seen from space.³³ Early Californian’s were able to transform an arid region into supply farmlands, which in turn helped spur on urbanization. The 49’ers built flumes and ditches for hundreds of miles in attempts to flush gold from the running water. However, after a while their success was limited, and many turned to farming. The development of canals in the Central Valley by individual farmers and private companies helped facilitate new growing operations. Water control and provision were essential for early farmers to grow crops. Thousands of miles of major levies were constructed to control the state’s inland waterways. This work was collaborative effort by individual farmers, the Army Corps of Engineers, and reclamation districts.³⁴ California water laws began to appear in the 1850s, and are compared to the English riparian rights. This means that water rights were given to the farmers whose lands bordered the source of water. However, this changed in 1887 with the establishment of the Wright Act. The Wright Act deemed water a public utility, and created irrigation districts under public control.³⁵ Initially, only a few districts found success, but at the turn of the century most of the Central Valley was being farmed as a result of public irrigation districts.

³² Mark Twain

³³ Library of the University of California, Berkeley, “California History of Agriculture”

³⁴ Alan L. Olmstead & Paul W. Rhode, *California Agriculture: Dimensions and Issues*, pg. 16

³⁵ Library of the University of California, Berkeley, “California History of Agriculture”

Attention is always paid to California's large-scale public projects to attribute growth towards the state's irrigation system. However, much of the growth was actually due to many small-scale private initiatives. Before the 1960s, individuals and partnerships were the pioneers in supplying water to the state's agriculture. By 1950, over one-half of the irrigated acres of land were products of private initiatives. Private irrigation initiatives were facilitated by a growing use of groundwater. Development of new pumping technology made it possible to reach previously untapped groundwater. Acres of land irrigated by groundwater increased more than thirtyfold from 1902 to 1950. Groundwater use was so prevalent, that by 1950 it was contributing to over 50 percent of California's irrigation. Individuals and partnerships dominated the groundwater scene from 1920 to 1950, and held accounted for about 80 percent of the ground water quantity during that time.³⁶

Individuals and partnerships, as well as groundwater use, reached its peak in 1950. By 1970, irrigation districts had taken control of the water market, and shift of power away from the individuals and partnerships was clear. Large-scale state projects were a large part of why this happened. World War II ended in 1945, resulting in an economic boom for the state of California. Metropolitan areas of Los Angeles and San Francisco were particularly affected. Thousands of tract homes and new businesses entered the areas, and it soon became apparent that the growing cities needed more water. Additionally, groundwater basins were being depleted at alarming rates in order to keep up with the agricultural needs. In 1945, the California legislature authorized an investigation into its own water resources. The results lead to the California Water Plan,

³⁶ Alan L. Olmstead & Paul W. Rhode, *California Agriculture: Dimensions and Issues*, pg.17

which offered details into developing water resources by means of major state projects and smaller local projects.³⁷ This plan was met with much controversy; as such a colossal project had never been attempted. Additionally, Northern Californians did not feel comfortable sending most of their water supplies to the south. Southern Californians were also uncomfortable, as they wanted guarantees that the north would not rescind water agreements.

This argument over water resources was the catalyst for providing a rivalry between southern and northern California that still exists today. By 1960, the Burns-Porter Act passed by a slim majority in a vote that saw the north and the south divided in two. The Burns-Porter act approved 1.75 billion dollars in bonds in order to complete the water project. Thus, construction began on what is currently the United State's biggest state-built water development and distribution system. The State Water Project became the centerpiece of the California water system with an impressive 21 dams complimented by 701 miles of pipes and canals. State Water Project has provided ample amount of water for California, until now. Unfortunately, the system cannot pump water when there is no rain. In January of 2014, state officials announced that the State Water Project had officially run dry, and would not be able to provide any water for the year. This is an unprecedented event, as the system has not failed to provide citizens water since the Burns-Porter Act passed 54 years ago.³⁸ Keep in mind that officials announced this in January, and were hoping to update the situation with winter wet months still

³⁷ "Liquid Gold: California's Water,"

<http://library.ucr.edu/view/wrca/grants/liquidgold.html>

³⁸ Paul Rogers, California Drought: State Water Project Will Deliver No Water this Year," Jan. 31, 2014,

http://www.mercurynews.com/science/ci_25036886/california-drought-state-water-project-will-deliver-no

ahead. The situation did improve slightly as February and March received a few good down pours. This resulted in the California Water project announcing in mid April that they would be able to distribute 5 percent of the system's allocations.³⁹ However, 5 percent of 100 cannot be a comforting figure. Now this does not mean that California citizens are going to go thirsty in 2014. However, local regions will have to fend for themselves by relying on local reservoirs, wells, recycled water, and from conservative attitudes towards their water. Parts of East Bay and Silicon Valley will be struck hard, as 80 percent of their water supply is pumped from the Water Project. Thousands of acres will go unplanted and will cause serious economic stress on California's rural regions, leaving many people jobless.

Chapter 3: Economics and Politics during Drought

California began measuring its precipitation in 1849, but after 124 years 2013 stands alone as the driest year on record. The three-year drought does not show any signs of slowing down, and precipitation readings for last winter were nearly record setting. According to the United States Department of Agriculture, "as of March 4th, over 94 percent of California's 45 billion dollar agricultural sector was experiencing severe, extreme, or exceptional drought, with the livestock sector more directly exposed to exceptional drought than the crop sector."⁴⁰ This means that the billion-dollar California agricultural industry is going to lose a lot of money, and many people living in rural California will lose their jobs this year. This is especially concerning because these

³⁹ Julie Cart, "For First Time in 15 years, Drought Hits 100% of California," Apr. 24, 2014, <http://www.latimes.com/science/sciencenow/la-sci-sn-california-drought--20140424-story.html>

⁴⁰ United States Department of Agriculture, <http://www.ers.usda.gov/topics/in-the-news/california-drought-2014-farm-and-food-impacts.aspx#.U2rnpMZCdFJ>

regions traditionally rank high for unemployment without drought conditions. In fact, in 2012 the US Census Bureau ranked 3 counties in the Central Valley as being in the top 5 poorest counties in the nation.⁴¹ The counties of Fresno, Modesto, and Bakersfield-Delano had the highest percentage of citizens living below the poverty line. This is an interesting figure when considering that the counties are home to the country's most powerful agricultural zones. The average farm worker has an annual income of 13,800 dollars, which is already very low.⁴² Field workers will be left without jobs, while farm owners could find themselves in debt by the end of the year. It should be noted that many of the farmworkers are uneducated, and unfit to work in industries outside of agricultural work. Additionally, many workers emigrated from Mexico illegally, are employed illegally, and do not have command of the English language. In fact, the USDA estimates that about half of all farm workers in California are undocumented.⁴³ Mendota, a city within Fresno County, reported a 97 percent Latino population in a 2010 census.⁴⁴ The mayor of Mendota expects an unemployment rate of over 50 percent this year, and will inevitably leave many impoverished and hungry people. Federal and state government offer financial assistance for needs-based purposes, and many of the families living in cities like Mendota will meet the financial requirements. However, a white paper on US agriculture, *Health-related Inequities Among Hired Farm Workers and the Resurgence of Labor-intensive Agriculture*, estimated that less than 1 percent of these financially qualified people received any financial assistance from the government. They

⁴¹ Gail Wadsworth, "No Water, No Work," Mar. 17, 2014, <http://www.cirsinc.org/index.php/rural-california-report/entry/no-water-no-work.html>

⁴² Gail Wadsworth, "No Water, No Work,"

⁴³ USDA

⁴⁴ Gail Wadsworth, "No Water, No Work,"

lack documentation necessary for proving citizenship, therefore disqualifying them from government programs meant for the survival of our poorest citizens. The white paper also notes that 75 percent of hired workers do not have any health insurance.⁴⁵ This is complimented by the fact that hired farm workers are five times more likely for a fatality in the workplace in comparison to employees from other industries. It is clear that the population of hired farm laborers, and their families, will be the ones to suffer the most from the current drought.

California's agricultural industry is a 45 billion dollar a year machine, and is responsible for almost half of all fruits, vegetables, and nuts grown in the United States.⁴⁶ The California Farm Water Coalition estimates that 800,000 acres will go unplanted this year. Coalition Executive Director Mike Wade, said this of the potential economic impact, "The negative impact to California's economy from lost farm production and associated business has increased almost 50 percent to \$7.48 billion from early estimates in February... On-farm production losses are expected to double from \$1.7 billion to an estimated \$3.56 billion based on the new survey results."⁴⁷ Consumers throughout the country have already started to notice the rising prices of fruits, vegetables, meat, and eggs. California is the largest producer of lettuce, avocado, broccoli, grapes, tomatoes, melons, peppers, berries, corn, and packaged salad. Professor Timothy Richards, an

⁴⁵ "White Paper Makes Case that Farm Workers are Most Vulnerable Members of US Workforce," Mar. 14, 2014, <http://kresge.org/news/white-paper-makes-case-farm-workers-are-most-vulnerable-members-us-workforce>

⁴⁶ Julie Schmit and Elizabeth Weis, "Californians brace for year of 'mega-drought'," Feb. 5, 2014, <http://www.usatoday.com/story/money/business/2014/02/04/california-drought-economy/5043691/>

⁴⁷ "Estimate of unplanted acres jumps to 800,000; consumers expected to feel impacts," <http://new.farmwater.org/new/new-31814-estimate-of-unplanted-acres-jumps-to-800000-consumers-expected-to-feel-impacts/>

agribusiness professor at ASU, projects large price increases this summer for specific crops. However, Professor Richards believes that these price increases will be more or less temporary. Food markets outside of California and the US will take advantage of the drought, and will begin to ship unavailable food to the states.⁴⁸ Row crops are expected to be impacted the most by the drought, which include tomatoes, broccoli, cantaloupes, lettuce, corn, peppers, and garlic. Farmers are more inclined to water and protect fruit and nut trees, as replacing a single tree can take up to seven years. Cotton, corn, and wheat fields will be the first fields idled by farmers in order to keep orchards watered. Mark Borba has been farming in California for 42 years, and keeps tomatoes, garlic, onions, lettuce, melons and almonds on 11,000 irrigated acres of farmland. Of those 11,000 acres, he expects to leave one third unplanted. He is most concerned with keeping the health of at least 300 acres of almond orchards, which he values at \$12,000 dollars an acre. In order to keep 300 acres alive, Mr. Borba spent \$800,000 dollars on a new well. Mark knowingly made the bad investment, and when asked why he responded by saying, “You do the math.... Does that make sense?... No, but it’s a slower death.”⁴⁹

Farmer Mark Borba is one of many farmers that are now attempting to extract ground water from their own lands, despite having to take out financially backwards loans. There is no statewide policy on withdrawing groundwater from private lands, but there absolutely should be! Lack of regulation is leading to phenomenon where well permits have spiked in the last few years. Extracting groundwater is literally causing the central valley to sink. A 2013 geological survey estimated that the Central Valley is

⁴⁸ Eric Morath, “Attention Shoppers: Fruit and Vegetable Prices are Rising,” Apr. 15, 2014, <http://blogs.wsj.com/economics/2014/04/15/attention-shoppers-fruit-and-vegetable-prices-rising/>

⁴⁹ Julie Schmit and Elizabeth Weis, “Californians brace for year of ‘mega-drought’,”

sinking at an average of 11 inches annually.⁵⁰ The sinking valley is causing major problems infrastructure problems for canals, roadways, railroads, bridges, pipelines, and other infrastructure lying on the valley floor. Some infrastructure, like all of the water carrying canals, relies on gravity to move water throughout the central valley. Thus, if the drought ever does end and the reservoirs have water to stream, the elevation changes from groundwater welling could put the whole system in jeopardy. California groundwater reserves are being drained at an annual rate of 800 billion gallons, which doubles the amount of water nature is returning!⁵¹ In comparison to surface water, groundwater takes much longer to replace. Writer Tim Philpott makes an excellent financial metaphor, “To live off surface water is to live off your paycheck. When you get a raise, you can spend more. But when your paycheck drops, you have to cut back, economize. To rely on groundwater, though, is to live off of savings. Every draft you take is one that you won’t be able to replenish, at least not easily.”⁵² Many farmers blame the government for not indulging them with more water from the reserves, but this ideology is self-serving. The California people should be blaming the government for not having strict law on groundwater usage.

To put it gently, the politics of California water are a nightmare, and the drought helps to amplify scare. The California Department of Water Resource does not even know the amount of agencies that support the state with water. Writer Tim Reid notes

⁵⁰ Tom Philpott, “California Farmers: Drill, Baby, Drill (for Water, That Is),” Apr. 2, 2014, <http://www.motherjones.com/tom-philpott/2014/04/california-drought-groundwater-drilling>

⁵¹ Lisa M. Krieger, “California Drought: San Joaquin Valley sinking as farmers race to tap aquifer,” Mar. 29, 2014, http://www.mercurynews.com/drought/ci_25447586/california-drought-san-joaquin-valley-sinking-farmers-race

⁵² Tom Philpott, “California Farmers: Drill, Baby, Drill (for Water, That Is),”

“while state regulators supervise three companies that provide gas and electricity for most of California, drinking water is delivered through a vast network of agencies which collectively do billions of dollars of business, setting rates and handing out contracts with scant oversight.”⁵³ One spokesman from the department estimates there to be around 3,000 agencies, but admits that they do not know the exact number.⁵⁴ The confusion often leads to mismanagement of water supplies, which was not problem for many until the state’s drought became serious. The drought is making obvious the flaws of California’s water organization, as there is not one overarching body that regulates its use.

In January, Governor Jerry Brown announced drought emergency for the state of California. At a San Francisco news conference, Governor Brown pleaded that all citizens to reduce water use by 20 percent.⁵⁵ Unfortunately for California, this was only the first emergency drought announcement the Governor made. On April 25th, Governor Brown announced that the state would begin rolling back environmental protections, and begin slackening water transportation rules for farmers. The governor also called upon individuals to stop watering their lawns, washing their cars, or even accepting water at a restaurant if not thirsty. Executive orders from the governor included propositions that would make it easier for cities to upgrade and develop their water systems. Additionally, it forbade homeowner associations from fining residents for having dead lawns.

⁵³ Tim Reid, “In California Drought, Big Money, Many Actors, Little Oversight,” Apr. 25, 2014, <http://www.businessinsider.com.au/r-in-california-drought-big-money-many-actors-little-oversight-2014-25>

⁵⁴ Tim Reid, “In California Drought, Big Money, Many Actors, Little Oversight,”

⁵⁵ Steve Gorman, “California Drought Crisis: A \$5B Hit to the Economy,” Feb. 6, 2014, <http://www.thefiscaltimes.com/Articles/2014/02/06/California-Drought-Pushes-Farmers-Curtail-Crops>

Governor Brown said the following about drought and it's relation to climate change, "The only way out over the long term is to substitute the fossil fuel with solar, with wind...we are playing Russian roulette with our environment."⁵⁶ Fortunately, Governor Jerry Brown understands what needs to be done, however it is going to take much more than that to fix California's broken water system. President Obama recently traveled to the Fresno County in response to Governor Jerry Brown's state of emergency address. The President promised \$183 million dollars of federal money for drought relief programs in California.⁵⁷ He met with farmers and ranchers as he toured the scarred countryside. The President is an intuitive individual, and realizes that California's water system is completely out of sync. "Water has been a zero-sum game: agriculture against urban, north against south...we're going to have to figure out how to play a different game." As always, President Obama gave a number of encouraging speeches, in which he demonstrated knowledge of all sides of the argument. However, playing a "different game" involves a reconstruction of not only law governing water, but a reconstruction of the peoples' philosophy towards its natural resources. This is increasingly difficult, as many suffering people would have the reserves pumped dry in order to end immediate suffering. The President was at all times surrounded by leaders from the state's Democratic Party, but failed to gain the presence of the state's top republicans. This

⁵⁶ Dana Feldman, "California governor issues second drought emergency proclamation," Apr. 25, 2014, <http://www.reuters.com/article/2014/04/26/us-usa-politics-california-idUSBREA3P02M20140426>

⁵⁷ NORIMITSU ONISHI and CORAL DAVENPOR, "Obama Announces Aid for Drought-Stricken California," Feb 14, 2014, http://www.nytimes.com/2014/02/15/us/politics/obama-to-announce-aid-for-drought-racked-california.html?_r=1

highlights a growing uneasiness between the two parties, as they hold very different views on how to respond to the drought.

A major point of contention has been the draining of the Sacramento-San Joaquin River Delta, and last month the Republicans passed a bill to continue pumping the already unhealthy waters. Farmers and Republicans alike believe that freshwater entering the ocean is a waste of resources. Democrats understand this bill to be water grab for the farmers, and believe it could lead to long-term environmental consequences.

Environmentalists continue to make passionate arguments for the Delta's importance.

Freshwater from the Sacramento and San Joaquin Rivers flow into the ocean, and help to keep the ocean from flowing into the rivers and groundwater supplies. Fishery groups remain concerned about the wildlife health of the Delta because endangered fish are

receiving less water than ever before. Thus, the farmers are pitted against the environmentalists, and the Republicans are pitted against the Democrats.⁵⁸ As mentioned before, the hired farm hands are the most vulnerable group of people during a drought.

The farmers may struggle financially, but ultimately it is the Latino based community that has the potential to slip into extreme poverty. However, it is very doubtful that Republicans are fighting for increased water for farmlands because they are concerned for the health of illegal Mexican workers. It is clear that the Republican Party is looking after the billion dollar agricultural industry. Once the drought subsides, the illegal migrant workers will supply the country with food through sweat and blood. Perhaps then the Republicans will continue to debate how to rid the country of people who make their multi-billion dollar agricultural business possible.

⁵⁸ Steve Gorman, "California Drought Crisis: A \$5B Hit to the Economy,"

The politics behind California's water are becoming more desperate, and lobbying efforts have increased dramatically in the last few years. The state is more or less divided into 3 main categories: the Northern Californian environmentalists, the Central Valley agriculturalists, and the vast population of Southern Californians who need drinking water. These 3 groups have been pushing a lot of money into politics through lobbying in attempts to gain political favor. The money flowing into government makes most of its impact through congress, and congress has been very busy this past year. The bill that recently passed allowing increased pumping from the suffering Sacramento-San Joaquin River Delta has lobbying money all over it. Westlands Water District, a company that owns water that feeds thousands of acres in Fresno and Kings counties, contributed \$600,000 dollars to 4 different lobbying firms in 2013. However, the \$600,000 dollars is only the amount that they disclosed through required disclosure documents. Internal documents, uncovered by Southern California Public Radio, read that Westlands donated an additional \$90,000 to former Rep. Tony Coelho for representation in Washington. The Westlands also shilled out another million dollars for an "outreach and awareness" campaign.⁵⁹ These are just the numbers that have been made public, what is really concerning is the money that is being back channeled through politics to keep the status quo. The Sacramento-San Joaquin bill allocates water resources to Westland farmlands, and proves that big money is making a difference in our water politics. Perhaps the most concerning part of the new bill is that it extends federal water service contracts for 40

⁵⁹ Kitty Felde and Viveca Novak, "The Politics of Drought: California Water Interests Prime the Pump in Washington," Apr.10, 2014, <http://www.opensecrets.org/news/2014/04/the-politics-of-drought-california-water-interests-prime-the-pump-in-washington.html>

years.⁶⁰ This type of law denies future lawmakers the ability to change the way water is distributed, which is obviously something that needs to be done this century.

Chapter 4: Ecological Design

The Central Valley is prepared to fail because they have failed to prepare. The farmers of the region have been slow to adopt water saving techniques that have been available for the last few decades. Flood irrigation is the most commonly used technique by farmers of the Central Valley, but it is far from being the most ecologically sound. Water is pumped over rows of crop a few inches deep, and is allowed to sit like a lake over the crops. Farmers would have recognized the ‘flooding of the field’ technique 7,000 years ago, which proves that they have been effective for growing crops for most of our history.⁶¹ However, human population levels are continuing to rise, and it is not responsible to continue farming with flood irrigation. Roughly half of the water used during flood irrigation is wasted, and never sees the crop it is intended to water. This is probably because plants are not supposed to be watered during a flash flood, but rather through a gentle rainfall. This is the basic idea behind drip irrigation methods. Not only does drip irrigation lead to water savings of 15-55%, but it the methods improve crop health and the health of the surrounding environment.⁶² Flood irrigation losses roughly half of the water intended for the crops, which results in fertilizers, herbicides, and pesticides seeping into the surrounding groundwater. This has become a major concern,

⁶⁰ Kitty Felde and Viveca Novak, “The Politics of Drought: California Water Interests Prime the Pump in Washington,”

⁶¹ David Johnson, “California Farms Are Slow to Adopt Water-Saving Technology,” Feb. 13, 2014, <http://www.newsweek.com/2014/02/14/california-farms-are-slow-adopt-water-saving-technology-245516.html>

⁶² “Drip Irrigation,” Irrigation Australia, <http://irrigation.org.au/wp-content/uploads/2013/03/Drip-Irrigation-brochure-final-for-print-v8.pdf>

especially for the southern Central Valley, as agrochemicals have begun to result in salty groundwater. As mentioned earlier, groundwater is being pumped at alarming rates in the central valley. Therefore, farmers watering their crop with contaminated ground are the same farmers that caused the contamination by using flood irrigation. The drip irrigation systems use precision water application methods to ensure that each individual crop is getting the proper amount of water. The reason California farmers have been slow to adopt drip irrigation is that it is initially an expensive investment. Government subsidies have provided farmers with more than enough water during years of average precipitation; therefore there has not been much of an incentive to make economic sacrifices to install the new technology. Additionally, instead of investing in the drip irrigation systems, farmers have instead invested in wells for pumping groundwater. Drip irrigation is a fantastic alternative to traditional irrigation, but is it too little, and too late for California's Central Valley? Contaminated and salty groundwater will continue to rise towards the taproots of the southern Central Valley, and the taproots continue to sink towards the groundwater. When the contaminated groundwater reaches taproots, the crops will die, and the land will no longer be supple.⁶³ Some foresee contaminated groundwater ruining the potential to farm in the southern Central Valley in 25 years. Regardless, a prolonged drought will make any type of irrigation impossible.

Climate change is drying out the state of California, and will likely desolate the once powerful agricultural industry. The drought may not last another 3 years, however it very well could. The question is not will the farming industry leave California, but when will the farming industry leave California. California's population is the highest in

⁶³ Dickson Despommier, *The Vertical Farm*

all of the country with a staggering 38.3 million people. In 2013, California added an average of 1,000 residents a day. The urban centers of San Francisco and Los Angeles are drawing the most people, as are most cities in California. Additionally, every county in the arid Southern California region grew in 2013.⁶⁴ The California Department of Finance projects that the state will surpass 50 million residents by the year 2049.⁶⁵ If the state remains in drought like conditions then it will not be possible to sustain both conventional farming methods, and water for basic human needs. The once powerful California agriculture industry will probably be forced out of the Central Valley. Rural communities are already beginning to empty, making for ghetto-like ghost towns across the valley floor. However, from an environmentalist standpoint this might not be viewed as a negative situation. Yes, the people of rural California will suffer, but the Central Valley may be able to start healing with the absence of human activity. For too long our species has developed cities next to farms, and farms next to cities. It is time for our species to integrate farm and city into one distinguished ecosystem.

The human species is the only living being on Earth that does not adhere to basic ecological rules, and our indifference towards the natural functions of the Earth are causing rapid climate change. Our farms and our cities continue to grow outwards across Earth's crust, but our species is running out of room to grow, and our population continues to boom. Climate change will likely run big business agriculture out of California, but that does not mean that California citizens have to rely on produce

⁶⁴ SCOTT GOLD, ANH DO, Lee Romney, "California's population rises to 38.3 million during 2013," Apr. 30, 2014, <http://www.latimes.com/local/la-me-calif-population-20140501-story.html>

⁶⁵ Department of Finance, http://www.dof.ca.gov/research/demographic/reports/projections/p-1/documents/Projections_Press_Release_2010-2060.pdf

shipped around the world to keep healthy. The concept of the “vertical farm” is relatively new, but it has the potential to change the world. Instead of continuing to ravage our landscapes by expanding outwards, the vertical farm suggests the idea of expanding upwards. Simply put, it is the idea of stacking technologically advanced greenhouses within an urban environment. Great technological advances within the fields of hydroponics, areoponics, and drip irrigation have taken place over the last few decades.⁶⁶ Technology of the modern era is amazing, but not always utilized for the right reason. Our governments are able to use advanced satellite technology to find the perfect landscapes to plant corn, but nobody asks the question: Should we be farming corn on that land? The vertical farming concept uses technology for the betterment of our species, and every other living being on the planet. By moving farming into urban environments, humans can take the first step towards closing off our urban ecosystems, letting a vast amount of environment begin to heal itself.

The disadvantages of the vertical farm are slim, so let's start with those. The initial costs of construction are obviously the first disadvantage. Constructing technologically advanced greenhouses within a building is not an easy or cheap feat. However, the long-term benefits definitely outweigh the initial start up costs. Any new technology is always more expensive, however as it becomes more popular the prices go down. If the vertical farm gains momentum, competitors will enter the market for construction, growing technology, and every other aspect that goes into creating a vertical farm. The second disadvantage is the displaced farmers left behind in rural parts of the country. However, this idea will not happen overnight, and a displaced farming

⁶⁶ Dickson Despommier, *The Vertical Farm*

community of the Central Valley will certainly find a way to move on. Increasing food production while increasing environmental repair are the ultimate advantages of vertical farming.

The Vertical Farm, a book written by the founding father of the vertical farm concept, details many advantages to vertical farming. The first advantage is the ability for “year-round crop production”.⁶⁷ Now, in California the weather allows for more or less of a year round crop production in the Central Valley, however pumping water to the Central Valley is obviously not a sustainable solution anymore. Crop-production has always been in adherence with the seasons, and with Mother Nature’s temperament. This is the first problem with traditional farming. It does not give us full control of our crop production, as crops are ultimately at the mercy of the environment. Bringing crops inside makes them impervious to whatever climate crisis is going on outside. Having a year-round ability to grow crops that were once only available seasonally offer a huge advantage to local vertical farmers, and the community. Local communities will not have to ship in-season produce half a world away, instead they can access the produce they want, when they want, all the time. Another advantage is that there are “no weather-related crop failures.” Florida is major producer of cattle and sugar cane, however they have become victim to increasingly violent hurricanes, which often damage farmlands. In 1992, Hurricane Andrew destroyed much of the state, and damage was estimated at \$34 billion dollars. After the storm, one farmer decided to rehabilitate his 30-acre farm by investing in one acre of high-tech greenhouse. He is able to produce 29 acres of fruit using hydro stacking technology within just one acre of greenhouse, and is able to

⁶⁷ Dickson Despommier, *The Vertical Farm*, pg. 146

produce fruit year-round. Additionally, he decided to leave the remaining 29 acres of previous farmland untouched, and much of the land has made vast biodiversity increases.

“No agricultural runoff” is a major advantage of vertical farming. The USDA understands agricultural nonpoint source pollution as the primary cause of pollution in the country.⁶⁸ Vertical Farm notes that California agricultural practices are in the most danger of losing farmland due to agricultural runoff pollution. Groundwater pollution, destruction of estuaries, and contamination of rivers containing drinking water are all serious threats to the region. Moving farming indoors could prevent pollution because it empowers indoor farmers to control the runoff. Recycling the runoff makes it possible to use water over and over again. Pesticides, herbicides, and fertilizers will not pollute the water runoff because the vertical farm does not need these chemicals to produce food. The buildings will be designed to keep out insects or other microbial pathogens that are looking for a free meal. Using pure water, infused with a balance of nutrients, can give plants growing indoor more than enough life. Growing food outside is more dangerous in the sense that it exposes our food to dangerous agrochemicals, or pathogens like *E. coli* or salmonella.

The reason vertical farming can save drought stricken California is because it uses 70-95 percent less water. Traditional agriculture uses 70 percent of the Earth’s available freshwater, all while polluting the natural water systems. Developments in hydroponics and aeroponics have changed the way biologists believe plants grow. Plants do not need soil to grow; or rather they just need the bare essentials to grow. If there is enough water, dissolved minerals, and a source of organic nitrogen, then plants can rise. Plants can rise

⁶⁸ Dickson Despommier, *The Vertical Farm*, pg. 150

from almost any type of environment, like a newly formed volcanic island, or a crack in New York City's sidewalk. Plants create the soil when the roots break apart rock and mineral, therefore soil does not create the plants. Dickson Despommier suggests that large agrochemical companies, which will surely resist the vertical farms, transition into companies that supply "ultrapure and chemically defined diets for crops grown in vertical farms." It could be an excellent transition for an industry seen as destroying our earth with runoff pollution. Hydroponics involves pumping water through designed piping in order to provide the perfect amount of water for each plant, and to promote the growth of plant uniformity. Technology today allows scientists to monitor the nutrients within the water, allowing for fewer mistakes in growing. Aeroponics is a new concept that was invented by Richard Stoner in 1982. The concept involves using tiny nozzles to spray nutrient-laden mist to the roots of growing plants, and is so conservative with water that it consumes even 70 percent less water than hydroponics!⁶⁹ Aeroponics is the next step in greenhouse technology, and is so new that my spellcheck continues to mistake "aeroponics" as a misspelled word. As water distributing technology continues to advance, the idea of growing all food in a controlled environment all while saving water begins to look more enticing.

Putting the farm within the city brings new meaning to the phrase "home-grown." Consumers are more likely to buy fresh produce that they can see growing. Bringing the farm within the city limits will bring a local food source right to the mouths of the consumer without having to ship produce across the world. This is an advantage because it greatly reduces society's carbon footprint, as food does not have to travel by plane or

⁶⁹ Dickson Despommier, *The Vertical Farm*, pg.165

ship across the world. The time it takes for food to travel across the world not only pumps Co₂ into the atmosphere, but also increases the likelihood for spoilage. The disadvantage of bringing the farm into the city is costly prices of urban real estate. However, there is opportunity within the cities for greenhouse growth, and can help poorer parts of the city regenerate healthy living conditions. Starting vertical farms within city boundaries offers opportunity for new jobs. California's cities, and the world's cities, are continuing to grow in population. A growing vertical farm industry offers new employment opportunities to local communities. Additionally, there will be opportunity for specialty businesses that create and distribute specialty grow systems needed for building vertical greenhouses. Now, the vertical farm will need a significant amount of energy to produce crops. The ability to incinerate postharvest portions of crops, and left over plant material can help with the problem of powering the building.

The vertical farm building must be carefully designed so that they do not emit carbon like that of a traditional skyscraper. Keep in mind that the idea of vertical farming was not realized until the year 1999, a fitting idea at the turn of the century. The concepts of what will make these farms perfectly sustainable and able to manufacture food are still in the works. However, the four concepts that Dr. Despommier notes are: "1. Capture sunlight and disperse it evenly among the crops 2. Capture passive energy for supplying a reliable source of electricity 3. Employ good barrier design for plant protection 4. Maximize the amount of space devoted to growing crops."⁷⁰ These 4 requirements are necessary for a building that takes full advantage of the sun, and that can produce healthy crop. Taking advantage of geothermal energy, tidal energy, and wind energies are also

⁷⁰ Dickson Despommier, *The Vertical Farm*, pg. 183

important for a sustainable building. Incinerating unused organic material provides another source of energy. “Employing barrier design for plant protection,” means that the buildings must be safe from infection or disease. However, if there came a situation where a vertical farm was breached, it could be dealt with much easier than a farming operation outdoors. The infected crops could be destroyed on the spot, and growing operations could regenerate the next day. A traditional farmer would have to destroy his crops, and wait a full year for the next growing season.

Conclusion:

California drought is just one example of rapidly changing environments resulting for climate change. However, I am a true believer that vertical farm movements, and other forms of urban agriculture, are the first steps towards moving California out of its water crisis. California has always been a pioneer in developing technology to better agricultural techniques. The state has set the standard for crop production, and has revolutionized the way agriculture is done today. However, the same historical advances making it possible for a semi-desert climate to bloom with fruits and vegetables are the same advances that are now destroying the environment. Confusion in California’s water politics reflects a confused society. What once made the state prosperous and great is now desolating the state’s environment. In economic terms, the farming industry was once prosperous, but for all outdoor farming’s shortcomings in a world twisted by climate change, the concept of farming outdoors is producing diminishing returns.

I had the honor and privilege to take a class called Ecology for Design in my last semester at Fordham University. The class was taught by the founding father of vertical farming, Dr. Dickson Despommier. Thus, giving evidence for my clear bias towards

solving my home state's water crisis with vertical farming concepts. The class was comprised of only 6 students, and we spent most of the time in round-table discussion on how to design the perfect eco-city. Dr. Despommier is unique because he recognizes all the amazing advantages our built urban environments have given us, but has an advanced academic understanding of how they are also destroying our environment. The population of the world continues to urbanize because people simply enjoy living in cities. Today's cities have the most work available, the best school systems, the most recommended doctors, the finest restaurants, and the advantages continue. However, if our populations want to live in say, Los Angeles or San Francisco, then cities must become ecologically sound. The first step to doing this is to move the food sources out of the fields, and into the cities. Technology got us into the mess, and now it can get us out. If we are able to leave our injured environments alone, while growing healthy food within urban neighborhoods, should we not do it?

The rise of the vertical farm movement is already on its way. The first prototypes were constructed in Japan, Korea, Holland, and England between 2010-2011.⁷¹ Keep in mind that this is merely 10 years after the idea was conceived. While the United States did not get the jumpstart on the vertical farm revolution, there have been grand openings within the last few years. The company, Green Spirit Farms, opened the largest vertical farm operation this year in our country's own Scranton, Pennsylvania. The US Defense Advanced Research Projects Agency recently started utilizing an 18 story vertical farm to

⁷¹ Dickson Despommier, *The Vertical Farm*

grow genetically modified plants used for vaccines.⁷² Smaller vertical farm and green house growing operations also are sprouting up around the country. California joined the party in the last few years. Famgro Farms, a vertical farm operation based out of an Oceanside warehouse, supplies fresh vegetables to Whole Foods and other organic food stores across the San Diego area. Company founder Steve Fambro estimates that their operation “uses about 3 percent of the water, 1 percent of the land and a fraction of the labor of traditional farming...and that the energy needed to grow 20 servings of some of Famgro's greens is equivalent to what's needed to heat a 10-minute shower.”⁷³

Highly efficient vertical garden operations are sprouting all around the state like drought-resistant mushrooms. Some operations are large, and have the opportunity to feed thousands through commercial grocery marts. Some are operations are small, and but have the capacity to feed a family fresh produce year-round. However, they are all equally important because they chip away at previously needed California farmland. Dr. Despommier said something in our last class that has stuck with me “We don’t want to live outside, why should our food?” This question sounds silly, but I find it to have serious existential truth. California’s current drought is a manifestation of climate change, but the economic and social problems it’s producing do not have to be. Mother nature will continue to weaken big agricultural business on her own, which will leave the door open for an urban agricultural revolution. Grassroots roots campaigns for urban agriculture need to bombard Sacramento within the next decade. Current water law in

⁷² Paul Marks, “Vertical Farms Sprouting all over the World,” Jan. 16, 2014, <http://www.newscientist.com/article/mg22129524.100-vertical-farms-sprouting-all-over-the-world.html#.U2r0PMZCdFJ>

⁷³ Mark Usheroff, “Shedding New light on Vertical Farming,” Dec. 6, 2013, <http://www.ocregister.com/articles/says-540609-fambro-greens.html>

California is disturbing. Government, corporations, small businesses, and individuals are sucking the California dry for self-interested agricultural operations. This tragedy of the commons scenario must change if Californians are to avoid long-term consequences.

Before the Spanish arrived in the 1500s, there were no farms. California must do it's best to retract our agricultural practices to urban environments, and let nature begin to heal itself.

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