WEATHER MODIFICATION AS A WEAPON OF WAR

Bernard Kokinchak

(Editor's Note: The following are excerpts from Bernard Kokinchak's recent MA thesis completed at WCSU on the same topic).

Introduction

The environment has a profound impact on human beings. There are several different consequences when a major environmental event makes an impact on human history. These rare and major events alter everyday life and can cause humans to change their behavior. Some of these environmental events include droughts, floods, tropical cyclones, and snowstorms. The impacts of these types of events are dependent on different factors including how humans prepare for them.

Just after the Second World War, a new technique was developed that would promise to enhance such preparation. This technique would become known as weather modification, and it changed how weather would be conceived. Weather modification could have constructive applications, and showed much promise. It could be applied for preventing crop failures and stopping floods and other negative weather effects. Yet despite these positive effects, these new techniques also caused debate over whether changing the weather was a form of playing God and altering unnaturally the human population. Therefore, although experiments in weather modification in the United States between 1946 and 1974 showed that it could be a useful element of military strategy, development assistance, and private corporate profit, weather modification was ultimately abandoned because the legal and ethical issues raised by modification practices outweighed the potential benefits.

Weather modification, like any other attempt by human to change their environment, is an attempt to bring a level of control and stability to the world and protect it from extreme change. These extreme changes could be simple as drought or flooding for a region that normally does not experience such weather conditions.

Weather modification seeks to alleviate extreme weather events to limit human suffering. Two useful examples of the need to alleviate natural but unusual weather events can be seen through examining the "dust bowl" event in the American Midwest in the 1930s and rare New England hurricanes.

The events of the Dust Bowl of the late 1920s and 1930s would be an example of how the weather produced profound geographical and geological changes, with considerable human implications. In that case, the attenuation of native vegetation in the form of grasses in the face of unusual weather destroyed the ability of native soil to remain in place. Despite the significance of the weather on these events, however, historians tend to focus only on the aftermath of these weather events, not on the weather itself.[84]

In the case of the Dust Bowl, like many other cases, the implications of weather events are only realized at a much later date. Given that the Dust Bowl devastated multiple states, congressional action was clearly required. Yet Congress only acted after the dust cloud had reached the capital in Washington DC.[85] Clouds of dust needed to traverse over 2000 miles for political action to be taken.

Tropical Storm Irene in 2011 and Hurricane Sandy in 2012 provide more evidence of how weather events tend to be ignored until their profound impact is felt by a critical mass of the population. Although major tropical storms are rare in New England, minor tropical weather events occur with some frequency, even if there is sometimes a long period of time between events. If the storm had hit the United States lower latitudes, it would not have been as bad because of the soil make-up in the Mid-Atlantic States or southern east coast of North America. Since the New England states have glacier till soil, a smaller hurricane causes a great deal of flooding and destruction in New England. These aforementioned examples show how the weather events can have a major impact on human life.[86]

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[84] Donald Worster, *Dust Bowl: The Southern Plains in The 1930* (New York: Oxford University Press, 2004), 7-8.
[85] Ibid., 184-185.
[86]Nicholas, K Coch. October 13, 2012. "Hurricane Irene - A Catastrophic Hydrological Disaster for the Northeastern U.S." Lecture, Science Building, Western Connecticut State University, Danbury, CT.

When the truly devastating impact of weather events is actually felt, humans have a natural tendency to want both to prepare for the next event, and if possible, to prevent it. Therefore human nature dictated that if given the means to control the weather and the environment, most would jump at the opportunity. Controlling the weather would be appealing because it would eliminate the uncertainty involved in the obvious inability to precisely predict weather events. Having such control over the environment would be very tempting.

The ability to control weather events is not merely a matter of science fiction. Human ability to control the weather and to predict outcomes of weather events were among the advances in the field of meteorology during and immediately after World War II. One of the advancements in the field of meteorology that made weather modification more feasible was radar technology. Radar's well-known military application was to detect aircrafts in flight; however, in a meteorology application it could also be used to detect water condensation in different forms and density. These advancements in the field of meteorology will be a main discussion point in this thesis, with particular attention paid to weather modification and its effect on regional weather patterns.

For the purposes of this thesis, weather modification will be defined as an intentional act to modify the weather. The paper will not discuss unintentional acts of weather modification. An example of an unintentional act to modify the weather would be what in common parlance is called "global warming"; that is, the human-caused increase in atmospheric levels of carbon dioxide, which has contributed to a shift in global temperatures. Our focus will be, in particular, on such techniques of willful weather modification such as cloud seeding, in which the weather modification has significant effects, and can even be used as a weapon of war. We will spend less time considering other methods of weather modification such fog dispersion, the effort to use techniques to control visibility for airplanes through clearing low clouds and fog. The limited space and time for this thesis will require us to focus on those aspects of weather modification with the greatest potential impact on human lives.

Another important consideration of this thesis is that understanding weather modification requires at least an elementary background in meteorology.

Therefore, a brief digression into meteorology, the modern-day study of weather, becomes necessary. Meteorology is a multidisciplinary field of science containing aspects of physics, chemistry, mathematics, and computer science; without combining these fields of study, the weather would be more difficult to study and understand. The vocabulary is also unique to the field, but every effort will be used to explain key terms when necessary, or technical terms will be replaced with other common-use terms that are more accessible to the public.

The first step necessary to understanding weather modification is the physics that occurs on the molecular level in clouds. Water is a dipole molecule, which means water functions like a magnet. However, the magnetic-like properties of water are not necessarily enough to cause water vapor atoms to be attracted to each other and coalesce into droplets to fall from the sky as rain. The production of rain also requires collision, which occurs in part at random and by chance.[87]

Other processes can cause water molecules to coalescence, but this depends on where the cloud is located in the atmosphere. There are two basic types of clouds. The first cloud, a warm cloud, is located in the atmosphere where the temperature is above zero degrees Celsius. The second type of cloud is located in an area of the atmosphere where the temperature is below zero degrees Celsius. The physics of how raindrops grow is key for understanding how weather modification programs work. There are several different theories and models about water droplet and ice crystal growth in clouds. The programs to be discussed in this thesis will involve both warm clouds and cold clouds. Any processes caused by humans that affect this process of cloud growth will be considered intentional and defined as weather modification for the purposes of this thesis.

Consider the location of the bulk of the United States land mass. In this land mass there could be a wide range of possible weather conditions and events, from tropical events to arctic events. An example of these variable weather conditions can be seen by the fact that the state of Arizona experiences a monsoon season, a tropical event involving warm clouds. Yet this very same state also experiences snowstorms from very cold clouds.

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[87] John Walles and Peter Hobbs, *Atmospheric Science: An Introductory Survey,* 2nd ed. (Burlington, MA: Academic Press, 2006), 209.

In other words, the United States encompasses a vast area that has wide-ranging weather events. The United States government, through various federal agencies, collects data about these weather events. The government has been doing this continually since 1890 with the help of citizens under the Organic Act, which created the Cooperative Observer Program. This program does not require citizens to participate in program, but rather supplies data freely to field meteorologists who can use these data as they see fit.[88] The government had accumulated over fifty years of data on weather by 1946, when the first experiment in weather modification occurred in the United States.

The government and military have always had an interest in weather, because of the impact weather has on society and humans. Therefore, weather control through weather modification became a very tempting tool to develop. If the government could control the weather, it would be more powerful than any military force because weather control meant the ability to create famine through crop failures, devastation through drought and floods, and the ability to destroy infrastructure, among other effects.

Ultimately the unpredictable negative impacts of altering weather patterns would be the undoing of research into weather modification in the United States. The people could not accept the changes that would cause by weather modification, especially in the volatile political climate of the late 1960s and early 1970s.

This study will employ a nearly chronological approach to the development and research of weather modification systems in the United States from the first experiments into modification in 1946 to the signing of the Weather Modification Convention in 1976. The only exception to this chronological approach is when evidence from newspapers is cause change and push Congress to act on the issues of weather modification. The reason for this decision to handle the evidence in this manner is effect more important at that time when comes public then when the event occurs. Also rather than studying every instance of the application of weather modification, this thesis will examine key turning points in both military and civilian weather modification operations. It will utilize sources from government

[88] National Weather Service, "NWS Cooperative Observer Program," accessed May 19,2013, http://www.nws.noaa.gov/om/coop/what-is-coop.html

publications about weather modification, as well as key pieces of investigative journalism from the 1960s and 1970s, as the press exposed to public previously secret military programs using weather modification technology. The significance of the order of events in these cases necessitates a chronological approach.

Weather is a global event. No matter how small a weather event may seem, it will in some way affect every place on planet Earth. Therefore, while this thesis focuses on United States weather modification operations, to give a more complete account of history of weather modification during this time period, a global approach becomes necessary. Part the reasoning for global approach is the Cold War that will exist between the United States and the Soviet Union. The foreign policy pursued by the United States is aid to other countries to prevent them from becoming communist countries. This thesis will thus examine weather modification at different places as building blocks to be used in piecing together how each piece of information forms a picture and a coherent story of weather modification.

The Postwar Period and the Determination of the Viability of Weather Modification

This section will examine the postwar years from 1946 to 1950, which can be classified as the early years of weather modification. During this time, scientists experimented with methods of cloud seeding. Both in the private and public sectors, such experiments with weather modification began shortly after the conclusion of World War Two. The weather modification experiments at the time required both military and civilian operations, and each had different aspects. The motives for these weather modifications in each operation were different, for the intended outcomes were dependent on the group of people who was carrying out the operation to modify the weather. Understanding the motives of these respective groups by an examination of their goals for those operations is crucial.

One of the first groups of people in the United States to begin experimentation with weather modification was those working for public works-related entities in the Western United States. They became involved because the water supply had been a known issue in this area. In the nineteenth century, the

increase of the population in the western parts of the U.S. taxed the natural water supplies to support such a population of people. An example of this concern about water shortage were the reservoirs built to supply water for arid regions of California and Western areas of the U.S. as the population grew in those regions.[89] The O'Shaughnessy Dam was built to supply the city of San Francisco, California with a stable water supply after that city's devastating earthquake in 1906. There were other projects that took place under the New Deal programs, such as the Hoover Dam for the city of Las Vegas, Nevada.

However, at the beginning of the postwar era, a new method for water management was under development in the western states. On November 13, 1946, the first large scale experiment was carried out by Vincent Schaefer. Schaefer worked for the General Electric Corporation under Irving Langmuir, who won a Nobel Prize in 1932 for his work in surface chemistry. Schaefer himself became known for copying a snowflake in 1940 using a thin plastic coating called Formvar.[90] Then, in the early 1940s, he began work with precipitation static, ice nuclei, and cloud physics.[91] By 1946, he was able to use dry ice as an agent to modify clouds by causing ice crystals to form in super cool clouds,[92] which in turn caused a cloud to precipitate.[93] Modification of clouds could be carried out to force clouds to precipitate prematurely, by the use of dry ice. Schaefer's experiment was sponsored by the General Electric Corporation.[94]

After this successful experiment, and the other similar experiments which replicated these results, private corporations began to consider the legal ramifications of this technology. In one particularly notable test, researchers with

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[89] Kendrick A. Clements, "Engineers and Conservationists in the Progressive Era" *California History*, 58:4 (Winter, 1979/1980): 285.
[90] M.E. Grenander Department of Special Collection and Archives, "VINCENT J. SCHAEFER PAPERS, (UA-902.010), 1891-1993," http://library.albany.edu/speccoll/findaids/eresources/findingaids/ua902-01.html accessed Dec. 6, 2013.
[91] Ibid.
[92] Supercooled clouds are clouds formed by water droplets which are below the freezing point of water, but the water remains in a liquid form instead of a solid form of ice crystals. Further definition and explanation can be found in: Wallace and Hobbs
[93] "Wartune" Magazine, Weather Under Control Forecast: High Legal Winds Followed By Better Climate, February 1948, Record Group 331, Box 7416, Folder 1, National Archive Records Administration, Archive II, College Park, Maryland. (hereafter cited as NARAII, RG331, Box 7416, Folder 1.) 1.
[94] Ibid., 1.

General Electric managed, on December 19, 1946, to cause precipitation of eight inches of experiment-made snow to fall over large parts of Vermont and New York, when the forecast only called for a "fair and warmer" day.[95] This result gave pause to General Electric about continuing these experiments, because of the very real the legal implications: General Electric lawyers imagined the possibility that the company would be sued for damages for modifying the weather to the detriment of some.[96]

Therefore, before General Electric could conduct any further experiment in weather modification, a solution was needed to continue their experiments while simultaneously reducing the liability they would incur from such experiments. The solution was found by General Electric through a contract with the Army Signal Corps that they obtained in March 1947.[97] The Army agreed to this joint venture in part because of their close connections to General Electric researchers at the time. The civilian meteorologists in the Signal Corps engineering laboratories were themselves former General Electric employees.[98]

Originally, however, General Electric had attempted to negotiate such a contract with the US Navy. The Navy later became a part of the contract as a cosponsor.[99] Both the Navy and Army had an interest in weather modification research. This combination of Army and Navy engineers, working together with private companies initially led by General Electric, became known as Project Cirrus.[100] Project Cirrus also involved the US Weather Bureau and eventually expanded its scope of operations from New Mexico and the Atlantic Ocean basin off the coast of Florida. In part, this geographic range reflected one of Project Cirrus's main goals: attempting to modify hurricanes.[101] The first priority was to modify the course or track of a hurricane as it made landfall. Yet this would merely result in hurricanes devastating a different area. Therefore, even the government was forced

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[95] Ibid., 7.
[96] Ibid.
[97] Ibid.
[98] Ibid.
[99] Ibid., 7-8.
[100] F.O. Carroll to Headquarter USAF, July 12, 1949, Sarah Clark: Correspondence File, Record Group 342, Box 3717 National Archive Records Administration, Archive II, College Park, Maryland (hereafter cited as NARAII), RG342, Box 3717.
[101] Congressional Research Service, *Weather Modification Programs, Problems, Policy, and Potential*, (1978; repr., Honolulu: University Press of the Pacific, 2004), 39.

to stop such hurricane experimentation because the unintended consequences and potential liability were simply too great.[102]

By 1950, the Air Force was being used as a source of supply for the cloud seeding operation. The Air Force supplied, for a test flight: "two (2) B-17 aircraft, one (1) L-5 aircraft and appropriate aircraft crews; four (4) pilots, one (1) Navigator and four (4) enlisted flight personnel."[103] The Air Force, by the commitment of the aforementioned supplies, became inextricably involved in Project Cirrus as well. However, the Air Force's involvement in the project is somewhat limited because of the small size of the force they commit to the project in 1950. The Air Force chose to not fully dedicate the supply above to the project, but rather to station them near central operations and make them available on short notice.[104] The cautious position taken by the Air Force in limiting their participation is somewhat perplexing, considering that the Air Force was a pioneer in weather modification. It had begun the process of cloud seeding in April 1948. The area targeted for cloud seeding by the Air Force at that time was a region of Japan that was then experiencing a drought.[105] The issues that arose from the lack of water were so acute that water had to be flown in from Tokyo. The water in this region was rationed, so that for several weeks, people could only access water for two hours per day.[106] The outcome of the Air Force attempts to cloud seed in this case are unclear. What was reported back was only a recommendation that cloud seeding be further researched.[107] However, an internal memo shows that Air Force planes could be used for the cloud seeding operation, and that therefore means had to be found for cloud seeding, such as artillery.[108] This process would use artillery shells to spread the chemical agents to generate the cloud.

One possible reason that this Japan experience caused the Air Force to be reticent about cloud seeding was a concern that this seeding might cause unintended weather effects on the Korean Peninsula. These lessons were brought to

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[102] Ibid., 39 - 40.
[103] F.O. Carroll to Headquarter USAF, July 12, 1949, NARAII, RG342, Box 3717.
[104] Ibid.
[105] M. H, Halef to Marquat April 3, 1948, NARAII, RG331, Box 7416, Folder 1.
[106] Levy and Marquat to Department of Army, April, 1948, NARAII, RG331, Box 7416, Folder 1. I
[107] Ibid., I.
[108] Ibid., I.

bear during Army experiments in Japanese cloud seeding in 1950 that followed the Air Force operations in Japan. The Army was aware of the legal liability it may incur during such operation, example of this legal liability consideration effect of such operation on neighboring countries such as Korea. This was particularly important to the United States Military at the time, since 1950 was the year that commenced the Korean War. The army reached the conclusion of cloud seeding operation in Japan in 1948 would have no policy impact on Korea.[109] This was important, as the United States did not want to add atmospheric uncertainty to the already volatile situation on the Korean peninsula. In any case, for whatever reason, by 1950 the Air Force seems to have been backing away from taking the lead on seeding operations to modify the weather. This position may be related to other events at the time.

Another agent of the government that was involved in modification was the Weather Bureau.[110] This civilian agency of the federal government took a different approach to weather modification. Weather Bureau scientists believed that silver iodine would be a better agent for a large-scale operation.[111] The Weather Bureau was also more focused on the modification of the energy of storms.[112] Their position resulted from the way storms are thought about in community of atmospheric scientists, as agents for the transfer of energy. This concept is similar to that of heat mechanics, in which heat is understood as a mechanism to transfer areas of energy from high amounts to an area of low amounts of energy.

On the West Coast, the California Electric Corporation was also conducting weather modification experiments in the late 1940s. These experiments were cloud seeding experiments to determine if clouds could be generated in a localized area to produce rainfall over a targeted reservoir in order to fill the reservoir during a period where natural low amounts of rain occurred. The army also kept records on the California Electric Corporation.[113] In a paper by Stuart A. Cundiff dated April 17,

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[109] Memo for the Record, April 9, 1948, NARAII, RG331, Box 7416, Folder 1.

[110] The Weather Bureau would be transformed in the 1960s as the National Weather Service under the National Oceanic Atmospheric Administration.

[111] Charles C. Bates and John F. Fuller, *America's Weather Warriors* (College Station, TX: Texas A&M University Press, 1986), 143.

[112] Horace R, Byers. "History of Weather Modification" in *Weather and Climate Modification,* ed. W. N. Hess (New York: John Wiley & Sons, 1974), 25-26.

[113] Ernest to Kennedy Record Group 331, Box 7416, Folder 2, National Archive Records Administration, Archive II, College Park, Maryland. (hereafter cited as NARAII, RG331, Box 7416, Folder 2.)

1950 explained the results of the experiments carried out by the California Electric Corporation in 1947 and 1946. In particular one of the results was a 14% increase in precipitation. This paper was placed into a military file about cloud seeding operations.[114] These experiments were covered in newspapers in the area and the US Army Signal Corps did compile a file on the experiments conducted there.[115] With these experiments and others, the military knew by early 1948 that cloud seeding could be successful and had major implications.[116]

Thus, in conclusion, by the postwar era, parts of the United States military were teaming with the private sector to use newly invented cloud seeding techniques to increase the water supply in drought-ridden regions. This was true not just in arid areas in the United States, but around the world as well. After World War II, the Army, along with the Air Force, had operations in Japan to increase the water supply by inducing rainfall. The introduction of ideas of how to induce rain occurred near the same time of Project Cirrus was being conducted. By late 1940s the military was intensely interested in weather modification by the method of cloud seeding, and this interest seems to be tied to the potential profitability of the technique for private sector corporations such as General Electric, which brought the idea of weather modification to the military as a means to reduce their legal liability. The Army conducted experiments in weather modification with other armed services beginning in October 1948 under Project Cirrus.[117]

The implications and outcomes of Project Cirrus can be evaluated in a few different ways. One feature of note from these files is that the Army and Air Force engineers seemed different points of view on weather modification, with the Air Force being much more concerned about the potential unintended consequences of using these techniques. As established above, the army had a pressing motivation for this research: the lack of drinkable water in Japan right after the war.[118] The Army was basically administering Japan after the war. If the population did not have

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[114] Stuart A. Cundiff, April 17,1950. "An Industrial Operation to Produce Precipitation" NARAII, RG331, Box 7416, Folder 2.
[115] Ernest to Kennedy NARAII, RG331, Box 7416, Folder 2
[116] Stuart A. Cundiff, April 17,1950. "An Industrial Operation to Produce Precipitation" NARAII, RG331, Box 7416, Folder 2.
[117] Ewin R. Petzing to Chief of Staff May 12, 1949 NARAII, RG342, Box 3717.
[118] Levy and Marquat to Department of Army, April, 1948, NARAII, RG331, Box 7416, Folder 1.

water to drink, it might have led resistance among the civilian population of Japan to the postwar occupation. The evidence of this concern is seen in correspondence written back and forth between officers stationed in Japan and the mainland about different ways to try to induce rain over Japan.[119] The Army went as far as to consider the implications of this action for the volatile Korean conflict if they were able to successfully cause rain to occur.

However, the Air Force was taking a much more limited role in cloud seeding operations. The Air Force was unwilling to dedicate equipment and men to a solo project of their own, and was only willing provided resources to the Army on a limited, on-call basis.[120] Despite Air Force caution, the interest in expanding both the civilian and military uses of weather modification in the 1950s led to its widespread use both in development assistance and as a weapon of war for more than two decades.

Weather Modification and the Second Indochina War

Weather modification activity in Vietnam undertaken by the US was purely under the auspices of a military operation. The operation's code name was Operation Popeye. It was primarily aimed at increasing the amount of rainfall over Vietnam from monsoons and other tropical weather systems, such as tropical storms. The United States' military forces would gain tactical advantages from such operations. One of these advantages would be control over where rainfall came from, at what time it came, and how much rainfall ensued. I will not argue the merits of such weather modification activities. Rather, I will contend that during the timeframe of escalating United States intervention in Southeast Asia (1965-1973), the United States military came to the conclusion that while weather modification can be effective in certain circumstances, its impact was hard to quantify.

The United States began operations of weather modification in Indochina in March 1966. These operations thus coincided with the Johnson administration's escalation of direct American involvement in Vietnam, which had begun in earnest in 1965. Operation Popeye was conceived in secrecy due to the politically sensitive

[119] Putt to Commanding General, May 19, 1949, NARAII, RG342, Box 3717
[120] Ibid.

status of weather modification at the time. The operation was therefore to be carried out under the guise of reconnaissance.[121]

The controversy that caused the military to carry out weather modification clandestinely stemmed from findings about the human cost of these programs. The impact of weather modification extended well beyond the scope of its military uses. By this time, weather modification was also known to affect the mood of people subjected to it, increasing the incidence of suicide, depression, and other psychiatric conditions. Also, weather plays a role in increasing crop diseases. By the mid-1960s, it was also known to have a negative (and unpredictable) effect on civilians' food and water supplies.[122]

Another reason for controversy was the unpredictable economic impact of weather modification. Although a change in weather could have a positive economic impact, the impact could also be negative, as explained in the unintentional snowfall in upstate New York mentioned earlier in this essay. The economic impacts could also be positive in one area but negative in another. Whether the economic, cultural, or climatic impacts of weather modification were seen as positive or negative depended on the point of view of the observer. This statement should be taken in its most literal sense, because depending on where an observer was located, increased cloud cover or precipitation could be good or bad. Drought over the Ho Chi Minh trail, for example, might fit the military objectives of the United States, but an ensuing drought in South Vietnam might not. This is the reason this operation need to carried out in secrecy, because the political fallout from robbing other people (such as in Cambodia and Laos) of rain to increase rain over Vietnam for military reasons would be immense.

The further reason for this operation was that there had been a successful test carried out over Laos. That test succeeded in extending the rainy season and was deemed a success by the U.S. Air Force, which supervised the operation. Therefore, based on these positive results, Operation Popeye went ahead as planned.

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[121] Seventh Air Force, "7AF Oplan 463-67 (R) Popeye, November 7, 1966 page 1, National Archive Records Administration, Records Group 472, Box 29, Folder 206-02, Archive II, College Park, Maryland (hereafter cited as NARAII).

[122] W. R. Derrick Sewell. "Weather modification: When Should We Do It and How Far Should We Go" in *Weather Modification Science and Public Policy.,* ed. Robert G. Fleagle (Seattle: University of Washington Press, 1970), 94-95.

The operation had three major objectives. The first major objective was to target areas for increased rainfall. There was different level of priority targets first primary target was to deny in many operations of logistical support. The second priority was to degrade the traffic ability or the movement of information along the lines of communications for the enemy. The last priority for increase rainfall was to annoy and harass the enemy troops. The second major objective was to dissipate or suppress clouds or rain fall in areas example of the targets were clouds that prevented because suspicions, air support, attacks where visual notification was necessary, mobile air defense missiles and other transient targets.[123]

However, back in the United States, another story was unfolding. In 1966, the National Science Foundation (NSF) pointed out that no one knew how many people used weather forecasts to influence the social and economic decision-making process. The NSF urged scientists to study the extent to which people relied on forecasts. This question was significant; if no one relied on weather forecasting, then weather modification might be seen as more innocuous, since, first, it was less likely that enemies in war would rely on such data to make business decisions, and second, it was less likely that they would actually be aware that such modifications were taking place at all. In 1967, the National Center for Atmospheric Research also took on the task of examining the impact of human manipulation of the atmosphere. One of the findings of the report was that a solution on air pollution must be found before it became a cause of conflict.[124]

However, the NSF report indicates that Johnson administration officials did not see reducing the potential damage caused by weather modification as a priority, since they had come to the conclusion by 1967 that weather forecasting was immaterial to a majority of Americans. This report then sidesteps the issue of whether using weather modification techniques as a tool to improve agriculture or for other purposes might have harmful unintended consequences. As mentioned in the earlier example in this thesis about the unintended increase of snowfall in New York State in 1948, private property landowners were already in fear of disaster if weather modification experiments continued. This example can be extended to

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[123] Seventh Air Force, "7AF Oplan 463-67 (R) Popeye", November 7, 1966 page A-I-1, NARAII, RG472, Box 29, Folder 206-02.
[124] National Science Foundation, *Weather Modification Ninth Annual Report, 1967*,70-71.

apply to this later point, as people might be interested in keeping unmodified weather systems for these reasons, and they would thus want to avoid intentional acts of modifying the weather.

While the unpredictable effects of weather modification continued to be a hindrance to using it for civilian purposes, that same unpredictability provided important advantages for the Air Force application of these techniques in Southeast Asia. If the Air Force could create a situation in which the enemy were forced to take some predictable action in response to unpredictable weather, this would operate as an aid to their military strategy. The importance of control over terrain and atmosphere on the battlefield was highlighted by US experiences in Operations Steel Tiger and Tiger Hound in 1965, the year prior to the inception of Operation Popeye.

In 1965 and 1966, through Operations Steel Tiger and Tiger Hound, the Air Force conducted bombing operations in parts of southern Laos, and a combination of various naturally-occurring but unpredictable weather events, such as monsoonal rainfall which produced mudslides and made areas of the Ho Chi Minh Trail very difficult to navigate, created a problem for the North Vietnamese Army (NVA).[125] The Air Force documents that reported this observation saw the value the weather could play in conjunction with conventional military tactics such as bombings.

In Operation Popeye (1967-1972), what the Air Force created was a system of weather modification to enhance 0ther mission operations in Vietnam. For example, defoliation missions that relied on dropping napalm on forests would be more effective in conjunction with reducing the chance of rain from cloud cover. A reduction in rainfall would allow fire to spread and burn more of the land.[126] Such a reduction in rainfall would also force local populations, who were presumed to be sympathetic to NVA and NLF elements, into an agonizing choice about how to use their water supplies. Local villages could either choose to fight the fires or to keep sufficient water for other uses such as drinking.

In considering the effectiveness of Operation Popeye, one important factor was that the operation was secret, and therefore was not subject to popular pressure or bad press. This would change, however on July 2, 1972, when a *New*

[125] Seventh Air Force, "7AF Oplan 463-67 (R) Popeye", November 7, 1966 page A-I-1, NARAII, RG472, Box 29, Folder 206-02.
[126] Ibid, A-I-1.

York Times report by Seymour Hersh claimed that the first attempt at weather modification occurred in South Vietnam as early as 1963.[127] That the Air Force had considered this tactic as early as this time period fits in the timeline of implementing it by 1967, when Operation Popeye formally began.

As we have previously mentioned, in the early 1960s most weather modification was carried out under the auspices of the State Department, which had implemented weather modification programs in the Middle East for the purpose of providing water via artificial rainfall. Hersh's article now showed how key members of the State Department opposed weather modification being turned into a weapon of war. [128]

Hersh was reporting this in July of 1972, around the same time as the *Pentagon Papers* were being made public by Daniel Ellsberg and the *New York Times*. In fact, the case reached the Supreme Court and the decision, which was announced on June 30, 1971 with a great deal of press coverage, ensured that the material in the *Pentagon Papers* would remain available on First Amendment grounds. In a sense, Operation Popeye was part of the case, as it appears in the Fourth Volume of the Gravel Edition of the Pentagon Papers, which was released in 1971.[129] Although Operation Popeye was classified, the materials in the *Pentagon Papers* were also classified; this was the major issue at stake in the case. The fact that the *Pentagon Papers* were made public clearly helped Hersh in his reporting. Hersh explains that the Central Intelligence Agency (CIA) first used weather modification when the Diem Regime was facing protests from the Buddhists in the summer of 1963; apparently the regime, with cooperation from the CIA, seeded clouds and created storms to disperse protesting monks. This tactic seemed to work, causing over seven inches of rain to fall on protests on two separate occasions.[130]

Hersh's understanding of the operations reflects the same tactical goals mentioned by the military itself, with some difference in emphasis. Hersh cites the deterrence of troop movements of the North Vietnamese Army and the suppression of anti-aircraft fire as the major operation objectives of weather modification. However, Hersh leaves out another objective, that of assisting the defoliation

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[127] Seymour Hersh, "Rainmaking is Used as Weapon by US," *New York Times* July 3, 1972
[128] Ibid.
[129] *The Pentagon Papers IV,* Senator Gravel ed. (Boston: Beacon Press 1971), 421.
[130] Hersh, "Rainmaking is Used as Weapon by US," New York Times July 3, 1972

mission of the Air Force, out of his report entirely, which is curious, because it was just as important to the operation. This part of the operation, of course, had considerable moral implications.

Part of the sensitivity of these operations and perhaps why they were classified had to do with the nature of their approval process. The operation required Presidential authorization before the plan went into effect.[131] This meant that if these operations were to cause drought or flooding, or lead to environmental genocide, the blame for these human rights violations would lie squarely at the feet of the President (at the time of Hersh's writing, Richard Nixon).

Operation Popeye grew as time progressed. Hersh reports how, by 1967, the weather modification operations were being conducted over Laos during the war. At this time, an operation was in force to add chemicals to warm stratus clouds. This chemical had the benefit of causing acid rain. The effect of acid rain is well known in current times, but back during this time period, as was mentioned before, it was not seen as a significant problem. This acid rain had high pH content. It was thus highly acidic, and was meant to react with the metal in artillery and military equipment to cause it to fail.[132] By extension, if the pH was high enough to cause a chemical reaction with metal, then the rain would also be acidic enough to change the pH of the soil and water. This change would have had an extremely detrimental effect on plants, animals and humans. It must have led to the loss of crops, livestock and fish. The uncertainties with this sort of very volatile approach to weather modification are considerable, and it might have led, with prolonged use, to the collapse of the entire Indochinese ecosystem. Perhaps most resistance to weather modification might stem from opposition to these kinds of tactics.

Hersh supported a call for change as well based on the persistence of weather modification efforts. Weather Modification Operations were supposed to be stopped in 1967 by order of Secretary of Defense Robert McNamara. However, they continued anyway, and were in effect as late as 1972. Along with the environmental dangers and ecological consequences that can occur from weather modification, Hersh was also concerned with secrecy within the State Department concerning

[131] Ibid.
[132] Ibid.

it.[133] An incident prior to operation Popeye becoming active with State Department prior the Vietnam War was using weather modification as a means of giving aid to countries that need increase in water supply. The most recent one relevant to the region was India. President Johnson had also used his State Department to conduct weather modification over India in 1965, because the rainfall had been short that year as the monsoons did not provide the rain that it would normally provide the region.[134]

Hersh's report makes it clear that the more weather modification became increasingly prevalent mechanism of war, the more that weather modification became unpredictable and problematic. Senator Claiborne Pell, reacting to the revelations about its use in Southeast Asia, commented that "this [weather modification] is Pandora's box." As a resident of Newport, Rhode Island, Senator Pell lived in an area which could be easily affected by weather modification; because the low lying nature of the land that Newport is located on. He held hearings about such activities in the Senate's subcommittee on Oceans and International Environment.[135]

Conclusion

Weather Modification as weapon of war, and the policies associated with it, came to a halt due to the profound legal, political and social pressure brought to bear on the military and Congress to stop it. The pressure to stop the potentially dangerous and unpredictable effects of weather modification grew as time progressed from the beginnings of the U.S. weather modification experience in 1947 to the signing of 1977 signing of the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental modification Techniques (ENMOD). The social effects of environmental modification ultimately are inextricable from their political and legal effects. Close observers could have noted this inextricability from considering the results of the General Electric experiments of the late 1940s, during which engineers caused over a foot of snow to fall over a wide area simply by mistake.

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[133] Seymour Hersh, "McNamara Orders to End the Rainmaking in 67 Reported," *New York Times,* July 3, 1972.
[134] Doel, Ronald, E., and Kristine C. Harper. "Prometheus Unleashed: Science as a Diplomatic Weapon in the Lyndon B. Johnson Administration." Osiris 21:1 (2006), 76.
[135] Hersh, "Rainmaking is Used as Weapon by US," New York Times July 3, 1972.

This event was important because it marked the beginning of government involvement in weather modification activities. The federal government realized that weather modification experiments by private corporations needed to be curtailed because of the legal impacts of the environment modification that might occur. Thus, weather modification activities were largely conducted under the auspices of the U.S. State Department during the 1950s, during which time the Department of State was using weather modification in several different countries to provide rain in order to prevent or curtail drought that was naturally occurring in these countries.

What is important about drought is that it is a natural process, which produces some benefits to other than just the negatives of creating crop shortages and famine. Droughts allow for landscapes to be renewed, much as natural wildfires are sometimes allowed to occur in order to thin out forests. In order to allow the ecosystem to restart a new and allow for other species of plants and animals to thrive again in order to rebuild a mature forest, sometimes fire is needed. Similarly, some of these cloud seeding operations were also occurring in the Middle East, an area that is notorious for having water shortages. In some respects, modifying the weather in order to create more artificial rain is not only an unnatural thing for the environment but modifying the environment in order to support more human life over the natural environment that would naturally occur there and only support a certain number of humans. But modifying the environment of which humans live in is nevertheless an understandable thing for humans to do, and of course other means of reducing the impact of the weather and the environment from dykes to dams to canals have existed for millennia.

Weather modification is an extension of the technologies that humans can use to modify their own environment, technologies that go beyond mere farming, building shelter, and a variety of other activities. The reason why humans engage in these supplementary activities is to modify the both the social and environmental structure around them for their own benefit. The mere ability to modify their environment allows for other activities of humans to occur in regions which otherwise might not support human habitation.

With the necessity to alter the environment comes the need to restrict these alterations so that they do not negatively affect others. Hence, with new technology,

new legal structures began to develop to decide which activities are acceptable versus which are not acceptable. In particular, with better technology developing for the weaponization of the environment in the postwar era, it became increasingly clear that these tools were especially dangerous and unpredictable, and therefore required special regulations. These weapons are especially dangerous because they threatened to destroy the natural environmental balance that is necessary for humans to survive on the planet. When the United States chose to cloud seed over Vietnam during the Second Indochina War, it began to pass over the boundary between modifying the environment for the benefit of all and creating a destructive non-livable situation for humans in the affected area.

What Operation Popeye represented was the worst kind of environmental modification. The United States cloud seeding over Indochina made the situation for Vietnamese, Laotian, and Cambodian people miserable and caused an environmental disaster—a disaster that only augmented the damage done by other damaging chemicals such as napalm and dioxin, and damage made only worse by seeing clouds with large amounts of lead. Thus, the United States not only cloud seeded but also combined it with its defoliation operation which led to the destruction of the land which would take years if not decades to renew itself.

Weather modification was used as a regular weapon of war during wartime by United States after World War II. The U.S. use of environmental weapons would eventually cause an international response to the growing ability of humans to modify their environment and the world around them in ways that could be destructive if not applied properly. The secrecy surrounding the United States' use of these weapons also caused the response it received from the international community and domestic community to be compounded and more negative about environmental modification as becoming a weapon of war than it otherwise might have been.

Senator Pell of Rhode Island was correct in calling weaponizing of weather a "Pandora's box"; once open, it caused immense environmental damage. Furthermore, the unpredictable effects of long-term environmental warfare, combined with ever-better technology, raised the specter that the weaponization of weather may have eventually wreaked havoc on the human race. Hence, Senate resolution 71, which demanded the executive branch to seek a treaty to ban such

activities of weather modification, was a useful corrective in stopping environmental modification from becoming a significant weapon of war. Once the Soviet Union took an active interest in this idea, it provided the catalyst to negotiate a treaty at the United Nations. While the United States did become a signatory to the treaty, the inaction of the United States' executive branch during the Nixon Administration was ultimately a public relations coup for the USSR, and the executive branch was made to look like it failed to act in the best interest of United States foreign policy. The recalcitrance of the executive branch was also against the interests of the Senate, which had directed the executive branch to seek the treaty.

Therefore the treaty, which banned environmental modification for hostile or military purposes, was an important but only initial step in managing the environment in a correct and responsible way on the international level. The example of weather cooperation on meteorological data should be a model for how environmental modification should be constrained in the future.