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Rain, Rain, Don't Go Away: Cloud Seeding Governance in the United States and a Proposal for Federal Regulation

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Rain, Rain, Don't Go Away: Cloud Seeding Governance in the United States and a Proposal for Federal Regulation

Melissa Currier*

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I. INTRODUCTION

Since ancient times, people have attempted to force rain from the clouds.¹ Until recent decades, the idea that humans could concretely and purposefully

* J.D. Candidate, University of the Pacific, McGeorge School of Law, to be conferred May 2017. I would like to thank my family for their endless support and encouragement, and my editors for their tireless efforts in making this Comment the best it could be.

1. WILLIAM SMITH, A CLASSICAL DICTIONARY OF GREEK AND ROMAN BIOGRAPHY, MYTHOLOGY AND GEOGRAPHY 378 (G.E. Marindin ed., 1925) (“[I]n times of drought the priest of Zeus . . . conjured rain by dipping an oak bough into the spring of Hagno.”)

influence the weather seemed a mere fantasy.² That fantasy became a reality when one scientist discovered cloud seeding in the 1940s.³ To extract the water, cloud seeders spray silver iodide particles into the cloud, causing droplets within the cloud to form snowflakes and fall to the earth.⁴ While many of these snowflakes would have eventually fallen anyway, the silver iodide makes the cloud release more water at that time than it would have released naturally.⁵

As the drought rages on in multiple areas of the United States, maintaining steady access to water has become increasingly difficult and unpredictable.⁶ According to a study by the National Research Council, droughts in the United States cause an average annual economic loss of between six and eight billion dollars annually.⁷ To remedy this, many states are looking to cloud seeding as an additional method of obtaining water.⁸ Although cloud seeding is not an ultimate solution to the drought, it does provide a useful tool to help increase water access.⁹ Current regulation of cloud seeding exists primarily at the local level,¹⁰ leading to inefficiency because different regions have different standards and guidelines.¹¹ This Comment first explains the current regulatory structure surrounding cloud seeding and advocates for federal regulation.¹² A unified federal program is necessary to make the cloud seeding process more transparent

2. *Id.*

3. 15 U.S.C. § 330 (2000) (defining cloud seeding as “any activity performed with the intention of producing artificial changes in the composition, behavior, or dynamics of the atmosphere.”).

4. Dry ice or liquid nitrogen can also be used. *Frequently Asked Questions (FAQs) Concerning Cloud Seeding Activities Designed to Increase Precipitation*, WEATHER MODIFICATION ASSOCIATION (Nov. 12, 2015), <http://www.weathermodification.org/faq.php> (on file with *The University of the Pacific Law Review*).

5. See Amanda Little, *Weather on Demand: Making it Rain is Now a Global Business*, Bloomberg Businessweek (Oct. 28, 2015), <http://www.bloomberg.com/features/2015-cloud-seeding-india/> (on file with *The University of the Pacific Law Review*) (describing how silver iodide can potentially be harmful to the environment in large quantities, but that issue is beyond the scope of this article); *contra* CAL. HEALTH & SAF. CODE § 25141.5 (explaining that silver iodide has specifically been excluded in California from being classified as hazardous waste due to its “acute oral toxicity”).

6. See Michael Brown, *Present and Future Regulation of Cloud Seeding Activities in California*, 43 J. WEATHER MODIFICATION 97 (2011) (showing that demand for water has grown while the supply has remained at a consistent level).

7. See Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. (2009) (“People in drought- and hail-prone areas willingly spend significant resources on weather mitigation programs.”)

8. See Brown, *supra* note 6, at 97 (arguing that cloud seeding is an economical alternative to desalinization and other forms of increasing water supply); see *Cloud Seeding Fact Sheet*, DESERT RESEARCH INSTITUTE, available at <http://www.dri.edu/images/stories/centers/ctrec/DRICloudSeedingFacts.pdf> (on file with *The University of the Pacific Law Review*) (explaining the Desert Research Institute’s estimates that water gained from cloud seeding has averaged 64 acre-feet per year during the last 15 years).

9. See Brown, *supra* note 6, at 97 (“[C]loud seeding is the only known method for directing rainfall to specific locations and thereby increasing surface water availability at such locations.”)

10. *Id.* at 103.

11. *Infra* Part IV (discussing how, as cloud seeding projects grow in numbers, it gets more difficult to regulate only at the state and local levels while maximizing efficiency).

12. *Infra* Part IV (explaining the regulatory structure and benefits of possible federal regulation of cloud seeding).

and thus more efficient to utilize.¹³ Ideally, this program would create a federal agency comprised of weather modification experts.¹⁴ This agency should have the power to regulate cloud seeding activities in the United States, provide operational guidelines, and conduct research on ways to make cloud seeding more effective.¹⁵ The federal laws promulgated by this agency should preempt state law, making cloud seeding regulation uniform across the country.¹⁶ As long as the new laws leave room for innovation and discovery, federal regulation of cloud seeding will benefit state governments, cloud seeders, and the public.¹⁷

Part II of this Comment will provide an overview of cloud seeding.¹⁸ This includes a brief overview of its history, a general summary of the science of cloud seeding, and a synopsis of the cloud seeding process.¹⁹ Part III explains the current governance of cloud seeding activities in the United States, including treaties, federal and state statutes, and local ordinances, in addition to relevant case law.²⁰ Part IV then explains how Congress has the power to regulate cloud seeding across the country, and discusses the benefits and concerns associated with federal cloud seeding regulation.²¹ Part V concludes that federal cloud seeding regulation is increasingly necessary as weather modification grows into an effective and reliable way of obtaining fresh water.²² Finally, this article suggests essential components of a federal regulatory program.²³

II. BACKGROUND

This section first gives a brief overview of cloud seeding history.²⁴ It then discusses the science behind cloud seeding.²⁵ Finally, this section summarizes the utility of cloud seeding and the evolution of public attitudes towards cloud seeding.²⁶

13. *Infra* Part IV (discussing the necessity of a unified federal cloud seeding program).

14. *Infra* Part IV (explaining the nuances of the proposed federal cloud seeding program).

15. *Infra* Part IV (laying out the ideal functions of the proposed federal agency in charge of regulating cloud seeding).

16. *Infra* Part IV (explaining the importance of preemption in this field).

17. *Infra* Part IV (discussing the benefits of federal cloud seeding regulation).

18. *Infra* Part II (explaining the background of cloud seeding).

19. *Infra* Part II (providing details on the history of cloud seeding).

20. *Infra* Part III (laying out the current cloud seeding regulations in the United States).

21. *Infra* Part IV (discussing the possibility and benefits of federal cloud seeding regulation).

22. *Infra* Part V (explaining why federal cloud seeding regulation is necessary given modern environmental issues).

23. *Infra* Part VI (detailing an ideal federal cloud seeding regulatory program).

24. *Infra* Part II.A (summarizing the history of cloud seeding).

25. *Infra* Part II.B (explaining the science behind cloud seeding).

26. *Infra* Part II.C (showing the utility of cloud seeding and how public attitudes towards the method have evolved).

A. *Cloud Seeding History*

Vincent Shaefer, a General Electric meteorologist, pioneered cloud seeding as a form of weather modification in the 1940s.²⁷ Shaefer found that shooting dry ice particles into a cloud caused increased rainfall.²⁸ By the 1950s, scientists regularly utilized cloud seeding to extract an estimated additional 10 to 15 percent of water from storm clouds.²⁹ During the Vietnam War, the United States used cloud seeding as an experimental weapon to flood northern Vietnam.³⁰ As a result, the United Nations banned cloud seeding as an act of warfare.³¹ Since then, cloud seeding uses have become more mainstream.³² Over the past few decades, entities from ski resorts to utility commissions have started relying on cloud seeding as a method of squeezing extra water from the sky.³³ During that same time, the United States government experimented with cloud seeding over open seas in an attempt to, among other things, suppress hurricanes.³⁴ After multiple failures resulting in increased tension with neighboring countries, the government ceased experimenting with cloud seeding over the open seas.³⁵

27. *Atmospheric Science, Cloud Seeding*, ENCYCLOPEDIA BRITANNICA, available at <http://www.britannica.com/science/cloud-seeding> (last visited on Nov. 12, 2015) (on file with *The University of the Pacific Law Review*) (“[S]ince then seeding has been performed from aircraft, rockets, cannons, and ground generators.”)

28. Virginia Simms, *Making the Rain: Cloud Seeding, the Imminent Freshwater Crisis, and International Law*, 44 INT’L LAW 915, 918 (2010).

29. ERIC I. HEMEL ET AL., AN ENVIRONMENTALIST’S PRIMER TO WEATHER MODIFICATION I (Stanford Environmental Law Society, 1977).

30. See Simms, *supra* note 28 (discussing that, although the cloud seeding was done in an attempt to flood the area, whether the flood was actually caused by the cloud seeding is unclear).

31. Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, Dec. 10, 1976, 1108 U.N.T.S 26 (showing that there are 48 signatories to the treaty).

32. See J.D. Howe, *Legal Moguls: Ski Areas, Weather Modification, and the Law*, 33 U. Pitt. L. Rev. 59, 60 (1971) (noting the many ways in which cloud seeding can be used); See also Brown, *supra* note 6, at 97 (“[C]urrently, public and private entities, primarily Utilities, practice some cloud seeding near California mountain ranges, primarily the Sierra Nevada Range, to increase water supply for the dual purposes of increasing hydroelectric power generation and water supply.”)

33. Howe, *supra* note 32, at 59–60 (discussing the multifaceted impact of weather modification on the ski resort industry); see Little, *supra* note 5 (noting that Pacific Gas & Electric Company spends millions of dollars cloud seeding in the Sierra Nevada Mountains, and has done so for decades).

34. MARSHA L. BAUM, WHEN NATURE STRIKES: WEATHER DISASTERS AND THE LAW 32 (2007) (documenting how Project Cirrus was an effort to dissipate a hurricane headed for land by injecting dry ice into the funnel cloud in attempt slow its velocity by lowering the temperature of the storm); *Committee Approves Bill Establishing Weather Modification Program*, KWTX NEWS (Nov. 17, 2005, 6:18 PM), <http://www.kwtx.com/home/headlines/1985602.html> (describing how Republican Senator Kay Bailey from Texas introduced the Weather Modification Research and Development Policy Authorization Act of 2005 on the basis that cloud seeding research could lead to a decrease in destructive storms such as Hurricane Katrina).

35. See BAUM, *supra* note 34, at 32 (explaining that, after the United States attempted to use cloud seeding as a means of slowing down a hurricane, Mexico expressed concern that the cloud seeding had contributed to its drought in the neighboring area; this tension caused the United States to put an end to its cloud seeding experiments over the open seas).

B. The Science of Cloud Seeding

The cloud seeding technology works as follows: Water vapor is always present in the air, but it only transforms into rain, snow, or hail under certain conditions.³⁶ Typically, gaseous water in the cloud must be able to attach to some sort of particle in order to turn into a water droplet.³⁷ These particles are known as condensation nuclei, and can consist of smoke, dust, or other materials typically present in the air.³⁸ Ice will only form in a cloud if there is a certain amount of condensation nuclei.³⁹ Cloud seeding involves injecting particles into a cloud to simulate these condensation nuclei, allowing water vapor inside the cloud to attach and form liquid water.⁴⁰

Today, silver iodide is the most commonly used chemical for cloud seeding; it is injected into clouds either from the ground or by plane.⁴¹ The Sacramento Metropolitan Utility District (SMUD) and Pacific Gas and Electric Company (PG&E), two utility commissions operating in Northern California, demonstrate how cloud seeders can accomplish their goals in different ways.⁴² PG&E uses remote-controlled ground equipment mounted on a trailer.⁴³ PG&E rolls the trailer into the necessary position and then shoots silver iodide upward into the clouds.⁴⁴ Conversely, SMUD releases silver iodide from aircraft flying directly through the clouds.⁴⁵ SMUD contracts with Weather Modification, Inc., a private, international cloud seeding company.⁴⁶ Drones will likely becoming the most practical method of cloud seeding as the available technology continues to advance.⁴⁷

After injection, water droplets in the cloud begin to freeze within 15 minutes.⁴⁸ Importantly, cloud seeding is only effective when a cloud is already

36. See HEMEL ET AL., *supra* note 29, at 5.

37. *Id.*

38. *Id.*

39. Ice forms, and if it melts before it hits the ground, it becomes rain. See *Cloud Seeding*, CLIMATE EDUCATION FOR K-12, available at <https://climate.ncsu.edu/edu/k12/CloudSeeding> (last visited Nov. 12, 2015) (on file with *The University of the Pacific Law Review*) (explaining the scientific process of rain formation).

40. *Id.*

41. See Simms, *supra* note 28, at 919 (explaining that silver iodide has a chemical structure that is similar to ice, making it ideal condensation nuclei); see also Brown, *supra* note 6, at 105 (“Currently there are no California-wide state laws dealing directly with silver contamination.”).

42. Matt Weiser, *Cloud Seeding, No Longer Magical Thinking, is Poised For Use This Winter*, SACRAMENTO BEE (Nov. 11, 2013, 12:00AM), <http://www.sacbee.com/news/local/article2582373.html>.

43. *Id.*

44. *Id.*

45. *Id.*

46. *Id.*; see Little, *supra* note 5 (explaining that Weather Modification, Inc., is the world’s largest private aerial cloud seeding company).

47. See Weiser, *supra* note 42.

48. See Simms, *supra* note 28, at 919.

formed.⁴⁹ Therefore, cloud seeding is not a quick fix for a drought, but is most effective as a “long term water management” tool.⁵⁰ It is most effective to cloud seed when precipitation levels are normal, and to hold the excess rain water in reservoirs in case of a drought.⁵¹ Even so, cloud seeding has provided some relief to communities facing water crises.⁵² Maharashtra, one of the largest and wealthiest regions of India, relies heavily on rainwater for its agriculture production and currently faces its third year of drought.⁵³ The water shortage is so severe that “over 1,300 debt-trapped farmers have committed suicide in Maharashtra” in the past six months alone.⁵⁴ In a seemingly radical attempt to mitigate the drought, the region is now beginning a \$4.5 million cloud seeding project lead by Weather Modification, Inc.⁵⁵

Another limitation on cloud seeding is that the temperature within the cloud cannot be too cold or too warm.⁵⁶ It is most effective to cloud seed when precipitation levels are normal, and to hold the excess rain water in reservoirs in case of a drought.⁵⁷ However, adding dry ice to clouds can lower their internal temperature and make conditions more conducive to cloud seeding.⁵⁸

In addition to making a cloud produce rain, cloud seeding can also prevent rain from falling.⁵⁹ This method has proved effective for a variety of purposes, including rain and hail suppression, fog diffusion, and mountain snowpack expansion.⁶⁰ Cloud seeding for these purposes is now so popular that at least 52 countries currently practice at least one method.⁶¹ At this time, United States cloud seeding efforts focus primarily on increasing precipitation and expanding snowpacks.⁶² Ten states regularly practice cloud seeding.⁶³

49. *Id.*

50. *See* Little, *supra* note 5 (noting that large concentrations of silver iodide can be harmful) (quoting Patrick Sweeney, Chief Executive of Weather Modification, Inc., “the world’s largest private aerial cloud-seeding company” based out of Fargo, North Dakota); *see also* HEMEL ET AL., *supra* note 29, at 12 (explaining that weather modification cannot “end a prolonged drought” because narrow conditions must be present for cloud seeding to be able to occur).

51. *See* Simms, *supra* note 28, at 919 (quoting Arlen Huggins, cloud-seeding expert).

52. *See* Little, *supra* note 5 (explaining how cloud seeding can provide such relief).

53. *Id.*

54. *Id.*

55. *Id.* (mentioning that this is the largest cloud seeding operation attempt in India to date).

56. *See* Simms, *supra* note 28, at 919 (explaining that the internal temperature of the cloud must be below 0°C for seeding to be effective).

57. *See* HEMEL ET AL., *supra* note 29, at 12 (“If the proper conditions of temperature, moisture, nucleant concentration, and vertical motion are not present, the modification efforts will be ineffective.”)

58. *See* CLIMATE EDUCATION FOR K-12, *supra* note 39 (explaining that this can only be achieved under narrow circumstances).

59. *See* Brown, *supra* note 6, at 98 (describing the method is known as over seeding).

60. *See* BAUM, *supra* note 34.

61. *See* Little, *supra* note 5 (quoting the World Meteorological Organization).

62. *See generally* Simms, *supra* note 28, at 917 (explaining that the United States is both fast-growing and has an arid climate, two factors contributing to our water shortage).

C. High-Profile Examples of Cloud Seeding

China has likely experienced the most notoriety from its cloud seeding practices.⁶⁴ In 2008, when the Olympic Games were scheduled to be held in Beijing, China engaged in extensive experimental cloud seeding both prior to and during the event.⁶⁵ China intended its cloud seeding to both reduce the level of air pollution and prevent rain from falling in the area where the Olympic Games were to take place.⁶⁶ To achieve these goals, officials set up cloud seeding stations outside Beijing to force rain out of the clouds before it would have naturally fallen on the city.⁶⁷ Ironically, rainfall helps clear the air of pollution; therefore, by using cloud seeding to deter rain on the Games, China may have actually prevented smog from dissipating over Beijing.⁶⁸ China continues to invest heavily in cloud seeding and currently has the “most extensive weather modification program in the world, with more than 35,000 people working in cloud seeding programs across the country.”⁶⁹

Like many other technological advancements in our past, cloud seeding has historically been met with both fear⁷⁰ and doubt as to its effectiveness.⁷¹ Because weather is inherently unpredictable, it remains difficult to measure cloud seeding effects.⁷² However, after decades of seeding, scientists now have reached a consensus that the technology is effective.⁷³ The Desert Research Institute, an organization that has been cloud seeding for over 40 years, uses a trace chemical

63. Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. (2009).

64. Simms, *supra* note 28, at 919; Rocky Barker, *Modifying Weather: Cloud Seeding Has Some New Believers*, U.S. News (Nov. 19, 2009), <http://www.usnews.com/science/articles/2009/11/19/modifying-weather-cloud-seeding-has-some-new-believers.html> (“China has the most extensive weather modification program in the world.”).

65. Simms, *supra* note 28, at 916.

66. *Id.* (noting that China is notorious for its smoggy air, and the International Olympic Committee had warned it would postpone the Olympic games if the air quality did not improve).

67. *Id.* at 923.

68. *Id.* at 923–24 (explaining the effect of rainfall on air pollution).

69. See Barker, *supra* note 64.

70. THEODORE STEINBERG, SLIDE MOUNTAIN, OR, THE FOLLY OF OWNING NATURE 110–18 (1995) (documenting how Fulton County, PA banned cloud seeding in 1964 out of fear that cloud seeding experiments had contributed to drought in the area; many citizens of Fulton also strongly rejected the idea of weather modification on moral grounds).

71. *Id.*; see HEMEL ET AL., *supra* note 29, at 13 (describing how in 1966, toward the beginning of cloud seeding efforts, the National Academy of Sciences was “unenthusiastic about the success of weather modification”).

72. See Little, *supra* note 5 (quoting Neil Brackin, President of World Modification, Inc., who analogizes cloud seeding to experimental medicine in that people will still continue to use cloud seeding even if it has not been proven to be 100% effective).

73. DESERT RESEARCH INSTITUTE, *supra* note 8.

technique to show that their operations produced an eight percent snowpack increase at one particular watershed.⁷⁴

In addition to being effective, cloud seeding programs are now much more reliable.⁷⁵ In fact, one French cloud seeding company guarantees a rain-free wedding venue for \$150,000.⁷⁶ Some cloud seeding attempts, however, have led to tragic results because of mismanagement.⁷⁷ For example, cloud seeding in China caused a snow blizzard that killed at least 40 people and caused over \$500 million in damages.⁷⁸ A different cloud seeding tragedy occurred in Mongolia when a government-operated cloud seeding plane dropped a shell full of silver iodide on a citizen's home, striking and killing him.⁷⁹ While cloud seeding itself is not dangerous, these incidents exemplify the need for the process to be regulated.⁸⁰

III. CURRENT CLOUD SEEDING GOVERNANCE

The current governance of cloud seeding in the United States consists of a complex network of primarily state, local, and private agencies.⁸¹ Federal and international law also plays a limited role in cloud seeding regulation.⁸² This section gives a brief overview of cloud seeding law in the United States. First, it examines pertinent case law. This case law illustrates how states differ in cloud seeder liability. Second, this section gives examples of state and local governance. Third, it explains the existing relevant federal and international laws.

A. *Current Case Law*

Many jurisdictions in the United States now have statutes governing weather modification.⁸³ However, most of these statutes are not comprehensive enough to answer the many questions that arise in cloud seeding litigation, such as resolution of weather modification torts.⁸⁴ These questions include determining

74. *Id.*

75. Bethany Hubbard, *Cloud Seeding Guarantees Perfect Wedding Weather*, DISCOVER MAGAZINE (Mar. 9, 2015, 4:36 PM), available at <http://blogs.discovermagazine.com/d-brief/2015/03/09/cloud-seeding-wedding-weather/#.VkVvMcpRWJ-> (on file with *The University of the Pacific Law Review*).

76. *Id.* (quoting Natasja Rasmussen, Head of Customer Service Experience at Oliver's Travels, who states that cloud seeding is now a mainstream tool).

77. Simms, *supra* note 28, at 921 (noting that cloud seeding is sometimes criticized as dangerous).

78. *Id.*

79. *Id.*

80. *Id.*

81. See Howe, *supra* note 32, at 61 (explaining why finding someone in charge of cloud seeding activities is difficult).

82. *Id.*

83. Ronald B. Standler, WEATHER MODIFICATION LAW IN THE USA 4 (Oct. 22, 2006), available at <http://www.rbs2.com/weather.pdf> (on file with *The University of the Pacific Law Review*).

84. *Infra* Part III (discussing state cloud seeding statutes currently in force).

who bears liability for negligent cloud seeding, whether unauthorized cloud seeding constitutes a trespass on underlying property, and what standard of care applies to cloud seeders.⁸⁵ Because state statutes generally fail to address these issues, case law provides the basis for much of cloud seeding law.⁸⁶

Over time, state courts have resolved cloud seeding litigation in various ways.⁸⁷ Perhaps the most contentious issue in this body of case law is determining liability, whether the plaintiff bases the action on negligence or strict liability.⁸⁸ The United States Supreme Court has not yet addressed cloud seeding liability, so at this point it remains as determined by individual state courts.⁸⁹ As with most torts, plaintiffs can bring suit for an injunction to prevent cloud seeding over their land, or for damages if the defendant's cloud seeding caused the plaintiff irreparable harm.⁹⁰

1. Negligence

In the existing cloud seeding case law, plaintiffs often argued that cloud seeders were negligent and damaged the plaintiffs' underlying land.⁹¹ Most state courts have found liability for cloud seeders negligently altering a landowner's property. This analysis relies on natural rights theory, which provides that certain inalienable rights are inherent in land ownership.⁹²

However, even in those states where courts have established liability for cloud seeders, many plaintiff landowners still face difficulties in proving

85. Standler, *supra* note 83, at 4, 33.

86. *Id.* at 5 (explaining that access to cloud seeding decisions can be difficult because many cloud seeding cases are concluded at the trial court level, and trial decisions are oftentimes unpublished).

87. *Id.* at 33.

88. *Id.* at 5.

89. *Id.* at 6–33 (listing all cases regarding cloud seeding, none of which were decided by the United States Supreme Court).

90. *Id.* (explaining that courts are much more likely to grant an injunction, and plaintiffs are rarely able to obtain damages in cloud seeding cases, due to the difficulty of proving causation); HOWARD J. TAUBENFELD ET AL., CONTROLLING THE WEATHER: A STUDY OF LAW AND REGULATORY PROCEDURES 10 (1970) (“[I]n the short run it may be easier to enjoin modification activities than to collect damages for the results, given the difficulty of proving a cause-effect relationship and the likelihood of varying scientific opinions on the subject of the effectiveness of modification in any particular instance.”)

91. *See* Southwest Weather Research, Inc. v. Duncan, 319 S.W.2d 940, 941 (Tex. Civ. App. 1958) (holding the defendants liable for property damage their cloud seeding caused on the plaintiffs' ranch); *see, e.g.*, Slutsky v. New York, 197 Misc. 730 (Sup. Ct. 1950) (holding that a “remote possibility of inconvenience” to resort owners was not enough to outweigh the public interest in water supplied by cloud seeding).

92. *Legal Remedies for “Cloud-Seeding” Activities: Nuisance or Trespass?*, DUKE L.J. 305, 306 (1960) (explaining that natural rights specifically include riparian rights, so that “no one has the right so to divert the waters of a stream as to interfere unreasonably with its use by lower riparian landowners”); *see also* Pa. Nat. Weather Ass'n v. Blue Ridge Weather Modification Ass'n, 44 Pa. D. & C.2d 749, 756 (C.P. 1968) (“The right to use land without the right to use it in its natural condition is valueless.”); *see also* Brown, *supra* note 6, at 101 (“Water in its natural state, whether on or below the surface, is considered an interest in real property, either as part of, or appurtenant to, the land.”)

causation.⁹³ The very nature of cloud seeding makes proving causation inherently challenging.⁹⁴ Experts considered cloud seeding science to be shaky for many years.⁹⁵ Although scientists are now certain that cloud seeding can cause a cloud to produce rain in the right conditions, it is still difficult to ascertain whether the cloud would have produced rain on its own, without the use of cloud seeding.⁹⁶ In order to recover, a plaintiff must prove that his or her land would not have been damaged but for the cloud seeding.⁹⁷ This is a high burden.⁹⁸ Because of this high burden, many cloud seeding plaintiffs have lost their cases for failing to prove causation.⁹⁹

2. *Strict Liability (Ultra-Hazardous)*

Under the Restatement of Torts, defendants are held strictly liable for damages resulting from abnormally dangerous activities.¹⁰⁰ Activities are considered abnormally dangerous when the activity poses a danger to people, land or chattel of others, and the danger cannot be eliminated by demonstrating reasonable care.¹⁰¹ The determination that cloud seeding is considered an abnormally dangerous activity varies among states.¹⁰² Statutes in several states classify cloud seeding as not abnormally dangerous.¹⁰³ Therefore, cloud seeders would not be held strictly liable for damage caused by cloud seeding in these states.¹⁰⁴

93. PA. Natural Weather Ass'n v. Blue Ridge Weather Modification Ass'n, 44 Pa. D. & C.2d 749 (C.P. 1968) (holding that the right to land extended to the air space and a right to clouds, but since the plaintiff's burden of showing irreparable harm had not been met, the action could not be maintained); see also Larry G. Davis, WEATHER MODIFICATION TECH. L. 11, 60 (Ray Jay Davis et al. eds., 1978) ("A person who genuinely feels he is injured by weather modification has no effective remedy because of the tremendous expense in what will probably be a futile effort with his insurmountable proof problems.").

94. TAUBENFELD ET AL., *supra* note 90, at 136 ("The courses of storms and rain clouds are erratic, and their effects vary considerably. No two storms are exactly alike.")

95. See Little, *supra* note 5.

96. *Id.*

97. See *Lunsford v. United States*, 570 F.2d 221, 228, 228 n.13 (8th Cir. 1977) (finding that the plaintiffs could not recover because they could not show that the flood damaging their land was directly caused by cloud seeding done over the property).

98. See generally *Lunsford v. United States*, 570 F.2d 221 (8th Cir. 1977) (providing an example of the high burden the plaintiff must meet in such cases).

99. *Id.*

100. RESTATEMENT (SECOND) OF TORTS § 520 (2ND ED. 1979).

101. *Id.*

102. See Standler, *supra* note 83.

103. *Id.* (noting those states are North Dakota, Texas, and Wisconsin).

104. *Id.*

The Pennsylvania Legislature, however, concluded that cloud seeding is abnormally dangerous, and therefore cloud seeders can be held strictly liable when their activities cause damage.¹⁰⁵

More commonly, neither state courts nor legislatures have addressed the question of whether cloud seeding is abnormally dangerous.¹⁰⁶ Therefore, in these states, cloud seeders can potentially be held strictly liable for cloud seeding “gone wrong.”¹⁰⁷

Historically, states have defined tort liability.¹⁰⁸ However, cloud seeding is an activity that is likely to have an effect on other states.¹⁰⁹ Because some cloud seeding sites actually straddle state lines, it is unclear how a cloud seeder may be liable if the cloud seeding causes damage to a plaintiff’s land in a neighboring state.¹¹⁰

Cloud seeding is often done by private parties who may hesitate to cloud seed near state borders if they are unsure about their liability.¹¹¹ Cloud seeding is becoming an increasingly important tool for bulking up the water supply.¹¹² Continuing to encourage cloud seeding while regulations are unclear is contradictory to that goal.¹¹³ It is because of this ambiguity that federal regulation of cloud seeding will be helpful in providing a clear standard.¹¹⁴

B. State and Local Regulations on Cloud Seeding

As mentioned, cloud seeding is most heavily regulated at the state and local levels.¹¹⁵ However, states have chosen to strike the balance between state and local regulation in different ways.¹¹⁶ Some states have codified statutes specific

105. *Id.* (showing that plaintiff still has the burden of showing immediate and irreparable harm); *See* 3 P.S. § 1114 (1968) (“Any licensee who by causing heavy downpours or storms which cause damage to lands as determined by the board shall compensate farmers and property owners for such damages.”); *See also* Pa. Nat. Weather Asso. v. Blue Ridge Weather Modification Ass’n, 44 Pa. D. & C.2d 749 (C.P. 1968) (describing defendants who were cloud seeding with the purpose of hail suppression and the cloud seeding planes allegedly caused a drought).

106. *See* Standler, *supra* note 83.

107. Simms, *supra* note 28, at 921.

108. *See generally* Standler, *supra* note 83.

109. *See generally* DESERT RESEARCH INSTITUTE, *supra* note 8 (this depends on the location of the cloud seeding site and how close it is to the state line).

110. *Id.* (The Walker Basin cloud seeding target area is in Nevada, alongside the California border).

111. *See* Little, *supra* note 5.

112. *Supra* Part I (explaining the importance of cloud seeding for the water supply).

113. *Id.*

114. *Infra* Part IV (describing proposed federal cloud seeding regulatory scheme); *See* Lunsford v. United States, 570 F.2d 221, 223 (8th Cir. 1977) (explaining that plaintiffs will still need to prove causation to succeed on their claims).

115. California alone has three different statutes pertaining to weather modification. *See, e.g.* CAL WAT CODE § 235; CAL PUB RESOURCES CODE § 5093.36; CAL WAT CODE § 402.

116. *See* Brown, *supra* note 6 (“There is currently no statewide regulation of cloud seeding activities”).

to weather modification while other states rely upon existing water statutes to find a place for cloud seeding.¹¹⁷

Other states, such as Colorado, have created comprehensive weather modification regulations through agency promulgation.¹¹⁸ These regulations include instructions on how a cloud seeder can obtain a cloud seeding permit, the experience he or she must have to rightfully obtain a permit, and the terms by which a permit may be revoked.¹¹⁹ The cloud seeder must renew his or her permit periodically, as the permit expires every 5 years.¹²⁰ He or she must also submit, as part of the application, his or her plan for cloud seeding.¹²¹ The regulation is very specific as to the conditions where cloud seeding is allowed, and provides for multiple scenarios when cloud seeding operations must be suspended for safety reasons.¹²²

Notably, these restrictions only apply to cloud seeders within the state of Colorado.¹²³ Cloud seeding sites are often located near state borders.¹²⁴ When cloud seeding is performed next to a state border, the effects may be felt in the neighboring state.¹²⁵ The lack of uniformity in cloud seeding regulation will likely cause issues between the states.¹²⁶ Utilities and private companies that engage in cloud seeding close to state borders may take issue as well if cloud seeding across the border has a negative impact on their ability to cloud seed in their state.¹²⁷ As cloud seeding becomes more reliable and widely recognized as an additional water resource, federal regulation is a clear step toward preventing potential disputes between the states.¹²⁸

C. *Federal Cloud Seeding Regulations*

Current federal regulation of cloud seeding is negligible, despite the fact that Congress clearly has the authority to regulate cloud seeding.¹²⁹ Currently, the

117. CAL. WAT. CODE §106.

118. COLO. REV. STAT. § 36-20-108.

119. *Id.*; COLO. REV. STAT. § 36-20-114.

120. COLO. REV. STAT. § 36-20-114.

121. *Id.*

122. *Id.* (“[ground based winter cloud seeding operations] must be suspended at any time the snowpack water equivalents exceed the following: 175% of average on December 1st, 175% of average on January 1st, 160% of average on February 1st, 150% of average on March 1st and 140% of average on April 1st”).

123. COLO. REV. STAT. § 36-20-108

124. DESERT RESEARCH INSTITUTE, *supra* note 8.

125. *See* BAUM, *supra* note 34, at 34.

126. Email with David Rizzardo, Chief Snow Surveys and Water Supply Forecasting, CALIFORNIA DEPARTMENT OF WATER RESOURCES (on file with *The University of the Pacific Law Review*).

127. *See* Little, *supra* note 5 (“for decades, Pacific Gas & Electric has spent millions annually on cloud seeding in the Sierra Nevadas.”)

128. *Infra* Part IV (describing proposed federal cloud seeding regulatory scheme).

129. *See* 15 U.S.C.S. § 330; The Commerce Clause of the United States Constitution permits Congress to regulate interstate commerce. U.S. CONST. art. I, § 8, cl. 3.

Weather Modification Policy Act of 1976 regulates weather modification.¹³⁰ However, the Act was passed at a time when weather modification science was still developing. Despite the progress cloud seeding science has made since the 1970s, the law has yet to be updated.¹³¹ The Act provides no substantive guidance as to liability or licensing requirements of cloud seeders, but does mandate that cloud seeders report their data to the Secretary of Commerce.¹³² The Secretary then reports his findings to the President and makes the information available to the public.¹³³

Congress has fruitlessly pursued comprehensive federal weather modification legislation.¹³⁴ In 2004, Kay Bailey, a Republican Senator from Texas, introduced the Weather Modification Research and Technology Transfer Authorization Act.¹³⁵ The stated purpose of the Act was “to develop and implement a comprehensive and coordinated national weather modification policy and a national cooperative Federal and State program of weather modification research and development.”¹³⁶ The bill established an 11-member Weather Modification Advisory and Research Board where each member has individual expertise relevant to weather modification.¹³⁷ The Board’s main duties were promoting research and development of weather modification in addition to financially assisting weather modification efforts.¹³⁸ Despite the need for regulation at a federal level, the Act failed to pass.¹³⁹ While the bill was under consideration, the co-chairs of the Committee on Commerce, Science, & Transportation expressed its opinion that federal regulation should be deferred until more research on

130. 15 U.S.C.S. § 330 (the stated purpose of the act is “to develop a comprehensive and coordinated national weather modification policy and a national program of weather modification research and development”).

131. *Id.*

132. 15 U.S.C.S. § 330a.

133. 15 U.S.C.S. § 330b (the report excludes Title 18 information); 18 U.S. CODE § 1905.

134. Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. (2009); Weather Modification Research and Technology Transfer Authorization Act, S. 2170, 108th Cong. (2004).

135. Weather Modification Research and Technology Transfer Authorization Act, S. 2170, 108th Cong. (2004); see *Harvesting the Texas Skies in 2015 - A Summary of Rain Enhancement (Cloud Seeding) Operations in Texas*, TEXAS DEPARTMENT OF LICENSING AND REGULATION, <https://www.tdlr.texas.gov/weather/summary.htm> (on file with *The University of the Pacific Law Review*) (Texas participates in cloud seeding and implemented its own weather modification regulations in 1967).

136. Weather Modification Research and Technology Transfer Authorization Act, S. 2170, 108th Cong. Sec. 2 (2004).

137. *Id.* (including a representative of the American Meteorological Society, a representative of the National Center for Atmospheric Research of the National Science Foundation, and a representative of a State that is currently supporting operational weather modification projects).

138. *Id.* (the board is required to promote and fund research and development to improve technologies for weather modification).

139. *Id.*

weather modification and its effects could be conducted.¹⁴⁰ The committee's concerns shed some light onto why the bill failed to pass.¹⁴¹

In 2009, Senator Bailey again attempted federal weather modification legislation, this time called the Weather Mitigation Research and Development Policy Authorization Act of 2009.¹⁴² The purpose of the bill was similar to that of its 2004 predecessor: "to develop a national cooperative Federal and State program of weather mitigation research and development."¹⁴³ This bill included extensive findings that recognized the growing importance of weather modification in the United States, the benefits of additional weather modification research, and the need for an increase in federal regulation.¹⁴⁴ The bill proposed the creation of a board of experts similar to the one proposed in the 2004 bill.¹⁴⁵ Despite containing extensive findings supporting the need for federal regulation of weather modification, the bill failed to pass.¹⁴⁶ Because weather modification legislation failed to pass five years before, it is likely the Legislature continued to have the same concerns about the lack of existing research.¹⁴⁷ Since water modification gained traction in the 1970s, the Legislature has been concerned with the cost of expanding cloud seeding operations.¹⁴⁸ Until recently, many people were of the opinion that weather modification was a hoax and, therefore, a federal program would not be worth the cost.¹⁴⁹ However, because scientists now agree that cloud seeding is effective technology, the Legislature is more likely to support comprehensive federal regulation next time it is introduced.¹⁵⁰

140. Letter from the Honorable Daniel Inouye and the Honorable Ted Stevens to Senator Kay Bailey (Dec. 13, 2005), available at <http://www.legislative.noaa.gov/viewsletters/marburgerweathermodviewsletter121305.pdf> (on file with *The University of the Pacific Law Review*) ("[T]here is a host of issues—including liability, foreign policy, and national security concerns—that arose in the past and should be adequately considered before the U.S. Government undertakes the coordinated national research program this legislation would require . . .").

141. *Id.*

142. Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. (2009) (changing or controlling, or attempting to change or control, by artificial methods the natural development of atmospheric cloud forms or precipitation forms which occur in the atmosphere" and therefore includes cloud seeding).

143. *Id.*

144. *Id.* (quoting research by the National Research Council: "Weather mitigation . . . related research in the United States has dropped to less than \$500,000 per year from a high of \$20,000,000 in the late 1970s.")

145. *Id.*

146. *Id.*

147. See Letter from the Honorable Daniel Inouye and the Honorable Ted Stevens to Senator Kay Bailey (Dec. 13, 2005), available at <http://www.legislative.noaa.gov/viewsletters/marburgerweathermodviewsletter121305.pdf> (on file with *The University of the Pacific Law Review*).

148. *Id.*; *Weather Modification: Programs, Problems, Policy and Potential*, SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION XXIII (1978), <http://ufdc.ufl.edu/AA00025909/00001/16x> (on file with *The University of the Pacific Law Review*).

149. STEINBERG, *supra* note 70, at 110–18; See also Barker, *supra* note 64.

150. See DESERT RESEARCH INSTITUTE, *supra* note 8.

D. International Cloud Seeding Law

The United States has several weather modification-related treaty obligations to other countries.¹⁵¹ These agreements have little to no effect on cloud seeders in the United States, as their main purpose is to delineate the government's responsibilities to other nations.¹⁵² As noted earlier, during the Vietnam War, the United States attempted to use cloud seeding to flood Northern Vietnam, but whether it was effective is unclear.¹⁵³ Even so, the United Nations forged a treaty soon after the war to ban the use of weather modification as a weapon.¹⁵⁴

The United States and Canada have a formal agreement to keep an open line of communication about their weather modification research.¹⁵⁵ This agreement was formed before the science of cloud seeding was fully understood, and with an acknowledgement that the effect on neighboring areas was still unclear.¹⁵⁶ Both countries actively utilize cloud seeding and have benefited from the extensive weather modification research performed over the past few decades.¹⁵⁷

IV. PROPOSED FEDERAL CLOUD SEEDING GOVERNANCE

As of now, there have been no documented disputes between states over cloud seeding.¹⁵⁸ However, there are cloud seeding sites that straddle state lines or exist in close proximity to state borders.¹⁵⁹ As the drought in many parts of the United States worsens, it is only natural for states to protect and guard their water

151. Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, Dec. 10, 1976, 31 U.S.T. 333, 1108 U.N.T.S. 151 (weather modification cannot be used as a weapon of war); Agreement Relating to the Exchange of Information on Weather Modification Activities, U.S.-Can., Mar. 26, 1975, No. 14202 (weather modification efforts must be reported to each country so that each will be aware and can benefit).

152. Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, Dec. 10, 1976, 31 U.S.T. 333, 1108 U.N.T.S. 151.

153. See Simms, *supra* note 28.

154. *Id.*; Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, Dec. 10, 1976, 31 U.S.T. 333, 1108 U.N.T.S. 151 (there are 48 signatories to the treaty).

155. Agreement Relating to the Exchange of Information on Weather Modification Activities, U.S.-Can., Mar. 26, 1975, No. 14202 (requiring that either country, upon gaining valuable weather modification knowledge through its research, will inform the other country within 5 days if possible).

156. *Id.*

157. *Alberta's Cloud-seeding Pilots See 2nd Busiest Year in 20 Years*, CBCNEWS (Aug. 22, 2014), <http://www.cbc.ca/news/canada/calgary/alberta-s-cloud-seeding-pilots-see-2nd-busiest-year-in-20-years-1.2744786> (Canadian insurance companies now routinely pay for cloud-seeding to reduce hailstorms and resulting damage).

158. See generally Brown, *supra* note 6 (explaining that the general public is still relatively unfamiliar with cloud seeding).

159. See DESERT RESEARCH INSTITUTE, *supra* note 8 (e.g., there are 11 cloud seeding operations currently being conducted in the Lake Tahoe region on the border of California and Nevada).

supply.¹⁶⁰ This could easily lead to accusations of one state stealing the other's potential rainwater via cloud seeding over the border.¹⁶¹ One possible solution would be for states to strike their own deals with neighboring states, similar to the Colorado River Compact of 1922.¹⁶² Seven states in the Southwest region of the United States entered into this Compact, all of whom used the Colorado River as a major source of water.¹⁶³ The purpose of the Compact was to fairly apportion the water according to each state's needs.¹⁶⁴

At first glance, a solution similar to the Colorado River Compact of 1922 may seem like an attractive option.¹⁶⁵ However, dividing portions of a river is a much more concrete process than trying to determine the fairness of cloud seeding near a state borderline.¹⁶⁶ Many of the same states that take part in the Compact now routinely engage in cloud seeding to bulk their water supply.¹⁶⁷ Naturally, several of these states border each other.¹⁶⁸ It is foreseeable that at least some of these states would take issue with the cloud seeding activities of a bordering state prior to having worked out an interstate compact with that state.¹⁶⁹ Federal regulation, if assembled effectively, would solve this problem by providing a means of redress for states that take issue with the cloud seeding of a neighboring state.¹⁷⁰

160. See BAUM, *supra* note 34, at 35 (the "impact of weather modification may be felt beyond the immediate area").

161. *Id.*

162. See Colorado River Compact of 1922, UNITED STATES BUREAU OF RECLAMATION, available at <http://www.usbr.gov/lc/region/g1000/pdffiles/crcompact.pdf> (on file with *The University of the Pacific Law Review*); Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. (2009) ("A separate cooperative agreement is in place for wintertime snowfall enhancement programs in the States of Utah, Colorado, and Wyoming to pursue water augmentation to benefit the entire Colorado River System.").

163. See Colorado River Compact of 1922, UNITED STATES BUREAU OF RECLAMATION, available at <http://www.usbr.gov/lc/region/g1000/pdffiles/crcompact.pdf> (on file with *The University of the Pacific Law Review*).

164. *Id.*

165. *Id.*

166. *Id.*; *Sharing Colorado River Water: History, Public Policy and the Colorado River Compact*, UNIV. OF ARIZONA (Aug. 1, 1997), <https://wrrc.arizona.edu/publications/arroyo-newsletter/sharing-colorado-river-water-history-public-policy-and-colorado-river> (on file with *The University of the Pacific Law Review*) ("Wyoming, Colorado, Utah and New Mexico were designated Upper Basin states and California, Arizona and Nevada Lower Basin states; Each basin was to receive 7.5 million acre-feet (maf) per year").

167. Colorado River Compact of 1922, UNITED STATES BUREAU OF RECLAMATION, available at <http://www.usbr.gov/lc/region/g1000/pdffiles/crcompact.pdf> (on file with *the University of the Pacific Law Review*) (these states include Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming).

168. *Cloud Seeding*, COLORADO WATER CONSERVATION BOARD, available at <http://cwcb.state.co.us/water-management/water-projects-programs/Documents/WeatherModification/CloudSeeding.pdf> (on file with *The University of the Pacific Law Review*) (Nevada, a cloud seeding state, borders California, Idaho and Utah, also cloud seeding states).

169. See Brown, *supra* note 6.

170. See Little, *supra* note 5.

This section first demonstrates that Congress has the power to regulate weather modification. Second, it notes the benefits of federally regulating cloud seeding in the United States. Third, it warns against the potential pitfalls that may come with federal regulation. Finally, it suggests specific elements that the federal regulation should include, compared to previously introduced weather modification regulations.

A. Congress Has the Power to Regulate Weather Modification

There are multiple ways that Congress could potentially regulate weather modification; the most persuasive argument is likely that Congress has the power to regulate under the Commerce Clause.¹⁷¹ The Commerce Clause of the United States Constitution grants Congress the power to regulate “Commerce with foreign nations, and among the several States, and with the Indian Tribes.”¹⁷² The Supreme Court has held that activities having a substantial effect on interstate commerce fall within the scope of the Commerce Clause.¹⁷³ In determining how substantial of an effect cloud seeding has on interstate commerce, the Court would determine whether the activity is economic.¹⁷⁴ Droughts in the United States cause an average economic loss between six billion and eight billion annually.¹⁷⁵ Cloud seeding is a tool frequently used to mitigate that economic loss.¹⁷⁶ It is therefore an economic activity, and has a direct impact on interstate commerce. It follows that it is within Congress’s power to regulate cloud seeding.¹⁷⁷ Cloud seeding also frequently occurs over or nearby state and Indian Reservation borders.¹⁷⁸ This strengthens the argument that cloud seeding is an activity conducted “among the several states and with the Indian tribes,” giving Congress another means to regulate.¹⁷⁹

B. The Benefits of Federally Regulating Cloud Seeding

Federal regulation of cloud seeding would result in several benefits.¹⁸⁰ Most persuasively, federal regulation ensures more efficient utilization of cloud

171. U.S. CONST. art. I, § 8, cl. 3.

172. U.S. CONST. art. I, § 8, cl. 3.

173. *Wickard v. Filburn*, 317 U.S. 111 (1942).

174. *See id.*

175. Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. (2009).

176. *Supra* Section I (explaining the economic benefits of cloud seeding).

177. *See Wickard v. Filburn*, 317 U.S. 111 (1942) (holding that, as an economic activity, the effect on interstate commerce may be aggregated to determine if it substantially affects interstate commerce).

178. DESERT RESEARCH INSTITUTE, *supra* note 8.

179. U.S. CONST. art. I, § 8, cl. 3.

180. *See generally* TAUBENFELD ET AL., *supra* note 90, at 136.

seeding so that we may most effectively fight droughts.¹⁸¹ In 2003, the National Research Council conducted extensive research on weather modification and concluded that a coordinated program on weather modification research is necessary.¹⁸² Resources in some cloud seeding states have plateaued, creating a need in those states for additional support.¹⁸³

As cloud seeding projects expand, local and state regulation while maximizing efficiency become more difficult.¹⁸⁴ Drought transcends state borders and significantly affects the US economy.¹⁸⁵ When it comes to offsetting the drought by adding more water to our reserves, cloud seeding likely has not yet reached its full potential.¹⁸⁶ Failing to create nationwide standards and thus passing up the opportunity to make cloud seeding a more effective means of obtaining fresh water, would be fiscally and environmentally irresponsible.¹⁸⁷

Federal cloud seeding regulation would also benefit cloud seeders themselves.¹⁸⁸ As it stands, states have the ability to determine whether cloud seeders can be found liable for negligently cloud seeding, or whether cloud seeding can be considered an abnormally dangerous activity.¹⁸⁹ This makes sense as tort law is traditionally seen as an area that should be regulated by the States.¹⁹⁰ If the federal government decided to preempt the area of weather modification, states should still have the ability to determine whether cloud seeders operating in their state are to be held strictly liable for their torts.¹⁹¹ However, federal regulation that provides for operational consistency of cloud seeding would make it easier for states to reach these conclusions.¹⁹² States

181. Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong., Sec. 3(1) (2009); *See also* TAUBENFELD ET AL., *supra* note 90, at 17 (“[W]ithout such a major research effort focused on obtaining relevant new knowledge, it will remain difficult to regulate weather modification operations for the general welfare.”)

182. *Id.*

183. *Id.*

184. TAUBENFELD ET AL., *supra* note 90, at 136 (“As projects become more numerous and larger and as more federal agencies become involved, there will be an increasing need for some federal institutional means of coordination.”).

185. Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. (2009).

186. *Id.* (“A 2006 evaluation by the Bureau of Reclamation of the Department of the Interior indicates the potential for 800,000 additional acre-feet of water”); *See also* TAUBENFELD ET AL., *supra* note 90, at 16 (“it is recognized that fragmentation of control over programs may lead to wasteful duplication and even to interference between projects”).

187. *See id.*

188. TAUBENFELD ET AL., *supra* note 90, at 136.

189. *See generally* Brown, *supra* note 6, at 101.

190. Alexandra B. Klass, *Tort Experiments in the Laboratories of Democracy*, 50 WM. & MARY L. REV. 1504 (2009) (“Tort law is seen as a classic area of ‘traditional state concern’ even as Congress and federal agencies play an ever-increasing role in regulating” numerous areas of the law.).

191. TAUBENFELD ET AL., *supra* note 90, at 139.

192. *Id.* (where federal interests are involved, it is important to federally regulate to ensure the quality performance of cloud seeding operations).

would be able to look to the federal regulation to see what rules cloud seeders must abide by to get a permit and engage in cloud seeding; this would notify states as to what constitutes negligent cloud seeding.¹⁹³

The federal government is in the best position to provide operational standards for cloud seeding over federal land.¹⁹⁴ The federal government owns a large percentage of the land in cloud seeding states.¹⁹⁵ For example, 45.8 percent of the land in California and 84.9 percent of the land in Nevada is owned by the federal government.¹⁹⁶ Since the discovery of cloud seeding, the federal government has acted as one of its main sources of funding.¹⁹⁷ Because the federal government owns much of the land in cloud seeding states and provides a large portion of the funding, it makes sense that the federal government should have more exclusive control over cloud seeding standards.¹⁹⁸

Cloud seeding within a state may naturally lead to an increase in moisture in a neighboring state.¹⁹⁹ Alternatively, cloud seeding may cause slight downwind water deprivation across state borders.²⁰⁰ In the past, courts have considered harm to downwind plaintiffs to be *de minimus*.²⁰¹ However, due to the severe drought currently raging in many areas of the country, deprivation of a seemingly small amount of water may no longer be considered *de minimus*, especially due to the drought occurring in agricultural areas.²⁰²

There may also be an issue with cloud seeding that affects the water supply of Indian reservations, similar to states affecting each other by cloud seeding over state borders.²⁰³ Foreseeably, residents of these reservations may take issue

193. *Id.* (for example, a state could find that any cloud seeder who fails to comply with the permit requirements is negligent per se).

194. *Id.* at 136.

195. Gorte, R. W., C. H. Vincent, L. A. Hanson, & M. R. Rosenblum, *Federal Land Ownership: Overview and Data*, Congressional Research Service 4 (2017), available at <https://fas.org/sgp/crs/misc/R42346.pdf> (on file with *The University of the Pacific Law Review*).

196. *Id.*

197. DESERT RESEARCH INSTITUTE, *supra* note 8 (the federal government has provided 2.5 million dollars in grants to the Desert Research Institute alone); See also TAUBENFELD ET AL., *supra* note 90, at 4 (“To date, the federal government has been the major contributor of funds for weather modification research and, through several agencies, has also conducted substantial laboratory and field-research operations itself.”).

198. Gorte, *supra* note 195.

199. HEMEL ET AL., *supra* note 29, at 99 (“[t]he Bureau of Reclamation’s snow augmentation project in the Upper Colorado River Basin, though requiring seeding only in Colorado, has also led to increased moisture in Utah, Arizona, and Nevada.”)

200. Standler, *supra* note 83, at 31.

201. *Id.* at 32.

202. *Id.*; Kat Kerlin, *Drought costs California agriculture \$1.84B and 10,100 jobs in 2015*, UC DAVIS (Aug. 18, 2015), <https://www.ucdavis.edu/news/drought-costs-california-agriculture-184b-and-10100-jobs-2015> (on file with *The University of the Pacific Law Review*) (noting that, in 2015, California’s agricultural economy took a \$1.84 billion hit as a result of the drought).

203. See Brown, *supra* note 6, at 98.

with cloud seeding near their borders.²⁰⁴ Federally recognized Indian tribes are considered individual sovereign nations by the United States.²⁰⁵ The federal government generally negotiates land disputes with Indian tribes, providing another reason to implement federal regulation of cloud seeding.²⁰⁶

Cloud seeding will likely be conducted using drones in the near future.²⁰⁷ Federal law regulates drone use in the United States.²⁰⁸ It is a logical step to federally regulate cloud seeding as well, in anticipation of the fact that cloud seeding will presumably soon be conducted with the use of drones.²⁰⁹

It is for all these reasons that cloud seeding should be federally regulated.

B. *The Potential Downsides to Federal Regulation of Cloud Seeding*

Federal regulation of cloud seeding inevitably creates more hoops for cloud seeders to jump through to make sure they are in compliance with the law.²¹⁰ Increased bureaucracy can stifle innovation.²¹¹ Since cloud seeding technology is still growing, any federal regulation must be flexible enough to allow for continued growth within the field.²¹²

Federal regulation is notoriously expensive.²¹³ Creating a new agency to regulate weather modification will be no different.²¹⁴ In 1966, the

204. *Id.* at 99 (“The rights of tribes to maintain existing natural precipitation patterns, if any, have never been litigated . . . recently, although not historically, federal courts have become highly protective of tribal sovereign rights.”)

205. Brown, *supra* note 6, at 99 (“Native American tribes are considered independent nations and as such are entitled to certain water rights.”)

206. U.S. CONST. art. I, § 8, cl. 3 (permitting Congress to regulate interstate commerce between the several states and Indian Tribes).

207. Lauren Sommer, *It's Not Magic On The Mountain, It's A Rain-Making Machine*, NPR (Jan. 9, 2014), <http://www.npr.org/2014/01/09/261070150/its-not-magic-on-the-mountain-its-a-rain-making-machine> (on file with *The University of the Pacific Law Review*) (quoting Jeff Tilley of the Desert Research Institute).

208. *Unmanned Aircraft Systems*, FEDERAL AVIATION ADMINISTRATION, <https://www.faa.gov/uas/> (on file with *The University of the Pacific Law Review*).

209. Sommer, *supra* note 207 (quoting Jeff Tilley of the Desert Research Institute).

210. Davis, *supra* note 93, at 66.

211. *Id.* (noting that agencies are bureaucracies, and therefore by nature geared toward self-preservation); see TAUBENFELD ET AL., *supra* note 90, at 16–17 (warning against the “risk of monopoly, including among others the risk of a certain sterility and a lack of adequate variety, coverage, and vitality to the effort.”).

212. Davis, *supra* note 93, at 66 (asserting that agencies can hamper innovation, discouraging maximum potential for research).

213. W. Mark Crain and Nicole V. Crain, *THE COST OF FEDERAL REGULATION TO THE U.S. ECONOMY, MANUFACTURING, AND SMALL BUSINESS 1* (2014), available at <http://www.nam.org/Data-and-Reports/Cost-of-Federal-Regulations/Federal-Regulation-Full-Study.pdf> (on file with *The University of the Pacific Law Review*) (“U.S. federal government regulations cost an estimated \$2.028 trillion in 2012 . . . an amount equal to 12 percent of [the Gross Domestic Product].”).

214. Homer E. Newell, *REPORT FOR THE INTERDEPARTMENTAL COMMITTEE FOR ATMOSPHERIC SCIENCES 11* (1966), available at http://www.geoengineeringwatch.org/documents/19680002906_1968002906.pdf (on file with *The University of the Pacific Law Review*) (estimating the cost for such a program in 1970 to be around 7 million).

Interdepartmental Committee for Atmospheric Sciences considered a proposal for a national weather modification program.²¹⁵ The Associate Administrator for Space Science and Application National Aeronautics and Space Administration estimated that the initial cost of implementing a federal weather modification program would be \$600,000.²¹⁶ Creating an entire weather modification agency will come with a much higher price tag.²¹⁷ However, federal regulation of weather modification will make cloud seeding operations more consistent, bringing some balance to the seemingly steep cost of a federal program.²¹⁸ Additionally, drones will likely be used as a primary means of cloud seeding in the future.²¹⁹ According to the Desert Research Institute, using drones for cloud seeding could lower costs.²²⁰ This shift in technology is another way to counter the cost of a federal program.²²¹

C. Necessary Elements of Federal Regulation

The most recently proposed weather modification legislation has laid the groundwork for successful cloud seeding federal regulation.²²² The *Weather Mitigation Research and Development Policy Authorization Act* (WMA) proposed a national weather modification policy, primarily centered on continuous research and development.²²³ Notably, the act called for a federal agency, comprised of 11 experts in different areas of weather modification.²²⁴ Experts that are familiar with existing and emerging cloud seeding technology are essential to an effective agency.²²⁵ Their unique knowledge will ensure that the agency produces regulations that are technologically up to date and relevant.²²⁶ Among the experts recommended, two of them would have

215. *Id.* at 1.

216. *Id.* at 11 (stating that the national program called for a budget that covered primarily the operational costs of weather modification and continuing weather modification research; \$600,000 amounts to approximately \$4,259,479.04 in 2016 after accounting for inflation).

217. *Infra* Part IV (outlining the necessary elements of a weather modification agency); *Weather Mitigation Research and Development Policy Authorization Act*, 111 S. 601, 111th Cong., Sec. 3(1) (2009) (demonstrating that the 2003 National Academy of Sciences Report questioned whether cloud seeding is worth the expense).

218. TAUBENFELD ET AL., *supra* note 90, at 137 (“As projects become more numerous and larger and as more federal agencies become involved, there will be an increasing need for some federal institutional means of coordination.”).

219. Sommer, *supra* note 207.

220. Weiser, *supra* note 42.

221. *See* Sommer, *supra* note 207.

222. *Weather Mitigation Research and Development Policy Authorization Act*, 111 S. 601, 111th Cong. Sec. 3 (2009).

223. *Id.*

224. *Id.* (explaining that the Act called for a Weather Mitigation Research Office with an advisory board to give recommendations regarding weather modification practices in the United States).

225. Davis, *supra* note 93, at 67.

226. *Id.*

represented states that had already been engaging in cloud seeding regularly.²²⁷ Carrying this forward as a requirement would help ensure that state interests are represented in the federal regulation.²²⁸ This is essential, as part of the goal of federal regulation would be to prevent conflict between the states.²²⁹ The weather modification agency could be formed as an independent entity, but including it as an extension of an existing body such as the National Science Foundation (NSF) may cut down on costs.²³⁰ This would also make sense given the stated purpose of the NSF: “to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense.”²³¹ One of the goals of the weather modification agency should be to coordinate cloud seeding research, and would therefore be a proper fit within the NSF.²³²

While the creation of a weather modification agency is the first essential step toward federal regulation, an effective federal plan for cloud seeding needs to take regulation a step further: federal regulation needs to include licensing requirements, operational guidelines, a fee collection structure, and potentially address liability issues at the state level.²³³ The agency implementing these requirements should have the power to research, investigate, and issue binding decisions.²³⁴ This agency could be analogized to the Environmental Protection Agency, which consists of experts in the field that are empowered to make decisions to preserve and protect the environment.²³⁵ The combination of these elements will collectively ensure that cloud seeding activities in the United States continue to be as effective as possible.²³⁶

227. Weather Mitigation Research and Development Policy Authorization Act, 111 S. 601, 111th Cong. Sec. 5 (2009).

228. *Id.*

229. Standler, *supra* note 83, at 4 (demonstrating that many states in the US already have some form of regulation established for cloud seeding).

230. ABOUT THE NATIONAL SCIENCE FOUNDATION, <http://www.nsf.gov/about/> (last visited Apr. 2, 2016) (on file with *The University of the Pacific Law Review*).

231. *Id.*; TAUBENFELD ET AL., *supra* note 90, at 5 (stating that the NSF is already familiar with weather modification, as it was given authority by Congress to require reports of weather modification activities from 1966 to 1968).

232. *See* Davis, *supra* note 93, at 66.

233. HEMEL ET AL., *supra* note 29, at 100; *see* TAUBENFELD ET AL., *supra* note 90, at 21 (“since weather respects no state boundary and since operators are likely to conduct activities in many states and to affect the citizens of many states by their activities, it seems reasonable to suggest that federal standards for an operators’ license be set and that a federal entity issue the license once an individual shows his competence”).

234. *See* Davis, *supra* note 93, at 60; *see also* TAUBENFELD ET AL., *supra* note 90, at 13 (arguing for legislation that has “at least uniform minimum standards with respect to professional licenses, operational permits, and standards of liability”).

235. *See* Ryan Matthews, *Congress and Chaos: Reexamining the Role of Congress in Combating Climate Change*, 47 U. OF PAC. L. REV. 6 (2015) (proposing an alternate structure for the Environmental Protection Agency which highlights a board of experts).

236. HEMEL ET AL., *supra* note 29, at 94; *see* TAUBENFELD ET AL., *supra* note 90, at 21 (“since weather respects no state boundary and since operators are likely to conduct activities in many states and to affect the citizens of many states by their activities, it seems reasonable to suggest that federal standards for an operators’ license be set and that a federal entity issue the license once an individual shows his competence”).

While all cloud seeding states require that cloud seeders obtain a license to engage in weather modification, many licensing statutes are lax.²³⁷ Weather modification experts agree that licensing needs to be somewhat strict for cloud seeding efforts to reach maximum efficiency.²³⁸ To be effective, licenses must be specific about establishing the minimum requirements to engage in cloud seeding.²³⁹ These requirements should be flushed out by the established weather modification agency, but should include several minimum prerequisites: the cloud seeder should have formal education and training in weather modification or meteorology.²⁴⁰ In addition to obtaining a degree, those seeking to cloud seed should already have several years of experience in either field research or cloud seeding operations.²⁴¹ Appropriate, specific licensing requirements will also aid states in determining cloud seeding liability issues.²⁴²

In addition to licensing requirements, operational guidelines and standards will be an equally important component of the federal regulation.²⁴³ Having standards in place that have been determined by experts in the field will have several benefits. First, unified standards will boost cloud seeding efficiency.²⁴⁴ Second, unified operating standards will promote safe practices while simultaneously cutting down on liability issues for cloud seeders and those in or around cloud seeding sites.²⁴⁵ Third, unified standards will make cloud seeding research more accurate.²⁴⁶ A license to cloud seed should be contingent on an agreement to carefully track the cloud seeding and report the information to the agency.²⁴⁷ This information will provide the experts with frequent, updated information regarding what works when it comes to cloud seeding practices.²⁴⁸ Finally, implementing a fee collection system should pay, in part, for the operating costs and research conducted by the weather modification agency.²⁴⁹ Prior weather modification legislation likely did not pass because Congress

237. HEMEL ET AL., *supra* note 29, at 92.

238. *Id.* at 91 (“Most weather modifiers and academicians concerned with weather modification agree that stricter licensing provisions would serve the public interest.”).

239. *Id.* at 92 (giving the example of having completed a degree in Meteorology or Cloud Sciences).

240. *Id.* at 93 (asserting that a degree in meteorology is does, alone, qualify someone to be competent in practicing cloud seeding).

241. *Id.* at 92 (asserting that the specifics of the qualifications would be determined by the weather modification agency experts).

242. *See* Davis, *supra* note 93, at 60 (discussing the difficulties plaintiffs generally face in clouding seeding actions).

243. HEMEL ET AL., *supra* note 29, at 94.

244. *Id.* (showing the inconsistencies that currently exist between different states).

245. TAUBENFELD ET AL., *supra* note 90, at 136.

246. *Id.*

247. *Id.*

248. *See* Agreement Relating to the Exchange of Information on Weather Modification Activities, U.S.-Can., Mar. 26, 1975, No. 14202 (allowing us to keep our agreement with Canada).

249. TAUBENFELD ET AL., *supra* note 90, at 7.

worried about a lack of existing research.²⁵⁰ If new legislation were introduced with the means and purpose of continuously gathering up-to-date research, Congress's fears should be abated.²⁵¹ Federal cloud seeding legislation is more likely to pass the next time it is introduced because scientists are more confident in the effectiveness of cloud seeding and the United States has increasingly been relying on cloud seeding to bulk its fresh water supply.²⁵² While the regulation must be comprehensive and specific in its requirements, it also must leave room for innovation so that the field may continue to grow and be a useful tool into the future.²⁵³

V. CONCLUSION

In recent years, cloud seeding has become an important tool to access fresh water in the United States.²⁵⁴ With scattered weather modification laws at the local, state and federal levels, the current regulatory system for cloud seeding is both incomplete and difficult to navigate.²⁵⁵ A unified federal program is necessary to make cloud seeding easier and more efficient.²⁵⁶ This program should include the creation of a federal agency comprised of experts in the field of weather modification.²⁵⁷ This agency should have the power to regulate cloud seeding activities in the United States, provide operational guidelines, and conduct research on ways to make cloud seeding more effective.²⁵⁸ The rules promulgated by the agency would preempt state law, making cloud seeding operations and research in the United States more efficient.²⁵⁹ However, states would still be able to determine cloud seeding liability within their state, using the federal operational guidelines as a starting point.²⁶⁰ Congress clearly has the

250. See Letter from the Honorable Daniel Inouye and the Honorable Ted Stevens to Senator Kay Bailey (Dec. 13, 2005), available at <http://www.legislative.noaa.gov/viewsletters/marburgerweathermodviewsletter121305.pdf> (on file with *The University of the Pacific Law Review*) (“There is a host of issues—including liability, foreign policy, and national security concerns—that arose in the past and should be adequately considered before the U.S. Government undertakes the coordinated national research program this legislation would require”)

251. *Id.* (recommending that the proposed weather modification bill be deferred until more research was available).

252. DESERT RESEARCH INSTITUTE, *supra* note 8; Little, *supra* note 5.

253. Davis, *supra* note 93, at 66 (noting that agencies are bureaucracies, and therefore by nature have a propensity to act out of self-preservation).

254. *Supra* Part I (noting importance of cloud seeding for accessing fresh water); See also Brown, *supra* note 6, at 97 (“California officials estimate that cloud seeding throughout the Sierra Nevada could easily produce another 300,000 to 400,000 acre-feet of water annually . . . an acre-foot is about enough water to supply a typical household for a year”).

255. *Supra* Part I (describing complex regulatory framework for cloud seeding).

256. *Supra* Part I (asserting the necessity of a uniform regulatory program).

257. *Supra* Part IV (describing aspects of proposed regulatory scheme).

258. *Supra* Part IV (describing aspects of proposed regulatory scheme).

259. *Supra* Part IV (noting the need for simplicity in cloud seeding regulation).

260. *Supra* Part IV (allowing states to maintain a certain level of sovereignty in regulating cloud seeding).

power to regulate cloud seeding and other forms of weather modification under the Commerce Clause.²⁶¹ As long as there is room left for innovation and discovery, federal regulation of cloud seeding will be beneficial for cloud seeders, state governments, and American citizens.²⁶²

261. *Supra* Part III (noting that Congress has the authority to regulate cloud seeding under the Commerce Clause).

262. *Supra* Part IV (emphasizing the importance of federal regulations not being too stringent).