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Bloomin' Disaster: Externalities, Commons Tragedies, and the Algal Bloom Problem

BLOOMIN' DISASTER: EXTERNALITIES, COMMONS TRAGEDIES, AND THE ALGAL BLOOM PROBLEM

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ABSTRACT

Toxic algal blooms are appearing with increasing frequency across the country. These blooms, fueled by rising global temperatures and nutrient pollution, pose serious risks to human health, the environment, and the economy. Although the federal government effectively regulates some sources of algae-causing nutrient pollution, exemptions under the Clean Water Act limit federal restrictions on nonpoint source nutrient pollution from agricultural activities. State governments' efforts to fill this regulatory void are often capable of addressing algal bloom risks within state-contained watersheds. However, relying upon state-level agricultural nutrient pollution regulation to prevent algal bloom problems tends to be less successful when interstate watersheds are involved. This Article analyzes the policy challenges associated with preventing algal blooms and offers specific proposals for overcoming these challenges. By analyzing algal bloom problems through Garrett Hardin's familiar commons framework and integrating the insights of Elinor Ostrom and others about how to address various types of commons tragedies, this Article exposes the shortcomings of existing policy approaches to algal bloom prevention and highlights some innovative alternative strategies for addressing the problem. This Article ultimately argues that algal bloom risks arising within larger interstate watersheds involve broader negative externality problems than state regulators are capable of effectively addressing, justifying stronger federal regulation of agricultural nonpoint source nutrient pollution in those contexts. One potential federal-level approach to the problem suggested in the Article is to allow states whose water resources are polluted by upstream states to enforce interstate Total Maximum Daily Loads ("TMDLs") against polluting states. By applying well-established legal academic concepts to an emerging policy challenge, this article seeks to influence how scholars and regulators approach algal bloom prevention policy in the years to come.

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INTRODUCTION

In the summer of 2014, a small, but concentrated, algal bloom appeared in Lake Erie's Maumee Bay.[1] The bloom manifested as a thick green sludge that contained microcystin, a toxin that "can cause nausea, vomiting, and liver damage if ingested."[2] Nearby City of Toledo intake pipes sucked up the toxic water and introduced it to the municipal water supply.[3] Officials soon determined that their city water contained dangerous levels of the toxin and issued this dire warning: "DO NOT DRINK THE WATER," and "DO NOT BOIL THE WATER."[4]

Toledo's municipal water not only became unsafe to drink, it had developed toxicity that actually became worse when boiled.[5] Soon, over 400,000 people in the Toledo area lacked clean drinking water.[6] Many panicked.[7] Stores quickly ran out of bottled water.[8] Restaurants, libraries, and schools closed.[9] Residents traveled to nearby towns, and some even left the state in search of potable water.[10] Ohio's Governor declared a state of emergency.[11]

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1. Codi Kozacek, *Toledo Issues Emergency 'Do Not Drink Water' Warning to Residents,* CIRCLE OF BLUE (Aug. 2, 2014), http://www.circleofblue.org/2014/world/toledo-issues-emergency-warning-residents-drink-water/.

2. *Id.*

3. *Id.*

4. *'Do not drink, do not boil' water: Crisis closes out second day with little information,* WTOL 11 NEWS (2014), http://www.wtol.com/story/26178506/do-not-drink-do-not-boil-water-advisory-issued-for-issued-for-lucas-county-surrounding-area.

5. *Id.*

6. Kozacek, *supra* note 1.

7. *See* Taylor Dungjen & David Patch, *Toledo-area water advisory expected to continue through Sunday as leaders await tests; water stations to remain open,* THE TOLEDO BLADE (Aug. 2, 2014), http://www.toledoblade.com/local/2014/08/02/City-of-Toledo-issues-do-no-drink-water-advisery.html.

8. *Id.*

9. Kozacek, *supra* note 1.

10. *See, e.g.,* Emma G. Fitzsimmons, *Tap Water Ban for Toledo Residents,* N.Y. TIMES (Aug. 3, 2014), https://www.nytimes.com/2014/08/04/us/toledo-faces-second-day-of-water-ban.html; *see also* Kozacek, *supra* note 1.

11. Kozacek, *supra* note 1.

Nearby, unaffected municipalities offered water to residents of Toledo for free.[12] The Red Cross and other charitable organizations created water distribution centers and delivery systems for those unable to leave their homes.[13] The National Guard delivered bottled water and military rations to homeless shelters and to other at-risk people who could not cook with their water.[14] After two excruciating days, city officials finally lifted the advisory;[15] but City officials warned residents to flush their household water lines.[16] Toledo's experience was a short-lived but vivid reminder to communities across the country of the potential dangers that toxic algal blooms create.

Toledo water treatment plants were unprepared for the 2014 algal bloom, despite the city's expenditure of millions of dollars on special water-treatment equipment during the previous year to protect against water toxins.[17] Treatments of bloom-contaminated water are expensive, and concerns about algal blooms have driven up spending on requisite equipment in recent years.[18] In the words of Adam Rissien, Director of Agricultural and Water Policy at the Ohio Environmental Council,

> I have every confidence in the water treatment plant to figure out how to make the drinking water safe. Unfortunately, the options available to them are costly and that means a rate increase—there's no way around it. Until we reduce phosphorus and address harmful algal blooms, I'm afraid it's going to come on the ratepayers' backs. And that's not fair.[19]

The bacteria that cause algal blooms are common throughout freshwater and marine ecosystems.[20] However, algal blooms are likely to occur at increasing rates and become more severe in many regions of the country in the coming years.[21] In 2016, major algal blooms appeared in Lake Erie;[22] the Gulf of

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12. *Id.*
13. *Id.*
14. *Id.*
15. *Id.*
16. *Id.*
17. Kozacek, *supra* note 1.
18. *Id.*
19. *Id.*
20. WORLD HEALTH ORGANIZATION, TOXIC CYANOBACTERIA IN WATER: A GUIDE TO THEIR PUBLIC HEALTH CONSEQUENCES, MONITORING AND MANAGEMENT § 1.1 (Ingrid Chorus & Jamie Bartram eds., 1999), http://www.who.int/water_sanitation_health/resourcesquality/toxcyanbegin.pdf.
21. *See, e.g.*, Pam F. Gorder, *Number of severe algal blooms in Lake Erie to double, forecast says: Climate change 'supercharges' algae, making it harder to prevent*, THE OHIO STATE UNIV. (Dec. 16, 2015), https://news.osu.edu/news/2015/12/16/eriecentury/.
22. Robert Ferris, *Why are there so many toxic blooms this year?*, CNBC NEWS (Jul. 26, 2016), http://www.cnbc.com/2016/07/26/why-are-there-so-many-toxic-algae-blooms-this-year.html.

Maine[23]; Utah Lake, Utah;[24] Lake Okeechobee, Florida;[25] Pyramid Lake, California;[26] Shasta Lake, California;[27] and elsewhere in more than twenty states.[28] In 2016, California alone posted algal bloom danger advisories for at least thirty lakes and reservoirs.[29] Although blooms sometimes happen naturally, many times they are caused by human-caused nutrient pollution,[30] which can come from urban storm runoff, wastewater treatment, fossil fuels, agricultural runoff, and household products.[31] In particular, runoff from commercial agriculture can be a significant contributor to algal bloom problems and is regulated less stringently than other sources of nutrient pollution.[32] Although some states have taken steps to regulate agricultural nutrient pollution within their own borders, these states cannot lower nutrient pollution from other states.[33] Therefore, the problem of interstate nutrient pollution is unlikely to be solved without additional federal regulation.

Without question, algal blooms are a worsening problem within the United States.[34] Growing nutrient loads in lakes and streams increase the incidences of algal blooms.[35] Current federal and state regulations have failed to sufficiently reduce nutrient loads, and severe algal blooms have become more common.[36]

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23. *Id.* (stating that the algal blooms in the Gulf of Maine "are almost entirely natural. However, in some cases, particularly in some freshwater blooms, humans are playing a part.").

24. Courtney Tanner, *Utah Lake closed due to health concerns from large algal bloom*, SALT LAKE TRIBUNE (Jul. 15, 2016), http://www.sltrib.com/news/4119973-155/utah-lake-closed-due-to-health.

25. Ferris, *supra* note 22.

26. Joseph Serna, *Summer conditions growing toxic algal blooms in two California lakes*, L.A. TIMES (Jul. 14, 2016), http://www.latimes.com/local/lanow/la-me-ln-pyramid-lake-algae-bloom-20160714-snap-story.html.

27. *Id.*

28. Lesley McClurg, *Poisonous Algal Blooms Threaten People, Ecosystems Across U.S.*, NPR NEWS (Aug. 29, 2016), http://www.npr.org/2016/08/29/491831451/poisonous-algae-blooms-threaten-people-ecosystems-across-u-s.

29. *Id.*

30. WHO, *supra* note 20, at § 1.1.

31. *Sources and Solutions*, ENVTL. PROT. AGENCY (Dec. 19, 2016), https://www.epa.gov/nutrientpollution/sources-and-solutions.

32. *See* Mary J. Angelo & Jon Morris, *Maintaining a Healthy Water Supply While Growing a Healthy Food Supply: Legal Tools for Cleaning Up Agricultural Water Pollution*, 62 U. KAN. L. REV. 1003, 1003-04 (2014) (noting that despite agriculture producing a significant percentage of nutrient pollution, the Clean Water Act's failure to regulate nonpoint source pollution through the National Pollutant Discharge Elimination System ("NPDES") has left agricultural run-off largely unregulated).

33. *See* Robin K. Craig & Anna M. Roberts, *When Will Governments Regulate Nonpoint Source Pollution? A Comparative Perspective*, 42 B.C. ENVTL. AFF. L. REV. 1, 12 (2015).

34. *See* J. Heisler et al., *Eutrophication and Harmful Algal Blooms: A Scientific Consensus*, 8 HARMFUL ALGAE 3, 4 (2008) ("It is generally recognized that there have been more coastal algal blooms, often of greater geographic extent and/or longer duration, with more toxic species observed, more fisheries affected, and higher associated costs from algal blooms in the past decade than in previous decades."); *see also* C.B. Lopez et al., SCIENTIFIC ASSESSMENT OF FRESHWATER HARMFUL ALGAL BLOOMS 9 (2008) (acknowledging that algal blooms have increased within freshwater systems).

35. Heisler et al., *supra* note 34, at 4.

36. Douglas R. Williams, *When Voluntary, Incentive-Based Controls Fail: Structuring a Regulatory Response to Agricultural Nonpoint Source Water Pollution*, 9 WASH. U.J. L. & POL'Y 21, 23-25 (2002).

Fortunately, Garrett Hardin's familiar "commons" framework and basic economics principles related to negative externalities help to highlight some of the factors contributing to this regulatory failure. Among other things, viewing algal bloom challenges through these frameworks reveals the need for stronger federal government involvement in certain settings and a greater emphasis on curbing agricultural runoff pollution to slow the increase of algal blooms and their costly consequences.

Part I of this Article explains how nutrient pollution and climate change have fueled increases in algal blooms in recent years and details how current laws have failed to address this trend. Part II frames certain specific instances of algal blooms as commons tragedies and others as interstate negative externality problems. Part III applies the principles associated with these frameworks to emphasize the unique regulatory challenges that algal blooms create within interstate watersheds, and to argue that a stronger federal approach is needed to stop algal blooms in those settings. Part IV describes specific federal government approaches capable of better addressing the nation's algal bloom risks. Among other things, Part IV advocates for laws that would empower states, whose algal blooms are occurring within interstate watersheds, to hold polluting states responsible for agricultural nonpoint source nutrient pollution that contributes to the problem.

I. THE GROWING ALGAL BLOOM PROBLEM AND ITS CAUSES

Algal blooms impose significant costs on local communities and greater society.[37] Unfortunately, for the reasons discussed below, they are likely to become even more commonplace and severe in the coming years. A major contributor to algal blooms is the introduction of excessive nutrients into water bodies.[38] One significant source of this nutrient pollution is agricultural nutrient pollution, which is not heavily regulated under the Clean Water Act and remains prevalent despite state-level regulatory efforts.[39] Accordingly, new laws that reduce agricultural nutrient pollution levels could be among the most cost-effective and promising means of reversing the nation's trend toward more frequent and severe algal blooms.

A. ALGAL BLOOMS CAUSE SIGNIFICANT DAMAGE

Toxic blooms, often referred to as harmful algal blooms,[40] are an exceptionally pernicious problem that can pose significant threats to human and animal health. The recent water crisis in Toledo was not the first time this hazardous type of algal bloom has imposed substantial adverse impacts on a local economy.[41] The dangers of algal blooms have been known for over 100 years, with

37. *See infra* note 52.

38. Heisler et al., *supra* note 34, at 4.

39. Angelo & Morris, *supra* note 32, at 1004-05.

40. *Harmful Algal Blooms: Tiny Organisms with a Toxic Punch*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/hazards/hab/ (last visited Mar. 3, 2017).

41. *See* Dilwyn J. Griffiths & Martin L. Saker, *The Palm Island Mystery Disease 20 Years On: A Review of Research on Cyanotoxin Cylindrospermopsin*, 18 ENVTL. TOXICOLOGY 78, 78-79 (2003) (explaining how, in 1979, a bloom in Australia released toxins into the local water supply that caused an outbreak of severe "hepatitis-like" illness. The illness was labeled the Palm

extreme cases causing thousands of animal deaths from ingestion of algae-poisoned water.[42] In some cases, large animals have died within minutes of exposure to cyanotoxins produced by algal blooms.[43]

In addition to threatening humans and animals, algal blooms also pose serious risks to the environment. Hypoxia refers to a state of oxygen depletion in a waterbody.[44] Hypoxic conditions can create a "dead zone" where plants, fish, and other animals cannot survive.[45] Hypoxic conditions occur as algal blooms exhaust nutrient supplies and die.[46] The decomposition process uses the available oxygen in the water, leaving nothing for other animals and plants.[47] In the northern portion of the Gulf of Mexico, a 10,250 square mile dead zone covers where the Mississippi and Atchafalaya Rivers enter the gulf.[48] Although this is the largest dead zone in the United States, others exist elsewhere, such as in the Chesapeake Bay and the Florida Everglades.[49] Algal blooms also block sunlight from entering the water column and thereby damage the ecology of the water body.[50] This lack of sunlight kills aquatic plants, which also consume oxygen as they decompose.[51]

For obvious reasons, algal blooms can likewise harm local and state economies.[52] Blooms can be very expensive to treat and prevent. One conservative estimate puts the cost of algal blooms in the United States at over $2.2 billion annually.[53] Algal blooms can diminish property values, necessitate additional

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Island Mystery Disease and hospitalized over 100 children, making it one of the more serious cases of human cyanobacterial poisoning in history).

42. Ian Stewart et al., *Recreational and Occupational Field Exposure to Freshwater Cyanobacteria - A Review of Anecdotal and Case Reports, Epidemiological Studies and the Challenges for Epidemiologic Assessment*, ENVTL. HEALTH, Mar. 24, 2006, at 1, 2-4 (detailing the potential for algal blooms to cause death, including an anecdotal account that blamed an HAB for the death of a teenage boy. The coroner who reviewed the case found that the boy died from accidental ingestion of neurotoxic cyanotoxin. This is the first recorded human death from recreational cyanobacterial exposure in the United States, though there are some questions about the reliability of the coroner's interpretation).

43. *Id.*

44. Angelo & Morris, *supra* note 32, at 1008.

45. *Id.*

46. Linda Breggin & D. Bruce Myers Jr., *Subsidies with Responsibilities: Placing Stewardship and Disclosure Conditions on Government Payments to Large-Scale Commodity Crop Operations*, 37 HARV. ENVTL. L. REV. 487, 496 (2013).

47. *Id.*

48. Angelo & Morris, *supra* note 32, at 1008-09.

49. *Id.*

50. Breggin & Myers Jr., *supra* note 46, at 496.

51. John Manuel, *Nutrient Pollution: A Persistent Threat to Waterways*, 122 ENVTL. HEALTH PERSPECTIVES, no. 11, Nov. 2014, at A304, A305 (2014).

52. *See* Walter K. Dodds et al., *Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages*, 43 ENVTL. SCI. TECH. 12, 16-18 (2009); *see also* Matilde Mereghetti, *Chile Drafts Emergency Plan for Future Algal blooms*, UNDERCURRENT NEWS, (Dec. 8, 2016, 4:32 PM), https://www.undercurrentnews.com/2016/12/08/chile-drafts-emergency-plan-for-future-algae-blooms/ (describing an algal bloom in the Los Lagos region of South America in the Spring of 2016 that destroyed approximately 40,000 metric tons of salmon, costing the salmon industry nearly $600 million).

53. H. Kenneth Hudnell, *The State of U.S. Freshwater Harmful Algal Blooms Assessments, Policy and Legislation*, 55 TOXICON 1024, 1024 (2010) (estimating the cost of harmful algal blooms in the U.S. to be somewhere between $2.2 billion and $4 billion).

funding to protect endangered species, threaten drinking water supplies, interfere with commercial fishing operations, limit local recreation and tourism, and cause a myriad of other problems.[54]

B. ALGAL BLOOMS OCCUR WITH GROWING FREQUENCY

Algal blooms become more frequent as temperatures rise and more nutrients enter water systems.[55] Cyanobacteria, or blue-green algae, can expand to massive proportions[56] and are found in oceans, lakes, the tropics, and in the Earth's poles.[57] These bacterial blooms appear as scum on the water's surface.[58] Algal blooms require warm water[59] and abundant nutrients to grow.[60] As such, global warming and growing levels of added nutrients in water systems create increasingly optimal conditions for algal blooms to occur.[61] For example, scientists project that the number of blooms in Lake Erie alone will double over the next 100 years.[62]

1. Climate Change Exacerbates the Problem of Algal Blooms

Global warming has the potential to encourage algal bloom proliferation in many regions because cyanobacteria reproduction generally occurs best at relatively high temperatures.[63] As the Earth's oldest known oxygen-producing organisms, cyanobacteria are particularly well adapted to survive environmental variations.[64] Additionally, rising water temperatures make it easier for cyanobacteria to accumulate at water's surface throughout the water column, facilitating dense, highly toxic blooms that appear earlier and stay longer.[65]

Carbon dioxide ("CO_2") emissions—a primary contributor to human-induced climate change[66]—further encourage algal blooms because higher rates of CO_2 in the air help blooms reproduce at greater rates.[67] Cyanobacteria require CO_2 to support photosynthesis, and surface blooms can absorb CO_2 directly

54. Dodds et al., *supra* note 52, at 12-18.

55. *Harmful Algal Bloom (HAB)-Associated Illness,* CTRS. FOR DISEASE CONTROL AND PREVENTION, https://www.cdc.gov/habs/index.html (last updated June 1, 2017).

56. Hudnell, *supra* note 53, at 1024.

57. Hans W. Paerl & Jef Huisman, *Climate Change: A Catalyst for Global Expansion of Harmful Cyanobacterial Blooms,* 1 ENVTL. MICROBIOLOGY REP. 27, 32-33 (2009).

58. *Harmful Algal Bloom (HAB)-Associated Illness, supra* note 55.

59. *See id.*

60. Manuel, *supra* note 51, at A305.

61. Gorder, *supra* note 21.

62. *Id.*

63. Paerl & Huisman, *supra* note 57, at 29-30.

64. *Id.* at 27.

65. *Id.* at 29-30 (explaining that water density changes with temperature, with water becoming denser as it becomes colder. Warmer water is less dense and allows dispersed cyanobacteria to float upwards and concentrate on the surface of the water. This process is called vertical stratification. Though vertical stratification in a water body may be a normal part of that ecosystem, warming global temperatures can cause a water body to stratify earlier in the spring, maintain that stratification through the summer, and de-stratify later in the fall. These concentrations of bacteria create blooms that are orders of magnitude more toxic than the surrounding water).

66. *Why does CO2 get most of the attention when there are many other heat-trapping gases?,* UNION OF CONCERNED SCIENTISTS, http://www.ucsusa.org/global_warming/science_and _impacts/science/CO2-and-global-warming-faq.html#.Wa20iTO-L-Y (last updated Aug. 3, 2017).

67. Paerl & Huisman, *supra* note 57, at 30.

from the atmosphere.[68] The growing proportion of CO_2 in the atmosphere provides algal blooms with an increasing supply of CO_2 that competing subsurface plankton species cannot access.[69]

To make matters worse, climate change further stimulates algal blooms by contributing to increased salinity levels in major water bodies.[70] Increased drought, rising seas, and increased use of freshwater for agricultural irrigation have raised salinity levels in numerous water bodies.[71] Higher salinity levels benefit buoyant cyanobacteria by enabling them to more easily rise to the surface.[72] Some species of cyanobacteria are much more tolerant of high salt levels than competing phytoplankton species, giving them an advantage when competing for resources.[73]

Climate change can even promote algal blooms by causing hydrologic and weather changes within watersheds.[74] For example, droughts punctuated by increasingly large storms wash large amounts of nutrients into watersheds, leaving water bodies nutrient rich and relatively undisturbed. This can create the perfect conditions for algal blooms.[75] Accordingly, as climate change worsens, these impacts will continue to exacerbate the problem of increasing algal blooms.

2. Human Nutrient Pollution Provides the Conditions that Algal Blooms Need

As stated above, algal blooms are thriving because of additional nutrients that human activities have introduced into watersheds.[76] Many nutrients, such as phosphorus and nitrogen, are normally found in water and soil, but human activities have significantly increased the levels of these nutrients in lakes and rivers.[77] For example, stormwater runoff from cities and towns carries nutrients into water bodies;[78] treated wastewater from sewers and septic systems causes the addition of nutrients into water bodies;[79] fossil fuels introduce nitrogen into

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68. *Id.*

69. *Id.*

70. *Id.* at 31.

71. *Id.*

72. *See id.* at 29-31 (explaining how higher salinity levels create what is called vertical density stratification. Buoyant cyanobacteria rise to the top of the water column which leads to more toxic blooms).

73. Paerl & Huisman, *supra* note 57, at 31-32.

74. *Id.* at 32.

75. *Id.* (explaining that larger storms create greater surface run-off which carriers more nutrients into the waterbody than smaller storms otherwise might. Furthermore, smaller, more frequent storms flush a water system, which makes cyanobacterial reproduction more difficult. However, long periods of drought interrupt these flushing cycles, leaving a nutrient-rich water body primed for cyanobacterial blooms); *see also* Ben Guarino, *'We've primed the system': Why disgusting toxic blue-green algae blooms seem increasingly common,* THE WASH. POST (Jul. 25, 2016), https://www.washingtonpost.com/news/morning-mix/wp/2016/07/25/weve-primed-the-system-why-toxic-blue-green-algae-blooms-seem-increasingly-common/?utm_term=.ddfbf9cff16d (explaining that severe storms can dredge up nutrients that have been trapped in sediment at the bottom of a water body and release them into the water column).

76. Manuel, *supra* note 51, at A305-06.

77. *Sources and Solutions, supra* note 31.

78. *Id.*

79. *Id.*

the air, which can make its way into a water body;[80] and household products such as detergent, pet waste, and yard fertilizer also contain nitrogen and phosphorus, which eventually make their way into local water systems.[81] However, enormous quantities of manure, fertilizer-laden runoff, and soil erosion make agricultural pollution one of the most significant sources of nutrient pollution in the United States and "one of the greatest environmental challenges of our time."[82]

The EPA has estimated that 28 percent of the nation's rivers and streams have elevated levels of nitrogen and 40 percent have elevated levels of phosphorus.[83] For the same reasons that these nutrients make effective fertilizers for crops, they also promote the growth of aquatic algal blooms.[84] In fact, aquatic plants like algae need far fewer nutrients to grow than terrestrial plants; by a "magnitude of thousands."[85] For example, a single pound of phosphorus can provide enough nutrients to produce up to 700 pounds of algae.[86] While a comprehensive solution to the algal bloom problem would necessarily include steps to curb climate change, reducing nutrient pollution represents a significant step towards preventing future blooms.[87]

C. WHY FOCUS ON AGRICULTURAL NUTRIENT POLLUTION TO ADDRESS ALGAL BLOOMS

Although various forms of human nutrient pollution and climate change contribute to the increased incidence of algal blooms in the United States, targeting agricultural nutrient pollution is arguably the most cost-justifiable means of addressing this problem in the short term. For one thing, reducing nutrient pollution within a single United States watershed is simpler than addressing global warming because no international coordination is required.[88] The efforts of a single state or country to reduce CO_2 emissions are valuable but insufficient to fully tackle the inherently global problem of climate change. In contrast, the causes and impacts of agricultural nutrient pollution within many watersheds in the United States are confined almost exclusively within the country's borders. Accordingly, short-term domestic strategies aimed at reducing nutrient pollution are more likely to successfully reduce algal blooms when compared to the unquestionably important challenge of curbing global greenhouse gas emissions.

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80. *Id.*

81. *Id.*

82. Angelo & Morris, *supra* note 32, at 1003-04.

83. Manuel, *supra* note 51, at A306.

84. *Id.* at A305.

85. Oliver A. Houck, *Cooperative Federalism, Nutrients, and the Clean Water Act: Three Cases Revisited*, 44 ENVTL. LAW REP. NEWS & ANALYSIS 10426, 10430 (2014).

86. *Id.*

87. *See* Gorder, *supra* note 21 (suggesting that nutrient reductions may not be enough to stop algal blooms while climate change continues, but that any algal bloom mitigation strategy should include nutrient pollution reductions).

88. *See, e.g.*, Sewell Chan, *Key Points of the Paris Climate Pact*, N.Y. TIMES, (Dec. 12, 2015) http://www.nytimes.com/interactive/projects/cp/climate/2015-paris-climate-talks/key-points-of-the-final-paris-climate-draft (explaining the complex process that lead to the Paris Climate Accord).

For at least two reasons, new restrictions on agricultural nutrient pollution have greater potential to reduce algal blooms in many regions of the country than regulations of other sources of nutrient pollution. First, among sources of human nutrient pollution, agricultural nutrient pollution is the single greatest contributor of nitrogen and phosphorus into the nation's water bodies.[89] Second, other contributing sources of nutrient pollution are already significantly regulated under existing laws, whereas sources of agricultural nutrient pollution often are not.[90]

1. Agriculture is a Significant Contributor to Nutrient Pollution

As previously stated, agricultural operations are one of the leading sources of nutrient pollution in the United States.[91] Agricultural nutrient pollution has become commonplace throughout the country in part because of the "Green Revolution" of the 1960's.[92] High-yielding varieties of grains like corn, wheat, and rice allowed farmers to produce greater quantities of food as the global population increased.[93] Scientists selectively bred plants to create more efficient, hybridized varieties that matured quicker and could adapt to year-round growing seasons.[94] These crops soon became standard throughout U.S. agriculture.[95]

Unfortunately, hybrid crops only produce their famously high yields when farmers supply them with large amounts of water and fertilizer.[96] The ever increasing amounts of nutrients farmers have provided their crops over time has led to U.S. farms shifting from "nutrient sinks" to "nutrient sources."[97] While it is true that these hybrid grains and fertilization practices resulted in a 150 percent increase in crop production in the past 60 years, they have also introduced enormous amounts of nutrients into water systems, placing serious strains on water quality.[98] Plants only absorb a small percentage of nutrients applied to a field, leaving the rest to make its way into water systems.[99] For example, in the last 50 years, 600 tons of phosphorus were applied to agricultural lands globally,

89. *See infra* § I(C)(1).

90. *See infra* § I(C)(2).

91. See Angelo & Morris, *supra* note 32, at 1005; Williams, *supra* note 36, at 22.

92. William S. Eubanks II, *A Rotten System: Subsidizing Environmental Degradation and Poor Public Health with Our Nation's Tax Dollars,* 28 STAN. ENVTL. L.J. 213, 251 (2009); *see also* Angelo & Morris, *supra* note 32, at 1005-06 (building upon Eubank's research into the Green Revolution).

93. Eubanks, *supra* note 92, at 256.

94. *Id.*

95. *Id.*

96. *Id.* at 252.

97. Angelo & Morris, *supra* note 32, at 1005-06 (explaining how before the Green Revolution, a farm provided the nutrients needed on that farm through fertilizers that were produced on that farm. These included animal manure and "green manure," which were crops that were planted and tilled under to replenish depleted soil. After the advent of the Green Revolution, farmers applied greater amounts of fertilizer to their fields than their farms could produce, making those farms nutrient sources. "What had been a mutually beneficial system in which animal wastes fertilized the crops that fed the animals in a relatively 'closed loop' system, with minimal pollution, became a serious environmental problem").

98. *Id.* at 1006-07.

99. *See id.* at 1005-07.

while only 250 tons of that phosphorus were actually used by the plants.[100] Similarly, agriculture is believed to produce approximately 66 percent of the nitrogen flowing out of the Mississippi River into the Gulf of Mexico's hypoxic dead zone.[101] Fertilizer and animal waste from farms generally contribute more nutrient pollution into United States water systems than other nonpoint sources.[102]

2. Other Significant Sources of Nutrient Pollution are More Heavily Regulated than Agricultural Nutrient Pollution

Moreover, although many sources of human nutrient pollution, such as wastewater treatment plants and stormwater runoff, are federally regulated, agricultural nutrient pollution largely is not.[103] Differing legal approaches to the categorization of nutrient pollution is at least partially to blame for persistently high levels of agricultural nutrient pollution in water bodies throughout the United States.

Sources of nutrient pollution are typically categorized as either point sources or nonpoint sources. A point source is a single identifiable source of pollution, such as contaminated water flowing through a pipe, ditch, ship, or factory.[104] In contrast, nonpoint sources of pollution are dispersed and not easily attributable to a single individual or location.[105] Point sources are regulated under the Clean Water Act, which makes it illegal to discharge a pollutant from a point source into waters of the United States without a National Pollutant Discharge Elimination System ("NPDES") permit.[106] In contrast, nonpoint sources of pollution, such as run-off from farms, are not included under the NPDES regulatory structure.[107] As such, agricultural nonpoint sources of pollution, like agricultural stormwater discharges and irrigation return flows, are specifically exempted from NPDES regulations.[108]

The NPDES system is responsible for successfully reducing nutrient pollution from point sources such as stormwater discharge, wastewater treatment plants, and factories.[109] However, nonpoint source nutrient pollution continues to be the leading impairment of rivers and lakes.[110] In fact, some prominent water law scholars consider nonpoint source pollution to be one of the last major water quality problems in the United States.[111]

Expanding regulation to encompass agricultural nutrient pollution is likely

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100. *Id.* at 1006.

101. *Id.* at 1008.

102. Manuel, *supra* note 51, at A306.

103. *See, e.g.,* 33 U.S.C. § 1342 (2012).

104. *Categories of Pollution: Point Source,* NAT'L OCEANIC & ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/education/kits/pollution/03pointsource.html (last updated July 6, 2017).

105. *Categories of Pollution: Nonpoint Source,* NAT'L OCEANIC & ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/education/kits/pollution/04nonpointsource.html (last updated July 6, 2017).

106. *See* 33 U.S.C. § 1342 (explaining that as a default rule all discharges from point sources require an NPDES permit; only those specifically designated by the Administrator are exempt from this requirement).

107. *Id.* (regulating point source pollution, but not pollution from nonpoint sources).

108. 33 U.S.C. § 1362(14) (2012).

109. Angelo & Morris, *supra* note 32, at 1004.

110. *Id.* at 1009.

111. Craig & Roberts, *supra* note 33, at 10.

to be a more cost-effective policy strategy for reducing algal blooms than is intensifying restrictions on other already heavily regulated pollution sources.[112] Over the years, certain nonpoint sources have come under the regulation of the NPDES program through congressional reclassification.[113] The most significant of which is the reclassification of captured and channeled stormwater that is then channeled or piped as a point source.[114] Industrial and municipal stormwater discharges are now regulated as point sources.[115] Regulatory changes that similarly reclassified at least some types of agricultural nonpoint source pollution are arguably a mere continuation of this trend.

Moreover, because agriculture generally produces more nutrient pollution than other nonpoint sources,[116] more stringent regulation could significantly reduce the number and severity of algal blooms.[117] Some water quality programs have already tried to offset agricultural nutrient pollution by increasing the regulatory burden on other sources, but such programs will ultimately fail to successfully address algal bloom problems.[118] Expanding regulation to cover agricultural nutrient pollution would be a more appropriate and promising way of responding to these challenges.[119]

Of course, any new pollution restrictions affecting the United States agricultural industry should be tailored so as not to unjustifiably injure this important and vulnerable sector of the nation's economy. Farmers face difficult choices when determining how much fertilizer to apply to a field. In many instances, uncertain soil and weather conditions can affect crop yields. Adding too much nitrogen to soil increases the likelihood that nitrogen will escape into the environment. However, under-fertilizing can cut into crop yields, tempting some farmers to over-fertilize to protect against their own downside risks.[120] These downside risks are significant for many farmers. Under the standard of a farm's Operating Price Margin, a farm is within the high-risk "critical zone" when its operating profits comprise less than ten percent of its gross cash income.[121] In

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112. *See e.g.*, RENA STEINZOR & EVAN ISAACSON, COUNTDOWN TO 2017: FIVE YEARS IN, CHESAPEAKE BAY TMDL AT RISK WITHOUT EPA ENFORCEMENT 25-27 (Ctr. for Progressive Reform 2016) (http://progressivereform.org/articles/Chesbay2017Countdown1601.pdf) (explaining how, in the context of the Chesapeake Bay, states have relied on greater reductions in nutrient pollution from point sources like wastewater treatment plants. Because of this, the Chesapeake Bay watershed boasts some of the largest and most advanced wastewater treatment plants in the country. However, the watershed faces a problem of decreasing returns. Technological improvements will ultimately be unable to compensate for the impact of unregulated sources of nutrient pollution).

113. Craig & Roberts, *supra* note 33, at 10-11.

114. *Id.*

115. *Id.* at 11.

116. Manuel, *supra* note 51, at A306.

117. *See e.g.*, STEINZOR & ISAACSON, *supra* note 112, at 6-7 (illustrating this idea within the context of the Chesapeake Bay).

118. *Id.*

119. *Id.* at 4 (referring to agricultural nutrient pollution within one watershed as the "largest pollution source and the most promising and cost-effective sector for future reductions").

120. *See* MARC RIBAUDO ET AL., U.S. DEP'T OF AGRIC., ERS NO. 127, NITROGEN IN AGRICUL- TURAL SYSTEMS: IMPLICATIONS FOR CONSERVATION POLICY 4 (2011) (explaining problems specific to nitrogen pollution, but which may be extrapolated to nutrient pollution in general).

121. Robert Hoppe, *Profit Margins Increase with Farm Size*, U.S. DEP'T OF AGRIC. (Feb. 2, 2015), https://www.ers.usda.gov/amber-waves/2015/januaryfebruary/profit-margin-increases-with

2013, sixty-nine percent of U.S. farms were in this critical zone.[122] Many only remain profitable by relying on other income to support the farm.[123]

Given that so many farmers operate under razor-thin margins, imposing substantial new costs on farmers through nutrient pollution regulations could place a significant burden on an already fragile industry. It is worth remembering that most agricultural emitters are not amoral polluters, but are merely rational actors in an imperfect system. Although additional regulation of agriculture may be justifiable to reduce the incidence and severity of algal blooms, a heavy-handed and punishing approach that puts many farmers out of business would be far less defensible. Any new laws aimed at curbing agricultural nutrient pollution would thus need to adequately account for their potential impacts on farmers and farming communities.

D. CURRENT FEDERAL NUTRIENT POLLUTION REGULATION IS INADEQUATE

Without question, federal regulations under the Clean Water Act fail to adequately address agricultural sources of algae-causing nutrient pollution. Although the NPDES program does not regulate agricultural nutrient pollution, the Clean Water Act does provide a kind of proxy nonpoint source regulation through Total Maximum Daily Load ("TMDL") requirements.[124] Under the Clean Water Act, states must set water quality standards for water bodies such as rivers, lakes, and streams to serve as a check on point source NPDES permits.[125] If a state fails to set an acceptable standard, the EPA is authorized to set the standard for the state.[126] In setting water quality standards, a state determines the designated uses of a waterbody, like fishing, industry, or agriculture, and then determines the level of pollutants it can sustain without damaging those uses.[127] If point source permits are insufficient to maintain the water body's water quality standards, the state will define the waterbody as impaired.[128] The state must then set a TMDL for each pollutant that impairs the water body.[129] A TMDL is the total maximum daily load of a pollutant that a water body can support and still meet its water quality standards.[130]

Although the federal government can compel states to create TMDLs, it cannot dictate how a state actually enforces those limits.[131] Instead, the state is free to determine how its TMDL limits are distributed among point source and nonpoint source polluters.[132] In *Pronsolino v. Nastri*, the Ninth Circuit specifically held that TMDLs do not create a federal mechanism to control nonpoint

-farm-size/.

122. *Id.*

123. *Id.*

124. 33 U.S.C. § 1313(d) (2012)

125. 33 U.S.C. § 1313(a).

126. *Id.*

127. Angelo & Morris, *supra* note 32, at 1012.

128. *Id.* (citing to Pronsolino v. Nastri, 291 F.3d 1123, 1127 (9th Cir. 2002)).

129. Pronsolino v. Nastri, 291 F.3d 1123, 1127 (9th Cir. 2002).

130. *Id.* at 1127-28.

131. Donald W. Stever et al., *Effluent Standards and Limitations*, 2 L. OF ENVTL. PROT. § 13:75 (2017).

132. *Id.*

source pollution.[133] Rather, the federal government uses the "threat and promise of federal grants to the states to accomplish this task."[134] In *City of Arcadia v. U.S. Environmental Protection Agency*, the court similarly held that a TMDL "does not, by itself, prohibit any conduct or require any actions," and "each TMDL represents a goal that may be implemented by adjusting pollutant discharge requirements in individual NPDES permits or establishing nonpoint source controls."[135]

E. STATE REGULATION OF NONPOINT SOURCE NUTRIENT POLLUTION IS INCONSISTENT AND HAS NOT ADEQUATELY ADDRESSED THE PROBLEM

Because the Clean Water Act largely leaves agricultural nutrient pollution regulation to the states, and since not all states regulate agricultural nutrient pollution, this pollution source continues to contribute to the nation's growing algal bloom problem.[136] Regulation of nonpoint source pollution remains the prerogative of the states.[137] Within the U.S., each state has developed its own nonpoint source regulatory scheme, resulting in fifty different nonpoint source management programs.[138] Indeed, states often elect not to regulate nonpoint sources.[139] Despite years of state regulation of nonpoint source pollution, agricultural nonpoint source pollution continues to be a major barrier to achieving state and national water quality goals.[140]

II. FINDING A SOLUTION TO ALGAL BLOOMS USING ECONOMIC THEORIES

Framing some algal blooms and excessive agricultural nutrient pollution as commons tragedies can provide insight into how to prevent future algal blooms. This Part II frames some types of algal blooms as commons tragedies when the actions of agricultural producers harm all water users within a given water basin, including the agricultural producers themselves. Section D of this Part II then draws an important distinction between algal blooms that fit nicely into a tragedy of the commons framework and those that are more accurately framed as general interstate negative externality problems. This distinction between these two classes of algal blooms, which is based primarily on the type of water basin in which the bloom occurs, is crucial to tailoring effective policy strategies for each class.

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133. *Pronsolino*, 291 F.3d at 1126.
134. *Id.* at 1126-27.
135. City of Arcadia v. U.S. Envtl. Prot.. Agency, 265 F. Supp. 2d 1142, 1444 (N.D. Cal. 2003).
136. See Williams, *supra* note 36, at 23.
137. Robin K. Craig, *Local or National? The Increasing Federalization of Nonpoint Source Pollution Regulation*, 15 J. ENVTL. L. & LITIG. 179, 186 (2000).
138. Craig & Roberts, *supra* note 33, at 12.
139. *Id.* at 2 (describing the current situation as a "de facto fifty-state experiment in regulation—or, often, non-regulation" of nonpoint source pollution).
140. See Williams, *supra* note 36, at 22.

A. THE TRAGEDY OF THE COMMONS

When there is open access to a scarce and rival resource, individual resource users are often incentivized to overuse the resource rather than protect it for the benefit of all users.[141] This familiar set of incentives can ultimately lead to the destruction or degradation of the shared resource, along with significant associated social costs.[142] Garrett Hardin famously highlighted this phenomenon in his seminal 1968 article, *The Tragedy of the Commons*.[143] In his article, Hardin described an example of a commonly-held field used by several herdsmen for grazing.[144] The herdsmen individually internalized the benefits of letting their animals graze on the field, while distributing the costs of overgrazing among all members of the group.[145] Hardin observed that overgrazing would ultimately lead to a ruined field that could not support any of the herdsmen's cattle.[146] Hardin noted that the herdsmen, as rational actors, were nonetheless "locked into a system" compelling them to add cattle to their herd until they destroyed the resource.[147] Each rational, self-interested herdsman in this example did not factor in the costs of overgrazing on the field when choosing how many animals to graze because this cost was borne collectively by the group.[148] In these situations, Hardin famously noted, "[f]reedom in a commons brings ruin to all."[149]

Hardin's metaphor is cited widely in efforts to justify environmental regulation.[150] Hardin refers to his herdsman story as a tragedy because the consequence of rational, self-interested action in these scenarios is collective ruin. Commonly shared resources are similarly said to present what are often referred to as collective action problems:[151] individual parties generally do not engage in behavior aimed at preserving a common resource if they believe all other parties will continue to destroy it.[152]

B. ALGAL BLOOMS AS A RESULT OF COMMONS TRAGEDIES

In watersheds confined within a single state, some algal blooms occur, in part, from patterns of behavior among agricultural producers that mirror the behavior of herdsmen from Hardin's Tragedy of the Commons. Farmers who

141. Carol M. Rose, *Rethinking Environmental Controls: Management Strategies for Common Resources*, DUKE L.J. 1, 3 (1991).

142. *Id.*

143. Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968).

144. *Id.*

145. *Id.*

146. *Id.*

147. *Id.*

148. *Id.*

149. Hardin, *supra* note 135, at 1244.

150. ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION 9 (1990) (Ostrom cites multiple authors including Heilbroner, Ehrenfeld, Carruthers, and Stoner who opined that some external control is necessary to avoid destruction of natural resources).

151. Barton H. Thompson, *Tragically Difficult: The Obstacles to Governing the Commons*, 30 ENVTL. L. 241, 244 (2000).

152. Rose, *supra* note 141, at 3 (describing the conundrum facing a fisherman who wants to preserve a hatchery because the benefits of restocking the hatchery or abstaining from taking more fish will mostly go to the other fishermen).

over-fertilize and allow excess nutrients to flow into the watershed are acting in their own best interest; they reap the benefits from adding more fertilizer to their crops, but do not bear the whole cost of polluting the common resource, the watershed.[153] When an algal bloom occurs downstream from the farmers overloading the watershed with nutrients, they assume the injury along with the rest of the citizens of the state. These harms include the human health, environmental, and economic harms borne by the state. Such cases present a justification for state regulation of the farmers because they should mutually agree to the "mutual coercion" that protects their interests.[154] Because these algal blooms in state contained watersheds fit within a tragedy of the commons framework, tried and tested solutions to similar commons problems could potentially prevent future algal blooms.

C. OVERCOMING INTRASTATE COMMONS PROBLEMS INVOLVING AGRICULTURAL NUTRIENT POLLUTION

Established principles for responding to commons problems can be helpful in evaluating potential means of reducing agricultural nutrient pollution and algal blooms within state-contained watersheds. Hardin suggested that it is generally possible to overcome the tragedy of the commons only through (1) privatization of the resource or (2) strong governmental regulation of the resource.[155] Elinor Ostrom opined that the optimal policy approach often varies depending on the situation, but sometimes local regulation by the resource users themselves is the best solution.[156] These proposed solutions are analyzed below in the context of nutrient pollution. It is worth noting that the solutions considered in this section apply only to those algal blooms occurring fully within intrastate watersheds and thus fit more squarely within the tragedy of the commons paradigm.

1. Hardin's Recommended Solutions

In cases of consumptive resource use, such as the field in Hardin's metaphor, privatization is often the best method to protect the resource.[157] Privatization places the costs of overexploitation on the resource users, ideally causing them to act to ensure the resource is not depleted.[158] One often-overlooked aspect of the privatization solution is the necessary administrative cost of dividing up a common resource.[159] Division of a natural resource inevitably leads to inequitable wealth distributions and high decision-making and enforcement costs.[160] Moreover, privatization is not a practicable means of reducing nutrient pollution because the waters receiving pollution in a watershed cannot be realistically privatized.

In the context of pollution, some scholars suggest that the only method of

153. Hardin, *supra* note 143, at 1244.
154. *Id.* at 1247.
155. *Id.* at 1245.
156. OSTROM, *supra* note 150, at 13.
157. *See* Hardin, *supra* note 143, at 1244; OSTROM, *supra* note 150, at 13.
158. Hardin, *supra* note 143, at 1247.
159. OSTROM, *supra* note 150, at 12.
160. *Id.*

overcoming the tragedy of the commons is through coercive laws or taxes.[161] For example, Hardin suggested taxation can encourage resource users to stop destructive behavior.[162] Due to the high complexity of measuring agricultural nonpoint source pollution and the unpredictable biology of algal blooms, such command and control regulations are costly. For example, the agency assigned to set limits on nutrient pollution must determine the water body's assimilative capacity, or the amount of pollution a water body can naturally assimilate without harming the water body.[163] These determinations can be costly.[164] Furthermore, agencies can only effectively regulate when they are sufficiently staffed and have the ability to efficiently enforce agency rules.[165]

Of the two solutions suggested by Hardin, government regulation is more likely to prevent algal blooms than privatization.[166] Regulation of nutrient pollution could happen in several ways, including taxes on nutrient inputs and requiring best management practices.[167]

Hardin's work suggests that actors caught within the tragedy of the commons are locked within a vicious, inevitable cycle.[168] Traditionally proposed solutions suggest that strong centralized government or privatization of the resource are absolutely necessary to overcome the tragedy of the commons.[169] However, some scholars believe a third option exists.[170] Based on research of small communities that have successfully managed common resources,[171] scholars, such as Elinor Ostrom, believe that some local resource users can overcome the tragedy of the commons through local, self-regulation.[172]

2. Ostrom's Insights on Overcoming Commons Problems in Smaller, Contained Systems

In some locations in which small communities share a scarce common resource, individual resource users have successfully overcome commons problems and preserved commonly-held resources.[173] In her book, *Governing the Commons*, Elinor Ostrom recognized some of the important, common characteristics that these small communities share.[174] For a local community to efficiently govern its common resource, the community is generally small, stable,

161. Hardin, *supra* note 143, at 1245.
162. *Id.*
163. Kenneth J. Warren, *Total Maximum Daily Loads: A Watershed Approach to Improved Water Quality*, SJ028 A.L.I.-A.B.A. 193, 198 (2003).
164. OSTROM, *supra* note 150, at 10.
165. *Id.*
166. *See* Hardin, *supra* note 143, at 1245-46 (noting that privatizing waters that receive nutrient pollution is not a practical solution because of the constantly flowing nature of these resources. Government regulation, however, can be used to influence the behavior of resource users to ensure protection of the common resource.).
167. *Id.* at 1247.
168. Elinor Ostrom et al., *Revisiting the Commons: Local Lessons, Global Challenges*, 284 SCIENCE 278, 278 (1999).
169. Hardin, *supra* note 143, at 1245-46.
170. Ostrom, *supra* note 168, at 278.
171. *Id.* at 278, 281-82.
172. *Id.*
173. OSTROM, *supra* note 150, at 58-102.
174. *Id.* at 89-90.

has well-delineated resource boundaries, enjoys relatively small negative externalities, and the dynamics of the resource are well understood.[175]

Recent scholarship has expanded on this research, highlighting two essential elements.[176] First, successful group management requires a high perception of risk associated with unified management of the resource.[177] For example, when a group does not perceive that a lack of cooperation among group members will harm members of that group, even initial restraint by some group members will ultimately fail to preserve the resource.[178] Second, successful group management is inhibited as group size increases.[179] Thus, a community is most likely to successfully regulate the commonly-held resource when the group size is small and the perception of risk is high.

Although self-regulation by resource users presents the most efficient method to overcoming a tragedy of the commons, it is likely not feasible on the scale of most algal blooms. This article has referenced algal blooms that occur in watersheds contained within one state and blooms that occur in interstate watersheds.[180] The tragedy of the commons problem only exists for state-contained watersheds.[181] In most watersheds, there are too many resource users for effective regulation of nutrient pollution by resource users without government intervention. Additionally, the perception of risk is unlikely to be high enough among agricultural nutrient polluters unless they are near the algal bloom.

3. Watersheds Contained within One State Fit a Tragedy of the Commons Framework

Hardin's proposed regulatory approaches have the potential to effectively reduce intrastate algal blooms because the scenarios under which the blooms occur fit within a tragedy of the commons framework. The perverse incentives of Hardin's tragedy exist within intrastate watersheds because the costs of pollution are internalized within the state.[182] Contrast this with an interstate watershed where an upstream state externalizes the costs of pollution to a downstream state and is ultimately unharmed by the downstream state's actions.[183]

175. NIVES DOLSAK & ELINOR OSTROM, THE COMMONS IN THE NEW MILLENNIUM: CHALLENGES AND ADAPTATION 12-13 (2003).

176. Francisco C. Santos & Jorge M. Pacheco, *Risk of Collective Failure Provides an Escape from the Tragedy of the Commons,* 108 PROC. FROM THE NAT'L ACAD. OF SCI. 10421, 10421-10425 (2011).

177. *Id.* at 10421-22.

178. *Id.* at 10421.

179. *Id.* at 10423.

180. *See supra* Sections II.B, II.C.

181. *See supra* Section II.B; *infra* Section II.D.

182. Hardin, *supra* note 143, at 1244-45.

183. *Compare id. with* N. GREGORY MANKIW, ESSENTIALS OF ECONOMICS 196 (6th ed. 2012) (The key to Hardin's tragedy is that all herdsmen were harmed by their communal actions. But an interstate negative externality problem does not fit this paradigm. Say, for example, one herdsman in Hardin's example decided to give up animal husbandry and build a foundry on the commons. In time, the smelter's foundry emits fumes that kill all the grass in the field and his neighbor's animals starve. The neighbor bears all the costs of the smelter's actions, but the smelter is free to continue polluting. Furthermore, even if the smelter's fumes do not kill his neighbor's herds, his smelting operation is not hurt in the slightest by overgrazing. The relationship between the smelter and the herdsmen is not a tragedy of the commons, but a negative externality problem, as is pollution in an interstate watershed. But, in cases where a watershed is entirely contained

States with water basins contained entirely within that state have more success controlling algal blooms caused by nutrient pollution.[184] This is because a watershed contained within one state is under its singular sovereign authority. The state is incentivized to regulate nutrient pollution because the costs of algal blooms are borne within that state. Furthermore, the state has regulatory control over polluters within its borders, which provides for complete and comprehensive control of nutrient pollution within the state.

In summary, commons scholarship is a useful lens for viewing algal bloom problems because it illuminates shortcomings in current nutrient pollution regulation and outlines the need for federal regulation in certain contexts. When a commons problem is fully contained within one state, successful reduction of algal blooms can occur through state regulation of nutrient pollution. However, state regulation is less likely to successfully regulate nutrient pollution in interstate watersheds.

D. SOME ALGAL BLOOMS DO NOT FIT WITHIN THE TRAGEDY OF THE COMMONS PARADIGM

In contrast, nutrient pollution in interstate watersheds does not present a neatly-contained tragedy of the commons problem. Interstate nutrient pollution does not harm all resource users equally. A negative externality is created when downstream water users bear the cost of the upstream pollution while upstream users remain unaffected.[185] A market failure exists when society subsidizes a cost that is not borne by the upstream polluter.[186] For agricultural producers, the costs to one that over-fertilizes his field are low, but the costs to the downstream user who must deal with the algal bloom are much higher.[187] In the absence of some deterrent for the upstream agricultural producer, they will continue to pollute above the socially optimal level.[188] Because interstate water basins extend beyond state borders, state regulators who declare waters within their state impaired do not have the authority to reach some of the polluters, making state regulation insufficient.[189] This negative externality problem requires federal intervention.

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within one state, the costs and benefits of pollution are all borne by the same group - the state, as is the case in a tragedy of the commons).

184. *See* Catharine Gross & James D. Hagy III, *Attributes of Successful Actions to Restore Lakes and Estuaries Degraded by Nutrient Pollution,* 187 J. ENVTL. MGMT., 122, 127-28 (2017) (comparing the success of programs to reduce nutrient pollution in water bodies. Tampa Bay in Florida and Bass Lake in Wisconsin met their goals for nutrient pollution reduction whereas some other states did not meet their nutrient reduction goals).

185. *See* MANKIW, *supra* note 183, at 196.

186. *Id.* at 196, 198.

187. *See, e.g.,* Gauri-Shankar Guha & Rodney Wright, *A Simulation of the Economic Impacts of Negative Externalities from Farm Management Practices in Northeast Arkansas,* J. BUS. ADMIN. ONLINE, Spring 2016, at § (I)(A).

188. *See, e.g.,* N. Gregory Mankiw, *Smart Taxes: An Open Invitation to Join the Pigou Club,* 35 E. ECON. J., 14, 16 (2009) (discussing negative externalities in terms of carbon dioxide emissions into the atmosphere).

189. Alexandra Campbell-Ferrari, *Managing Interstate Water Resources: Tarrant Regional and Beyond,* 44 TEX. ENVTL. L.J. 235, 235-236 (2014).

1. How Interstate Algal Blooms Present Negative Externality Problems

State regulation is unlikely to reduce algal blooms occurring from negative externality problems in interstate watersheds because states lack the authority to govern out-of-state polluters. Water bodies in the United States are considered common resources because citizens have open access to their use.[190] In a hypothetical stream within an interstate water basin, a person could pollute the stream with algae causing nutrients, but be so far from the scene of an algal bloom that she would never bear the cost of her actions. All the nonpoint source polluters contribute to an impaired water, but the effects of the impaired water are disproportionately felt by downstream states. Downstream states can set TMDLs for impaired waters within their borders, but they lack authority to enforce these limits against upstream polluters in other states.

Nonpoint source nutrient pollution shifts the cost of pollution to downstream water users in the form of a toxic algal bloom. The paradigm of a negative externality is a better framework for analyzing nutrient pollution in interstate watersheds, because often the polluters in interstate watersheds do not bear the cost of overloading the watershed with nutrients. Rational action does not lead to common ruin;[191] instead, it contributes to ruin for downstream users. Because not all polluters are located where an algal bloom occurs, federal regulators are better situated than state regulators to reduce algal blooms in interstate watersheds.

2. General Strategies for Overcoming Negative Externality Problems

Regulators generally attempt to address negative externality problems either by: (1) proscribing certain behaviors; or (2) using market forces to influence behavior.[192] The first method is commonly referred to as command and control regulation. This form of regulation reacts to negative externalities by punishing actions that create them.[193] In the case of algal blooms, regulators could attempt to stop the problem by prohibiting the discharge of nutrient pollution into waterbodies. Unfortunately, it is virtually impossible to completely prohibit all pollution.[194] Therefore, regulators can choose between limited proscription of destructive behavior or market manipulation. For example, regulators can force actors to internalize the cost of externalities by taxing activities that create negative externalities.[195]

Regulation of negative externality-causing actions relies on the theory that such regulation will correct a market failure and provide the best outcome for society.[196] The optimal level of nutrient pollution will not lead to algal blooms, because algal blooms impose a high cost on society.[197] In the context of the

190. *See generally* Stephen D. Osborne et al., *Laws Governing Recreational Access to Waters of the Columbia Basin: A Survey and Analysis,* 33 ENVTL. L. 399, 409-10 (2003).

191. *Contra* Hardin, *supra* note 143, at 1244.

192. N. GREGORY MANKIW, ESSENTIALS OF ECONOMICS 202 (7th ed. 2015).

193. *Id.*

194. *Id.*

195. *Id.* at 202-03.

196. *Id.* at 202.

197. Houck, *supra* note 85, at 10430.

tragedy of the commons, in theory the resource users should agree to be governed because their actions create algal blooms that harm the resource users.[198] In interstate water basins, the resource users would not similarly agree to such governance, because others bear the costs of their pollution. The solutions to negative externalities attempt to shift the cost of pollution back on to the polluters. In the context of interstate water basins, only the federal government has the authority to regulate polluters in interstate water basins.

III. CRAFTING FEDERAL REGULATION TO REDUCE INTERSTATE ALGAL BLOOMS

In cases where watersheds are completely contained within a state, the cooperative federalism approach of the Clean Water Act may be sufficient to address the problem of algal blooms. In states where the costs that algal blooms impose within a state are high, those costs are likely to lead the state to regulate nutrient pollution within its borders. However, interstate watersheds require more federal regulation than currently exists. Because the costs and benefits of nutrient pollution within interstate watersheds are not borne equally among states, polluting states that do not bear those costs are unlikely to regulate nutrient pollution. Until effective federal regulations govern interstate watersheds, the increased incidence of algal blooms is likely to continue.

A. THE COOPERATIVE FEDERALISM APPROACH OF THE CLEAN WATER ACT CAN WORK IN STATE-CONTAINED WATERSHEDS

Some states have begun to combat the problem of algal blooms by regulating nonpoint source nutrient pollution.[199] Since 1972 when Congress made a deliberate decision to leave regulation of nonpoint source nutrient pollution to the states, the U.S. has seen decades of state-based attempts to solve this problem.[200] Encouragingly, some states have taken significant steps to regulate nonpoint source nutrient pollution.[201] A survey conducted by the Environmental Defense Fund found that nineteen states impose mandatory, enforceable requirements on agricultural nonpoint source pollution.[202] In these nineteen states, the problem of agricultural nonpoint source nutrient pollution is being solved through state regulation, albeit slowly. But why? And can this same progress be expected in the remaining thirty-one states?

States that regulate agricultural nonpoint source pollution do so because algal blooms pose a risk to their individual state economies.[203] However, it is unlikely that risk is felt universally among states. States that regulate nonpoint source nutrient pollution have "significant and politically salient non-agricultural interests in water quality."[204] These interests are particularly important because

198. Hardin, *supra* note 143, at 1247.

199. Craig & Roberts, *supra* note 33, at 2.

200. *See id.* at 2.

201. *Id.* at 2-3.

202. *Id.* at 12 (noting that even these mandatory programs widely vary in the extent of their regulation, with some programs imposing stricter regulations than others).

203. *Id.* at 13 (explaining, inter alia, that states that regulate agricultural nonpoint source pollution have significant non-agricultural interests in water quality).

204. Craig & Roberts, *supra* note 33, at 13 (outlining six common factors among states that

they allow the state to overcome opposition to agricultural nonpoint source regulation that comes from entrenched agricultural interests.[205]

In cases where a watershed is entirely contained within a single state, the costs of algal blooms are primarily felt within that state. As such, in-state disbursement of costs should sufficiently promote effective nutrient pollution regulation. For example, Florida is a major agricultural state, ranking seventh among agricultural exporting states in 2011.[206] In that year, agricultural exports from Florida valued above $4 billion.[207] However, Florida's tourism industry is valued at $76 billion dollars, a significant portion of which is tied to freshwater recreation, such as sport-fishing and other tourism.[208] The state government implemented significant regulation after determining that agricultural nonpoint source pollution posed a threat to those interests.[209] Factoring in the broader impacts of the pollution borne within the state, regulators seemingly concluded it worthwhile to regulate pollution sources rather than clean up watersheds after the fact.[210] Other states that regulate agricultural nonpoint source pollution are similarly situated; they bear most of the broader costs of nutrient pollution within their own state boundaries.[211]

B. THE COOPERATIVE FEDERALISM OF THE CLEAN WATER ACT HAS FAILED INTERSTATE WATERSHEDS

In contrast, some polluting states may not have the incentives needed for cooperative federalism to effectively reduce nutrient pollution in interstate watersheds if the costs of algal blooms are not borne by them. Interstate nutrient pollution problems allow for actors in some states to shift the cost of their actions on to other states. Federal regulation is necessary to solve this negative externality problem. Otherwise, algal blooms will continue to appear in interstate watersheds.

States that do not bear most of the costs of the algal blooms they cause lack incentives to regulate nutrient pollution. Providing us with a salient example is the Gulf of Mexico's hypoxic dead zone.[212] While dead-zone border states like Louisiana, Texas, and Mississippi could strengthen nutrient pollution regulations as the problem worsens, other upriver, agricultural states like Iowa will not perceive the risks from algal blooms and hypoxia in the same way. Such is the

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actively regulate agricultural nonpoint source pollution: (1) each state regulates nutrient pollution that is exempt from the national NPDES system; (2) agriculture is a significant element of the state economy; (3) each program seeks to solve problems outlined in the CWA; (4) each state has significant non-agricultural interests in water quality; (5) each program has been identified as at least partially effective; and (6) each state approaches regulation in its own unique way).

205. *See id.* at 1, 13.

206. *Id.* at 13.

207. *Id.*

208. *Id.*

209. *Id.* at 14.

210. Craig & Roberts, *supra* note 33, at 14.

211. *See id.* at 16–24 (outlining the specific situations of Oregon and Wisconsin agricultural and water quality interests).

212. *See* Sarah White, *Gulf Hypoxia: Can a Legal Remedy Breathe Life Into the Oxygen Depleted Waters?*, 5 DRAKE J. AGRIC. L. 519, 519–24 (2000) (providing, inter alia, an overview of the conflict that nutrient pollution in the Mississippi River creates between upriver agriculture and downriver fishing and coastal interests).

weakness of the Clean Water Act's cooperative federalism approach. By leaving regulation of nonpoint source nutrient pollution to the states, the Clean Water Act sets interstate watersheds up to fail.

To solve the problem of algal blooms in interstate watersheds, the federal government must either regulate nutrient pollution directly or somehow shift the costs of pollution back onto the agricultural nonpoint sources in polluting states. Only through that approach can nutrient pollution be curtailed at the source. Agricultural nonpoint sources that pollute interstate watersheds will bear the cost of pollution, regardless of their proximity to the resulting algal bloom.

IV. SPECIFIC POLICY STRATEGIES FOR ADDRESSING NEGATIVE EXTERNALITIES IN INTERSTATE NUTRIENT POLLUTION

Although the peculiarities of waterbodies would tend to favor local and state control of watershed management over federal control, state regulation does not adequately address the interstate externality problems associated with agricultural nonpoint source nutrient pollution. The lack of federal nonpoint source regulation allows actors in some states to shift the costs of their actions onto actors in other states, creating negative externalities that are difficult for states to address. However, creating a workable federal-level response to this problem is deceptively difficult. Merely expanding the reach of the Clean Water Act's NPDES program is unlikely to be successful, and enacting national programs that mirror successful state programs ignores the unique nature of individual watersheds. States can effectively regulate intrastate water basins. An ideal approach to interstate water basins will allow for state control as much as possible, yet allow for federal intervention when more localized governance fails.[213]

A. CHIPPING AWAY AT THE AGRICULTURAL LOOPHOLE IN THE CLEAN WATER ACT'S NPDES PROGRAM

One of the most initially attractive solutions to the problem of interstate agricultural nutrient pollution and algal blooms is to remove the exemption of agricultural discharges from the Clean Water Act. Increased federal control of point source pollution through NPDES regulation has produced results.[214] However, bringing nonpoint source pollution within regulation of the NPDES program could be problematic. Agricultural nonpoint source pollution is difficult to measure.[215] The amount of nutrient pollution that leaves a field varies with the weather, soil conditions, geology, etc.[216] This is fundamentally different from the measurement of point source pollution, where measurement occurs

213. *See* Rose, *supra* note 141, at 12-14.

214. Angelo & Morris, *supra* note 32, at 1004.

215. *See* MARC. O. RIBAUDO ET AL., U.S. DEP'T OF AGRIC., ERS NO. 782, ECONOMICS OF WATER QUALITY PROTECTION FROM NONPOINT SOURCES 21 (1999) (explaining that nonpoint source pollution is prohibitively expensive to measure because the "amount and quality of runoff leaving a field depend not only on factors that can be measured, such as the technology used and the use of variable inputs, but also on factors such as rainfall that vary daily and are difficult to predict").

216. *Id.*

at the point of discharge.[217] In addition to nonpoint source pollution, agricultural operations produce point source nutrient pollution that is exempt from regulation under the Clean Water Act.[218] These include agricultural return flows,[219] agricultural stormwater discharges,[220] and *potentially* drainage tiles, ditches, and pipes.[221] These sources of nutrient pollution do not share the same measurement difficulties as nonpoint sources, and thus, could fit under NPDES program regulation as point sources.[222]

The definition of a point source has been extended in the past to cover previously unregulated sources of pollution.[223] The most significant of which was the reclassification of municipal or industrial stormwater discharges as point sources.[224] This brought municipal and industrial stormwater discharges under the regulation of the NPDES program.[225] In theory, current unregulated point sources like agricultural return flows, agricultural stormwater drainage, and other drainage could fit under the NPDES program in the same way. However, an examination of each should occur to protect against an unintentional increase of nutrient pollution.

1. Regulating Agricultural Stormwater Discharges under the NPDES Program

Previous expansions of the NPDES program took care to avoid creating perverse incentives for those operating under them.[226] In 1987, Congress's Stormwater Amendments to the program recognized that channeled, piped, or captured stormwater should be regulated as a point source under the Clean Water Act.[227] These amendments contained a few important exceptions. For example, under the Stormwater Amendments, NPDES permits are not required for stormwater that is diverted around mines or oil and gas operations that does not contact wastes from those operations.[228] This keeps these mining and fossil fuel operations from becoming regulated as point sources of pollution.[229] If stormwater diversions were regulated as point sources while runoff was not, a mining operation would be incentivized to avoid any regulatory burden by allowing undiverted runoff to carry pollutants from the operation into a

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217. *Id.*

218. 33 U.S.C. § 1362(14) (excepting agricultural return flows and stormwater drainage from the definition of regulated point sources under the Clean Water Act).

219. *Id.*

220. *Id.*

221. *See* Complaint at ¶¶ 1, 10, Bd. of Water Works Tr. v. Sacramento City Bd. of Supervisors, No. 5:15-cv-04020 (N.D. Iowa Mar. 16, 2015) (pending litigation alleging that drainage systems that remove nitrogen from soil and introduce it into a river are required, inter alia, to obtain an NPDES permit under the Clean Water Act).

222. *See* RIBAUDO, *supra* note 215, at 21 (similar to traditional point source discharge, the nutrients from these sources can be measured at the point of discharge).

223. Craig & Roberts, *supra* note 33, at 10.

224. *Id.* at 10-11 (explaining how piped, channeled, or captured stormwater, when discharged, is now classified as a point source falling under regulation under the NPDES program).

225. *Id.*

226. Craig, *supra* note 137, at 191-92.

227. Craig & Roberts, *supra* note 33, at 10.

228. Craig, *supra* note 137, at 191-92.

229. *Id.*

water body.[230] The pollution in this situation would be worse than any incidental nutrients picked up through a diversion. This same rationale applies to agricultural stormwater discharges.

Regulating agricultural stormwater discharges under the NPDES program would unfortunately be likely to create perverse incentives. Under the Stormwater Amendments, agricultural stormwater discharges are also exempt from NPDES regulation.[231] Removing this exemption could create the same problems that would come from stormwater regulation of a mine. Instead of diverting stormwater away from farm fields, farmers would be incentivized to allow runoff to flow through fields. Undiverted stormwater would then pick up fertilizers and nutrients along the way. Thus, even though NPDES regulation of agricultural stormwater discharges would seem to make sense, it ultimately could make the problem of agricultural nutrient pollution worse.

2. Regulating Agricultural Return Flows under the NPDES Program

As stated above, regulating agricultural return flows under the NPDES system could reduce agricultural nutrient pollution, but it is undesirable because it could create incentives for inefficient water use. The return flow exemption was created primarily to protect farmers in western states who rely on irrigation for their water needs.[232] Farmers claimed that NPDES permits for return flows discriminated against farmers in arid western states where water scarcity made ditches and drains vital.[233] Indeed, requiring NPDES permits for return flows could create perverse incentives for farmers in a similar way to agricultural stormwater regulation. In western states, water shortages are a real danger.[234] However, requiring NPDES permits for return flows could create disincentives for farmers to return unused and sorely needed water back to the system.[235] Unless the federal government were to regulate both agricultural point sources and agricultural nonpoint sources, it would be almost impossible to craft regulation to avoid this problem. Thus, regulation of agricultural return flows is better left to the states to ensure that a comprehensive approach is taken.

B. MANDATORY BEST MANAGEMENT PRACTICES

Mandating best management practices ("BMPs") to reduce agricultural runoff nutrient pollution is unlikely to reduce nutrient levels enough to stop algal blooms. BMPs can have a surprisingly large influence on common behavior.[236]

230. *Id.*

231. 33 U.S.C. § 1342(l)(1).

232. Andrew C. Hanson & David C. Bender, *Irrigation Return Flow or Discrete Discharge? Why Water Pollution from Cranberry Bogs Should Fall Within the Clean Water Act's NPDES Program*, 37 ENVTL. L. 339, 352 (2007).

233. *Id.*

234. Brian C. Howard, *Worst Drought in 1,000 Years Predicted for American West*, NAT'L GEOGRAPHIC (Feb. 12, 2015), http://news.nationalgeographic.com/news/2015/02/150212-megadrought-southwest-water-climate-environment/ (citing studies that predict an over 80% chance of a "megadrought" in the American West by 2100. This drought would be expected to last 35 years or longer).

235. Hanson & Bender, *supra* note 232, at 352.

236. *See* David Zaring, *Best Practices*, 81 N.Y.U. L. REV. 294, 323-24 (2006).

The major drawback to BMPs, however, is that they encourage common practices instead of the most effective practice.[237] Federal statutes direct agencies to consider best practices in many different areas of regulation.[238] Despite this drawback to BMPs, they are still used by many agencies because they have relatively low administrative costs and they successfully influence behavior. The EPA currently seeks to incentivize the use of best management practices to limit nonpoint source pollution.[239]

1. Success of BMPs for State-Contained Water Basins

BMPs have been successful at reducing nutrient pollution at the state level when the target water body is contained entirely within a state. Success can be attributed to the small number of users who can recognize the importance of protecting the resource.[240] The most common BMPs for reducing phosphorous from agricultural runoff are buffer zones, which involves the application of fertilizer below the soil and utilization of cover crops.[241] Although best management practices can be useful for reducing nitrogen pollution from agricultural runoff for waterbodies contained within a single state, the program is less effective at the federal level.

2. Failure of BMPs in Interstate Water Basins

Although BMPs have changed the behavior of farmers at the state level, they are unlikely to have a similar impact at the federal level. Under section 1329 of the Clean Water Act, states are required to create an assessment report for navigable waters within their jurisdiction that will not meet water quality standards due to nonpoint source pollution.[242] States must also create management programs that must identify the BMP the nonpoint sources will employ and the method the state will use to ensure nonpoint sources adopt these BMPs.[243] This is the current strategy that the Clean Water Act uses to reduce nonpoint source pollution before the state declares a water to be impaired. The advantages to BMPs are flexibility and lower administrative costs for the government and agencies.[244] Despite the perceived advantages of BMPs for reducing nonpoint source nutrient pollution, algal blooms continue to appear with

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237. *Id.* at 298.

238. *See id.* at 296 (citing multiple statutes that direct agencies to consider best practices, including 7 U.S.C. § 6711(c) (2012) for agricultural programs); *see also* Arnold W. Reitze, Jr., *A Century of Air Pollution Control Law: What's Worked; What's Failed; What Might Work*, 21 ENVTL. L. 1549, 1597–98 (1999) (describing how the EPA created guidelines in 1976 to lower greenhouse gas emissions that allowed factories to build tall smokestacks to meet emissions requirements in lieu of emission limitations. Ultimately, the guidelines led to a massive increase in the number of tall smokestacks but no reduction in greenhouse gas emissions because factories chose to build taller smokestacks, rather than pay for more expensive, but also more effective pollution controls).

239. 33 U.S.C. § 1329(b)(2)(A)–(B).

240. *See* DOLSAK & OLSTROM, *supra* note 175, at 12–13.

241. Marion Renault, *Ohio State researchers team up to fight algae blooms*, THE COLUMBUS DISPATCH (Dec. 18, 2016), http://www.dispatch.com/content/stories/local/2016/12/18/ohio-state-researchers-team-up-to-fight-algae-blooms.html.

242. 33 U.S.C. § 1329(a)(1)(A).

243. *Id.* § 1329(b)(2)(A)–(B).

244. Zaring, *supra* note 236, at 299.

growing frequency, an indication that nutrient pollution remains a problem for navigable waters that are required to implement BMPs.

Because the adoption of BMPs is voluntary in most states, BMPs do not present a realistic solution to curbing the proliferation of algal blooms. Under the CWA, the adoption of BMPs is voluntary, which leads to inconsistent results.[245] Recognizing that there might be little incentive for some states to require BMPs from non-point sources, the EPA currently offers funds for the continuation of best management programs when states can show that the BMPs used are effective at meeting the state's water quality goals.[246] Although the BMPs that have been adopted appear to be effective at reducing nutrient pollution,[247] they are generally too expensive for most farmers and not enough farmers utilize the practices.[248] Farmers are reluctant to adopt expensive practices, especially when there is often no guarantee that the BMPs will lead to a reduced risk of algal blooms.[249]

Ultimately, BMPs are not the best solution for reducing nutrient pollution in interstate water basins. Although some of these solutions have been effective at reducing nutrient levels in agricultural runoff, BMPs alone do not address the issue of the assimilative capacity of the water body. If nutrient pollution reductions are not targeted at meeting the assimilative capacity of the water body, then algal blooms could continue to proliferate despite reductions of nutrient pollution. The practices are meant to reduce nutrient pollution, but even if all farmers adopt the best common practices for reducing nutrient pollution, that might not be enough to reduce nutrient loads enough to stop algal blooms.

C. TAXES AND INCENTIVES

Taxes could influence farmers to reduce nutrient application to their fields, leading to less nutrient pollution and fewer algal blooms. If the cost of fertilizers containing nitrogen and phosphorous were raised by a tax, farmers would be induced to purchase and use less fertilizer. This form of market correcting tax is commonly known as a Pigouvian tax, drawing its name from Arthur Pigou.[250] An input Pigouvian tax artificially raises the cost of the nutrients, forcing the producer to internalize the cost.[251] Input Pigouvian taxes present the only feasi-

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245. Debra L. Donahue, *The Untapped Power of the Clean Water Act Section 401*, 23 ECOLOGY L.Q. 201, 284 (1996).

246. Zaring, *supra* note 236, at 329 (citing to 33 U.S.C. § 1329(h)).

247. *See* Hector German Rodriguez et al., *Environmental and Economic Impacts of Reducing Total Phosphorous Runoff in an Agricultural Watershed*, 104 AGRIC. SYS. 623, 627 (2011) (finding that all ten of the best management practices tested in the Lincoln Lake basin in Arkansas were effective in reducing phosphorous from agricultural runoff); *but see generally* Emily DeMarco, *Measuring 'Best' Practices to Curb Farm Pollution*, INSIDE SCIENCE (Sep. 23, 2016), https://www.insidescience.org/news/measuring-best-practices-curb-farm-pollution (analyzing the effectiveness of best management practices utilized in the Chesapeake Bay watershed).

248. *See* Renault, *supra* note 241.

249. Glenn Sheriff, *Efficient Waste? Why Farmers Over-Apply Nutrients and the Implications for Policy Design*, 27 REV. AGRIC. ECON. 542, 550 (2005).

250. MANKIW, *supra* note 183, at 203.

251. *See* Robert E. Martin, *Externality Regulation and the Monopoly Firm* J. PUB. ECON. 347, 360-61 (1986); *see also* Punam Parikh et al., *Application of Market Mechanisms and Incentives to Reduce Stormwater Runoff: An Integrated Hydrologic, Economic and Legal Approach*, 8

ble method of shifting the cost of nutrient pollution back onto the polluter, because pollution from nonpoint sources is difficult to measure and track.[252] Because the cost shifting for nutrient pollution is difficult to track in agricultural runoff, the only way to raise the cost of pollution for the agricultural producer is by increasing the cost of the nutrient inputs.

1. Potential for Pigouvian Success

Pigouvian taxes can incentivize famers to fertilize at the optimal level for society.[253] One of the benefits of a nutrient input tax over command and control regulation is the ability to shift the cost of pollution back on to the polluter at a relatively low cost to the government while avoiding the difficult issue of identifying and quantifying pollution from nonpoint sources.[254] If the regulator could set the cost of the tax at the level of the external cost of the pollution, then the farmers would pollute at the socially optimal level.[255] In addition, a Pigouvian tax would have the added benefit of raising revenue that either could be used to lower other taxes or to clean up existing algal blooms.

A tax on nutrient inputs can be compared to the carbon tax, which is one of the most popular solutions for reducing greenhouse gas emissions among economists.[256] In the absence of a deterrent tax, people have no incentive to reduce carbon emissions because the cost of carbon emissions are borne by society, creating a negative externality problem.[257] Increasing a tax on carbon emissions would encourage the development of cleaner energy and less consumption of fossil fuels. Similarly, a tax on nutrients should encourage farmers to develop alternative methods of fertilizing crops because the cost of fertilizing at the same level will be too expensive.

2. Inevitable Failure of Pigouvian Taxes in Reducing Algal Blooms

However, farming operations are so diverse and complex that a universal Pigouvian tax on nutrient inputs is unlikely to effectively reduce algal blooms without causing unintended consequences. One of the major deficiencies of a nutrient input tax is that it universally raises the cost of nutrient fertilizer on all farmers. Therefore, all farmers must spend more to fertilize their crops, regardless of how much algae-causing nutrient pollution they discharge. Some crops will require far less nitrogen and phosphorous than other crops. Additionally, some farms are in locations where natural buffer zones or low water tables lead to less nutrients in agricultural runoff. Targeting a tax so that it only applies to polluting actors, would significantly raise the administrative cost of

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ENVTL. SCI. & POL'Y 133, 138 (2005) (explaining how behavior can be influenced in a cost-effective manner by setting the stormwater charge at the marginal aggregate cost to the watershed).

252. Sheriff, *supra* note 249, at 547-48.

253. MANKIW, *supra* note 183, at 203.

254. *See* Mankiw, *supra* note 188, at 16-17; *see also* Sheriff, *supra* note 249, at 550.

255. MANKIW, *supra* note 183, at 203-04.

256. *See* Brian Andrew, *Market Failure, Government Failure and Externalities in Climate Change Mitigation: The Case for a Carbon Tax*, 28 PUB. ADMIN. & DEV. 393, 393-94 (2008).

257. Mankiw, *supra* note 188, at 16.

the tax.[258] Allowing the tax to apply universally would be unfair and could encourage less than optimal fertilization by farmers.

Additionally, determining the appropriate price of a Pigouvian tax is difficult. Ideally, the cost of the increase in nutrient inputs should equal the cost borne by society.[259] This is difficult to measure. Finally, many farmers operating under tight margins would be unable to afford the higher cost of fertilizers. Due to this increased cost of setting the appropriate price for the tax and the inability of the tax to target polluting nonpoint sources, the Pigouvian tax is not the best solution for reducing nutrient pollution from agricultural producers.

D. EDUCATIONAL PROGRAMS

Because it is possible that some farmers simply do not know that overloading of nutrients in waterbodies can lead to algal blooms, another potential means of combating the growing incidence of algal blooms is to implement more educational programs concerning nutrient pollution for farmers. Educational programs can inform farmers about a potentially unknown externality, which could cause farmers to factor the cost of pollution into their decision-making.[260] Educating farmers about the negative effects of their actions will also have the effect of increasing their perception of risk to the common resource. An increased perception of risk could encourage more responsible behavior to protect the common resource. When the perception of risk is high and there is a small number of resource users, it is possible for the common resource to be preserved by local self-regulation.[261]

Educational programs can be an attractive method to encourage better nutrient management because the administrative costs are low and no action is compelled from farmers.[262] Although there are theories that suggest that educational programs can be an effective method for overcoming negative externalities, these programs by themselves will not be enough to stop nutrient pollution and the resulting algal blooms.

1. Existing Theory Supporting the Use of Educational Programs

Under the theory regarding self-regulation of common resources, a common resource can be protected by the resource users if there are a small number of resource users and the perception of risk to the resource is high among resource users.[263] An educational program describing the dangers of nutrient pollution raises the perception of risk for farmers because it explains how nutrient pollution causes algal blooms. Despite the raised perception of risk, it is unlikely that polluters will perceive the risk to them as high enough for them to stop polluting. There is also empirical evidence that suggests that educational

258. *Id.* at 20 (describing how a gasoline tax is not a perfect Pigouvian response for driving congestion because some roads are more congested than others, but the tax increases the cost of gasoline for all drivers).

259. MANKIW, *supra* note 183, at 203.

260. Marc A. Ribaudo & Richard D. Horan, *The Role of Education in Nonpoint Source Pollution Control Policy*, 21 REV. AGRIC. ECON. 331, 335 (1999).

261. Santos & Pacheco, *supra* note 176, at 10421-23.

262. Ribaudo, *supra* note 260, at 332, 340.

263. Santos & Pacheco, *supra* note 176, at 10421-23.

programs, coupled with other management strategies, can effectively encourage the adoption of environmentally friendly practices.[264] However, these educational programs are generally only effective when the reduction in nutrient loading also leads to increased profitability for the farmers.[265]

2. Why Educational Programs for Nutrient Management Fail at Correcting Negative Externalities in Nutrient Pollution

Unfortunately, educational programs alone are not likely to sufficiently alter farmers' nutrient loading practices to prevent major algal blooms. Particularly for interstate waterways that span many states, it is possible for nonpoint source polluters to be so far removed from resulting algal blooms that it is unlikely that farmers will change polluting behavior even if they know that it could be causing problems downstream. Due to the complexity of nutrient pollution and the number of potential nonpoint source polluters, it is difficult to prove which farmers contribute to nutrient pollution and algal blooms.[266] For similar reasons, an educational program in California aimed at influencing farmers to adopt more efficient nitrate management practices has not been effective despite four years of efforts.[267] In general, educational programs only have the desired effect of influencing behavior to adopt better management practices if the new practice will also be more profitable for the farmer or if the information indicates to the farmer that water quality is impaired on his property.[268] Because the success of educational programs is dependent on how farmers will react to them, educational programs are not a good solution to slow the growing incidence of algal blooms.

E. FORCING POLLUTING STATES TO BEAR THE COST OF NUTRIENT POLLUTION

Even interstate, basin-wide TMDLs will not stop algal blooms in interstate waters until affected states or the EPA are empowered to compel polluting states to curb nutrient pollution. State-led, nonpoint source regulation is not stopping algal blooms in interstate watersheds.[269] Many water basins cover multiple states, which means that pollution in one state obviously has adverse impacts on downstream states. Consequently, many state-based programs for the regulation of nutrient pollution have failed. Basin-wide TMDLs could internalize the externalities created by this market failure. However, TMDLs need a mechanism to allow the federal government to force polluting states to comply with the TMDL requirements.[270] Until states or the EPA have enforcement power over

264. Ribaudo, *supra* note 260, at 332 (citing to Darrell J. Bosch et al., *Voluntary Versus Mandatory Agricultural Policies to Protect Water Quality: Adoption of Nitrogen Testing in Nebraska*, 17 REV. AGRIC. ECON. 13, 15 (1995)).

265. RIBAUDO, *supra* note 120, at 25-26; *see also* Ribaudo, *supra* note 260, at 336.

266. Ribaudo, *supra* note 260, at 338.

267. *Id.* at 337-38.

268. *Id.* at 340.

269. *See, e.g.*, STEINZOR & ISAACSON, *supra* note 112, at 4 (where the Chesapeake Bay's interstate TMDL has still not ended nutrient pollution because of a lack of enforcement).

270. *Id.* at 2.

TMDLs, even interstate TMDLs cannot stop algal bloom-causing nutrient pollution.

1. The Chesapeake Bay TMDL and the Weaknesses of Interstate TMDLs under Current Law

As the interstate TMDL for the East Coast's Chesapeake Bay shows, such interstate TMDL policies are only effective if sufficient enforcement mechanisms and powers are in place. The Chesapeake Bay TMDL is an ambitious attempt at basin-wide pollution control, but thus far it has not been as effective as hoped. The creation of an interstate TMDL in the Chesapeake Bay watershed and certain other watersheds is an important step in combating nutrient pollution and algal blooms. However, unenforced interstate TMDLs are still lacking necessary enforcement power and are thus limited in their effectiveness.[271]

The Chesapeake Bay watershed is so massive that effective regulation of nutrient pollution necessitates an interstate approach.[272] The bay spans over 64,000 miles and is one of the most productive water bodies in the world.[273] Five major rivers and over 100,000 streams drain into the bay from a watershed that spans six states.[274] The Chesapeake Bay is both gigantic and shallow, which allows for the incredible diversity of life that exists in the bay.[275] But shallow water also keeps nutrients, pollution, and heat from flushing out to sea.[276] Not surprisingly, the Chesapeake Bay is vulnerable to algal blooms and hypoxia.[277] The health of the Bay became such a dire problem that in 2010, the EPA worked with states within the watershed to create an interstate TMDL.[278]

The Chesapeake Bay TMDL is the largest water restoration project in the world[279] and was created to regulate pollution levels for the District of Colombia and the six states found within its water basin.[280] This TMDL was created through the joint efforts of the EPA and the states within the water basin.[281] Spanning seven major jurisdictions, it is the most complex TMDL in the country.[282] The TMDL sets nitrogen and phosphorous pollution allocations for the

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271. *Id.* at 2-3 (asserting that the Chesapeake Bay TMDL is destined to fail without EPA enforcement).

272. *See* Houck, *supra* note 85, at 10426 (explaining how the EPA determined that the TMDL needed to be set for the water basin based on 25 years of failed efforts to clean up the bay through the normal process of allowing the six states within the watershed to set TMDLs).

273. *Ocean Facts: Where is the Largest Estuary in the U.S.?*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/facts/chesapeake.html (last visited Jan. 19, 2017).

274. Shana C. Jones, *Making Regional and Local TMDLs Work: The Chesapeake Bay TMDL and Lessons from the Lynnhaven River*, 38 WM. & MARY ENVTL. L. & POL'Y REV. 277, 281 (2014).

275. *Id.* at 281-82.

276. *Id* at 282.

277. *Id.*

278. Lewis C. Linker et al., *Development of the Chesapeake Bay Watershed Total Maximum Daily Load Allocation*, 49 J. AM. WATER RES. ASS'N 986, 986 (2013).

279. Jones, *supra* note 274, at 293.

280. Houck, *supra* note 85, at 10441.

281. U.S. ENVTL. PROT. AGENCY, CHESAPEAKE BAY TMDL EXECUTIVE SUMMARY ES-3 (2010).

282. Jones, *supra* note 274, at 293.

water basin states and requires the EPA to work with the states to develop watershed implementation plans.[283] These plans were originally developed by the states and approved or modified by the EPA.[284] The watershed implementation plans describe which technologies the states have committed to implement to meet the pollution allocations for the watershed.[285]

The Chesapeake Bay TMDL is an example of how interstate cooperation is needed to set realistic pollution reduction goals. The interstate TMDL in the Chesapeake Bay sets an impressive standard for interstate TMDLs because it engaged individual actors, such as nonpoint source polluters, and states in the effort to create a basin-wide TMDL.[286] The Chesapeake Bay TMDL can serve as a model of federal and state collaboration for other interstate water basins. It is only through this goal setting and planning process that interstate water bodies will set meaningful goals for reducing nutrient pollution and preventing future algal blooms. The more difficult aspect of using interstate TMDLs to reduce nutrient pollution will be the issue of enforcing state compliance with these goals.

Despite the creation of an ambitious interstate TMDL for the Chesapeake Bay, states within the watershed will probably not meet their 2017 interim goals without enforcement of the standards set by the TMDL.[287] Some states within the watershed have made progress by further reducing nutrient pollution from already regulated sources.[288] However, increased reductions of point sources will ultimately be insufficient to meet the goals of the TMDL, and unregulated nonpoint source pollution will still need to be curtailed to meet them.[289] For example, Virginia and the District of Columbia relied heavily on state-of-the-art wastewater treatment plant pollution control but have not regulated any other sources of nutrient pollution.[290] Meanwhile, in Pennsylvania, the agricultural sector alone contributes over twenty-five percent of the nitrogen pollution in the watershed, which is more than all other pollution sectors in the state of Virginia.[291] Without an enforcement mechanism to compel states like Pennsylvania to act, the Chesapeake Bay TMDL will be unable prevent future algal blooms in the once pristine Chesapeake Bay.[292]

2. Empowering Affected States to Compel Polluting States' TMDL Compliance

Strengthening the TMDL program to allow the EPA or affected states to compel action by polluting states could be one means of providing the additional power needed to reduce future algal blooms in interstate water basins.

283. U.S. ENVTL. PROT. AGENCY, *supra* note 281, at ES-1.
284. *Id* at ES-2.
285. *Id* at ES-1.
286. Jones, *supra* note 274, at 315.
287. STEINZOR & ISAACSON, *supra* note 112, at 1-2.
288. *Id.* at 3.
289. *Id.*
290. *Id.*
291. *Id.* at 2.
292. *See* STEVER, *supra* note 131, at § 13:75 (explaining that enforcement of nonpoint source compliance with TMDL limits is left to the states); *see also* STEINZOR & ISAACSON, *supra* note 112, at 2-3.

Because TMDLs are watershed-based, they are better tailored to address the negative externality problems that contribute to algal blooms in these settings by holding all actors within a watershed accountable. TMDLs are created in collaboration with states, which gives voice to state interests and concerns. However, a state's failure to meet its target goals should result in federal enforcement of those goals. Alternatively, states could be empowered to compel action by bringing claims against polluting states that have agreed to TMDL levels set through an agreement between the states. This would provide a means for affected states to shift the externalities created by upstream, pollution states back onto those actors.

Creating an interstate TMDL enforcement mechanism would reduce algal bloom-causing nutrient pollution in interstate watersheds to more cost-justifiable levels. For the same reasons that states attempt to balance their own costs and benefits when regulating nutrient pollution within their borders, strengthening interstate TMDL enforcement could promote more cost-effective and optimal regulation when interstate watersheds are involved.

IV. CONCLUSION

Nutrient pollution from agricultural nonpoint sources is contributing to a growing algal bloom problem in the United States. In recent years, inadequate regulation of nonpoint sources has been a major factor that has led to an increased quantity and severity of algal blooms. This growing nutrient pollution problem is largely attributable to conditions creating what legal scholars often refer to as commons tragedies, general externality, and collective action problems. Because agricultural nonpoint sources lack sufficient incentives to curb algae-causing pollution, stronger government intervention is necessary to address this issue and reduce future algal blooms.

The distinction between algal blooms that occur in interstate watersheds and those that occur within state-contained watersheds is important in addressing these challenges. Among other things this distinction helps to explain why some states have been successful at regulating nutrient pollution whereas others have not. Algal blooms in state-contained watersheds can often be framed as commons tragedies, where all those who contribute to the problem also directly suffer its consequences. In these settings, it should generally be possible for state level pollution regulation to emerge that is capable of addressing the issue because the harms of the pollution are contained within the state. In contrast, algal blooms that occur in interstate watersheds represent a broader negative externality problem. State governments are often not as motivated to effectively regulate in these instances because many of the harms resulting from the pollution are suffered outside the state where the pollution occurs. Accordingly, federal government regulation is necessary to regulate nutrient pollution in these watersheds.

One potential means for more effective regulation of nutrient pollution in interstate watersheds would be to increase the federal government's authority to enforce interstate TMDLs. The Chesapeake Bay TMDL illustrates why such an approach is necessary in these circumstances. Other interstate watersheds could benefit from utilizing a similar cooperative approach for setting interstate TMDLs that also empowered individual states to bring actions against out-of-state actors when interstate pollution is a material contributor to algal blooms. Through thoughtfully-designed policies tailored to algal blooms' unique characteristics, policymakers can hopefully curb the growth of these blooms and protect our precious waterways and water bodies for many generations to come.