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The 'Lungs of our Land:' Deforestation and Climate Change's Destructive Circular Relationship

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THE 'LUNGS OF OUR LAND': DEFORESTATION AND CLIMATE CHANGE'S DESTRUCTIVE CIRCULAR RELATIONSHIP

I. Introduction

> "Forests are the lungs of our land, purifying the air and giving fresh strength to our people."
>
> —Franklin D. Roosevelt[1]

The quote above is an excerpt from former President Franklin D. Roosevelt's (President Roosevelt) speech in 1935, when he accepted the Society of American Foresters' Forestry Medal for contributions to forestry management.[2] Eighty-one years later, the scientific community is still discovering the significance of his words.[3] Current studies empirically show the complex way the 'lungs of our land' control local and global climates.[4] This research mainly revolves around trees' ability to control climate through things, like precipitation and carbon storage.[5] According to an eco-climatologist at NASA's Jet Propulsion Laboratory, in discussing this new research, "'This area is a frontier,'" . . . "'but a frontier because

1. *See Franklin D. Roosevelt and Conservation: Volume One*, U.S. General Services Administration, *http://www.nps.gov/parkhistory/online_books/cany/fdr/part2.htm* (last visited Jan. 21, 2016) (transcribing Roosevelt's speech).

> A forest is not solely so many thousand board feet of lumber to be logged when market conditions make it profitable. It is an integral part of our natural land covering, and the most potent factor in maintaining nature's delicate balance in the organic and inorganic worlds. In his struggle for selfish gain, man has often heedlessly tipped the scales so that nature's balance has been destroyed, and the public welfare has usually been on the short-weighted side.

Id.

2. *See id.* (showing Roosevelt's appreciation for being recognized).

3. *See* Tim McDonnell, *Could wildfires undermine California's grand climate goals?*, Grist (May 5, 2015), http://grist.org/climate-energy/could-wildfires-undermine-californias-grand-climate-goals/ (explaining deforestation's effects on climate). The United States National Park Service's top climate change scientist, Patrick Gonzales, advocates for the study of forestry management and its effect on carbon emissions. *Id.* Louis Blumberg, Director of California's Nature Conservancy Climate Program, also advocates for a look at the deforestation and climate relationship, stating, "Deforestation 'is a new part of the puzzle,' . . . "'[b]ut it's essential.'" *Id.*

4. *See* Jim Robbins, *Deforestation and Drought*, The New York Times (Oct. 9, 2015), http://www.nytimes.com/2015/10/11/opinion/sunday/deforestation-and-drought.html?_r=0 (describing forests' place in ecosystem).

5. *See id.* (asserting eco-climatology's potential).

it's difficult, not because it's neglected.' "[6] Exploring this frontier is especially salient today due to increasing rates of deforestation and the compounding effects of climate change.[7] Globally, at the current rate of deforestation, the world's rainforests could completely disappear in the next one hundred years.[8] Nationally, the United States is also struggling with deforestation.[9] For example, Louisiana is losing coastal wetlands at "approximately one football field an hour."[10] As a result, the 'lungs of our land' are ceasing to function.[11] These lost forests no longer store carbon in their limbs or control global precipitation.[12] Rather, by their death, these forests' legacies of releasing their previously stored carbon contribute to climate change.[13] The United Nations (U.N.) Intergovernmental Panel on Climate Change estimates deforestation contributes to about seventeen percent of all greenhouse gas emissions.[14] This contribution to greenhouse gases is more than the contribution of the global transportation sector, and only second to the contribution of the energy sector.[15]

The effects of climate change and deforestation do not occur in isolation of one another.[16] On the contrary, there is a circular relationship between the loss of forests and climate change.[17] Deforestation exacerbates climate change through the release of the

6. *See id.* (justifying scientific community's slow movements on eco-climatology).

7. *Deforestation: Here's what you need to know about the warming planet, how it's affecting us, and what's at stake.*, NATIONAL GEOGRAPHIC, http://environment.nationalgeographic.com/environment/global-warming/deforestation-overview/ (last visited Jan. 21, 2016) (illuminating stakes of deforestation).

8. *See id.* (explaining how deforestation occurs and effects).

9. For a discussion of areas in the United States harmed by deforestation, see *infra* note 10 and accompanying text.

10. *See* Steve Zwick, *Study Sees $1.6 Billion for Blue Carbon in Louisiana Wetlands*, ECOSYSTEM MARKETPLACE (Feb. 23, 2015), http://www.ecosystemmarketplace.com/articles/study-sees-1-6-billion-blue-carbon-louisiana-wetlands/ (asserting loss of coastal wetland).

11. For a discussion of the effects of deforestation, see *infra* notes 91-119 and accompanying text.

12. For a description of the complex consequences of increased deforestation, *see infra* notes 91-119 and accompanying text.

13. For a discussion of how forests can contribute to climate change, see *infra* notes 91-119 and accompanying text.

14. *About REDD+*, UN-REDD PROGRAMME, http://www.unredd.net/about/what-is-redd-plus.html (last visited Feb. 4, 2016) (detailing effects of deforestation).

15. *Id.* (detailing amount of carbon released in comparison to other sectors).

16. For a discussion of deforestation and climate change's circular relationship, see *infra* notes 91-11067 and accompanying text.

17. For a description of deforestation and results of climate change, *see infra* notes 91-147 and accompanying text.

lost forests' stored carbon, which then contributes to the greenhouse gases that produce climate change.[18] But climate change also exacerbates deforestation because it causes global temperatures to rise.[19] The Earth's average temperature has increased one and half degrees Fahrenheit in the past one hundred years, and it will only continue to rise.[20] This rising average temperature catalyzes devastating droughts and wildfires, which destroy forests.[21] The increased rate of deforestation causes more greenhouse gases to enter the atmosphere, in turn exacerbating climate change, compounding the antibiosis, and perpetuating the destructive circular relationship between the two.[22]

In response to this devastating cycle, the United States' federal and state governments, as well as the U.N., are working to enact laws and regulations to protect the world's forests.[23] First, state governments are working to incentivize their citizens to maintain, and properly manage, privately owned forests through eco-services payments.[24] Second, the federal government created the Conservation Reserve Program (CRP), which rents land from private owners to rehabilitate and return forests to their original eco-system.[25] Lastly, the U.N. maintains the REDD+ and UNREDD programs, which distribute aid to less developed nations in exchange for forestry regulation and rehabilitation programs.[26] In this article, Part I addresses deforestation rates in the United States and around the world.[27] Part II analyzes how this deforestation exacerbates climate change.[28] Part III addresses how climate change aggravates defor-

18. For an in-depth discussion of carbon release, see *infra* notes 91-101 and accompanying text.

19. For an in-depth discussion of how climate change increases deforestation rates, see *infra* notes 121-147 and accompanying text.

20. *Climate Change: Basic Information*, EPA, http://www3.epa.gov/climatechange/basics/ (last updated Sept. 29, 2016) (describing climate change's current effects).

21. For a full discussion of the intersection of drought, wildfires, and climate change, see *infra* notes 121-147 and accompanying text.

22. For an in-depth discussion of carbon release, see *infra* notes 91-101 and accompanying text.

23. For a detailed discussion of government programs, see *infra* notes 154-212 and accompanying text.

24. For an at-length discussion of state programs, see *infra* notes 186-212 and accompanying text.

25. For a detailed discussion of federal programs, see *infra* notes 154-185 and accompanying text.

26. For a detailed discussion of U.N. programs, see *infra* notes 213-233 and accompanying text.

27. *See infra* notes 38-59 and accompanying text.

28. *See infra* notes 91-119 and accompanying text.

estation.[29] Lastly, Part IV presents the steps already taken to mitigate deforestation and what steps should follow.[30]

II. BACKGROUND

> "Only when the last tree has died and the last river been poisoned and the last fish been caught will we realize we cannot eat money."
>
> —Cree Indian Proverb[31]

This section addresses national deforestation in terms of historical and present-day statistics.[32] Next, it focuses on areas of the United States that face the most destructive instigators of deforestation, such as invasive species infestations, drought, and forest fires.[33] Finally, it addresses global deforestation rates.[34] This section primarily focuses on the worst offenders of deforestation and their contribution to global greenhouse gas emissions.[35]

A. National Deforestation

In 1630, United States' forests comprised an estimated land area of 1,023 million acres, or about forty-six percent of the total land area; contrastingly, in 2012, forests comprised 766 million acres, or about thirty-three percent of the total land area.[36] Most of the destruction occurred from 1850 to 1910, when Americans cut down an average of thirteen square miles of forest every day for fifty years.[37] Since 1910, however, forest area has remained stable.[38]

29. *See infra* notes 121-147 and accompanying text.

30. *See infra* notes 154-233 and accompanying text.

31. *Native American Indian Wisdom*, UNITEDEARTH, http://www.unitedearth.com.au/tipiwisdom.html (last visited Jan. 21, 2016) (reporting Native American proverbs).

32. For more information on specific statistics surrounding deforestation, see *infra* notes 38-49 and accompanying text.

33. For a review of various natural and unnatural causes of deforestation, see *infra* notes 39-49 and accompanying text.

34. For a further discussion on deforestation's global scale and how prevalent it truly is, see *infra* notes 50-59 and accompanying text.

35. For more information on what causes the highest percentages of deforestation, see *infra* notes 50-59 and accompanying text.

36. *See U.S. Forest Resource Facts and Historical Trends*, UNITED STATES DEPARTURE OF AGRICULTURE (Aug. 2014), http://www.fia.fs.fed.us/library/brochures/docs/2012/ForestFacts_1952-2012_English.pdf (analyzing U.S. forests statistics).

37. *See id.* at 7 (explaining historical deforestation).

38. *See id.* (describing deforestation trends). "Stable forest area, however, does not mean that the character of the forest has not changed. In addition to reversions to and from agriculture and more intensive land uses like urban devel-

Forests are still affected by human manipulation, however, including urbanization and agriculture.[39]

Further, deforestation rates are not uniform across the United States.[40] Different regions are affected disproportionately by invasive species, drought, and fire.[41] In the West, activity of the southern pine beetle, an invasive species, has been at historically high levels throughout the past twenty years.[42] Additionally, infestation rates intensify during times of drought.[43] For example, in California, trees are more susceptible to infestation because of the long drought.[44] Consequently, there has been a severe increase in tree mortality.[45] In a letter to the United States Agriculture Society, California Governor Edmund G. Brown (Governor Brown) stated, "California is facing the worst epidemic of tree mortality in its modern history. A crisis of this magnitude demands action on all fronts."[46] Furthermore, this large-scale tree mortality increases the risk of severe forest fires.[47] In response, Governor Brown declared a state of emergency and requested federal action, asserting the magnitude of the tree die off was "beyond the control of the services, personnel, equipment and facilities of any single county . . . or city and require the combined forces of a mutual aid region."[48] This request demonstrates the severity of American tree loss due to natural causes.[49]

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opment, forests respond to human manipulation, aging and other natural processes." *Id.*

39. *See id.* (analyzing U.S. forests statistics). Furthermore, an average of two million acres are planted each year. *Id.*

40. *See id.* at 8-9 (displaying deforestation rates by region).

41. For a further discussion of regional effects of deforestation, see *infra* notes 42-48 and accompanying text.

42. *See U.S. Forest Resource Facts and Historical Trends*, *supra* note 36, at 30-33 (discussing U.S. forests statistics). Finding seventy-seven million acres of U.S. forests are at potential risk of twenty-five percent or higher mortality because of insects and disease during the next fifteen years. *Id.* Some invasive species include: southern pine beetle, spruce budworm, western spruce budworm, and the gypsy moth. *Id.*

43. *See Governor Brown Takes Action to Protect Communities Against Unprecedented Tree Die-Off*, CA.GOV (Oct. 30, 2015), https://www.gov.ca.gov/news.php?id=19180 (describing reasons for tree mortality).

44. *See id.* (asserting California's precarious situation).

45. *See id.* (detailing consequences of California's years long drought).

46. *See id.* (explaining Governor Brown's need to proclaim state of emergency).

47. *See id.* (explaining potential consequences).

48. *See Governor Brown Takes Action To Protect Communities Against Unprecedented Tree Die-Off*, *supra* note 43 (describing current predicament from drought and beetle).

49. *See id.* (announcing California's deforestation predicament).

B. Global Deforestation

Forests cover about ten billion acres of the world's land area.[50] On average, however, deforestation amounts to thirty-two million acres per year.[51] Between 1990 and 2005, Brazil led the world with the record-high total deforested area.[52] The country lost 42,330,000 hectares of forest, which is roughly the size of California.[53] Additionally, Indonesia contributes significantly to world deforestation rates.[54] From 2000 to 2012, Indonesia suffered a loss of over twenty-three thousand square miles of forest, which amounts to roughly the size of West Virginia.[55] Additionally, like California, Indonesia has also suffered from fires.[56] By October 2015, Indonesia suffered nearly one hundred thousand fires so large that they could be seen from space.[57] Lastly, China is also a leading contributor to deforestation, based on the country's indiscriminate consumption of cheap wood.[58] According to nonprofit research group Forest Trends, with China's increasing demand for wood, countries, like Indonesia and Papua New Guinea, are incentivized to perform "unsustainable and sometimes illegal logging practices."[59]

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50. *See* Toni Johnson, *Deforestation and Greenhouse-Gas Emissions*, COUNCIL ON FOREIGN RELATIONS, http://www.cfr.org/forests-and-land-management/deforestation-greenhouse-gas-emissions/p14919 (last updated Dec. 21, 2009) (describing statistics of world's forests).

51. *See id.* (detailing rate of deforestation).

52. *See generally* Rebecca Lindsey, *Tropical Deforestation*, EARTH OBSERVATORY (Mar. 30, 2007), http://earthobservatory.nasa.gov/Features/Deforestation/printall.php (explaining Brazil's deforestation rates).

53. *See id.* (describing Brazil's socioeconomic characteristics affecting forest management practices).

54. *See* Tim McDonnell, *Indonesia's huge fires might be the worst climate change crisis on Earth right now*, GRIST.ORG (Oct. 27, 2015), http://grist.org/climate-energy/indonesias-huge-fires-might-be-the-worst-climate-change-crisis-on-earth-right-now/ (detailing Indonesia's current deforestation rates).

55. *Id.* (describing Indonesia's rates of deforestation); *but see* John Vidal, *Rate of deforestation in Indonesia overtakes Brazil, say study*, THE GUARDIAN (June 29, 2014), http://www.theguardian.com/environment/2014/jun/29/rate-of-deforestation-in-indonesia-overtakes-brazil-says-study (reporting on Indonesia's lack of transparency). "Indonesia has greatly under-reported how much primary rainforest it is cutting down, according to the government's former head of forestry data gathering." *Id.* New studies suggest Indonesian deforestation is nearly twice as much as Brazil's. *Id.*

56. *See* Tim McDonnell, *supra* note 54 (explaining Indonesia's susceptibility to wildfires).

57. *See id.* (detailing Indonesia's wildfire problem).

58. *See* Toni Johnson, *supra* note 50 (describing China's consumerism tactics and effect on deforestation).

59. *See id.* (expanding on China's consumerism tactics and effect on deforestation). Don J Menick, a conservation biology professor at Columbia University, asserts, "China has a seemingly limitless appetite for cheap wood." *Id.*

In sum, though deforestation rates vary greatly both within the United States and among the international community, unsustainable forest management practices are a global problem.[60] The United States government, at both the federal and state levels, struggles to combat natural causes of deforestation.[61] Increasing levels and intensity of forest fires, invasive species, and droughts are creating new problems without easy solutions.[62] Comparatively, members of the international community, like Brazil and Indonesia, struggle even more to manage not only natural disasters, but also illegal conduct indiscriminate buyers incentivize.[63]

III. DEFORESTATION EXACERBATES CLIMATE CHANGE

> "God always forgives, we men forgive sometimes, but nature never forgives. If you give her a slap, she will give you one. I believe that we have exploited nature too much."
>
> —Pope Francis[64]

This section describes in detail how intact the 'lungs of our land' are and how damaged forests affect their role.[65] Specifically, it addresses trees' ability to store carbon.[66] It also discusses the effect of that carbon's release when trees are cut down.[67] Finally, this section addresses trees' influence on precipitation and the water cycle.[68]

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60. For a discussion of the global predicament resulting from deforestation and unsustainable forest management, see *supra* notes 38-59 and accompanying text.

61. For a further discussion of the federal and state government's struggle to combat deforestation, see *supra* notes 38-39 and accompanying text.

62. For a discussion of these problems relating to forest fires, drought, and invasive species, see *supra* notes 38-49 and accompanying text.

63. For a discussion of the international communities' forest management practices, see *supra* notes 50-59 and accompanying text.

64. Taryn Salinas, *Nature Never Forgives: 7 of Pope Francis's Greenest Quotes*, NATIONAL GEOGRAPHIC (Sept. 20, 2015), http://news.nationalgeographic.com/2015/09/120150920-pope-francis-environment-climate-quotes/ (providing Pope Francis' views on environmental responsibility).

65. For a discussion of the benefits of sustainable forest management, see *infra* notes 69-119 and accompanying text.

66. For a discussion of tree's ability to store carbon, see *infra* notes 69-90 and accompanying text.

67. For a discussion of carbon release, see *infra* notes 91-101 and accompanying text.

68. For a discussion of tree's participation in the water cycle, see *infra* notes 102-119 and accompanying text.

A. Carbon Storage

During their lifetimes, trees store carbon in their cells through photosynthesis, a process resulting in tree compositions of fifty percent carbon.[69] Trees subsequently release their stored carbon back into the atmosphere when they are cut down, burned, or die of disease or old age.[70] Consequently, depending on the age and number of tree deaths, a forest can be a carbon sink, a net source, or a source of carbon.[71] When considered a carbon sink, the forest, in the aggregate, stores more carbon in its limbs than the carbon it emits when the forest dies.[72] Contrastingly, forests are a source of carbon when enough trees are cut down that the forest, in the aggregate, releases more carbon than it stores.[73] Finally, forests are a net source of carbon when forests, in the aggregate, store an equal amount of carbon as the carbon they release when they die.[74] According to the United States Forest Service, forest ecosystems are "the largest terrestrial carbon sink on earth. . . ."[75]

Nationwide, United States' forests store more carbon than they emit each year.[76] Consequently, United States' forests are considered to be a carbon sink.[77] According to the United States Department of Agriculture, in 2012, forests offset close to fifteen percent of greenhouse gas emissions.[78] As a result, rather than the forests releasing carbon into the atmosphere and contributing to greenhouse gases that cause climate change, the forests sequestered and stored fifteen percent of the United States' carbon emissions.[79]

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69. *See* Toni Johnson, *supra* note 50 (exploring forests' part in eco-climatology).

70. *Id.* (describing process of carbon storage).

71. *See generally* Rebecca Lindsey, *Tropical Deforestation*, EARTH OBSERVATORY (Mar. 30, 2007), http://earthobservatory.nasa.gov/Features/Deforestation/printall.php. (discussing carbon sink, versus source, versus net source).

72. *See generally id.* (describing carbon sequestration).

73. *See generally id.* (illustrating complexities surrounding carbon sequestration).

74. *See generally id.* (comparing forest sequestration rates).

75. *See* Sonja N. Oswalt & W. Brad Smith, *U.S. Forest Resource Facts and Historical Trends*, UNITED STATES DEPARTURE OF AGRICULTURE (August 2014), http://www.fia.fs.fed.us/library/brochures/docs/2012/ForestFacts_1952-2012_English.pdf (asserting forest's abilities).

76. *See id.* at 27 (detailing U.S. forest's contributions in fighting climate change).

77. *See id.* (describing forest sequestration rates).

78. *See id.* (noting U.S. forest's contributions in fighting climate change). It is important to understand however these calculations include urban forest and harvested wood products. *Id.*

79. *See id.* (describing United States' forests' carbon sequestration). Specifically, U.S. forests store 955 tetragrams (Tg) of carbon dioxide. *Id.* In contrast,

Jonathan Thompson, a research ecologist at the Smithsonian Conservation Biology Institute, studies the carbon sequestration rates of New England forests.[80] Thompson found New England forests provide a "tremendous public benefit by storing carbon that would otherwise contribute to climate change."[81] Thompson specifically found that "[i]n Massachusetts, forests capture approximately 2.3 million metric tons of carbon each year[;] [t]hat is equal to the amount of carbon dioxide emitted from the energy used by one million American homes annually."[82] Still, even more data collection regarding forest carbon storage is needed, as scientists recognize the necessity of sequestering carbon and the potential of American forests.[83]

Global forests have vastly different carbon storage and carbon release rates than those of the United States.[84] For example, the trees in the Amazon contain more carbon than ten years' worth of human-produced greenhouse gases.[85] Whether intact tropical forests are a net source or a carbon sink is not certain.[86] According to NASA Earth Observatory, intact tropical forests are most likely a net source of carbon.[87] Science regarding tree carbon storage, however, is still evolving.[88] In 2014, the Smithsonian Tropical Research Institute scientist Richard Condit found that "[r]ather than slowing down or ceasing growth and carbon uptake, as we previously as-

forests emit only 270 Tg of carbon dioxide back into the atmosphere through wildfire combustion. *Id.*

80. *See Development will Reduce Carbon Stored in Forests, Smithsonian & Harvard Scientists Predict*, SMITHSONIAN INSIDER (Apr. 16, 2012), http://smithsonianscience.si.edu/2012/04/development-will-reduce-carbon-stored-in-forests-smithsonian-harvard-scientists-predict/ (showing New England's carbon storage rates).

81. *See id.* (noting findings regarding carbon storage's benefits). Researchers measured carbon sequestration by creating scaled towers into the forest canopy and measuring the trunks of trees. *Id.*

82. *See id.* (detailing Massachusetts' energy use and carbon storage).

83. *See id.* (noting facilities appearing across United States). David Foster, Director of the Harvard Forest, commented on the growing field of ecology: "[W]ith three decades of data meticulously collected as part of the LTER Network [Long-Term Ecological Research Network], we have reached a crucial transition where we are now able to tackle major environmental challenges such as the fate of forest carbon, across large landscapes." *Id.*

84. *See generally* Lindsey, *supra* note 71 (detailing global deforestation).

85. *See id.* (noting Amazon carbon storage rates).

86. *See id.* (addressing uncertainties in data). "In the Amazon, huge volumes of carbon dioxide escape from decaying leaves and other organic matter in rivers and streams that flood large areas of forests during the rainy season." *Id.*

87. *See id.* (detailing components of carbon storage).

88. *See Trees Grow Faster and Store More Carbon As They Age*, SMITHSONIAN INSIDER (Jan. 15, 2014), http://smithsonianscience.si.edu/2014/01/trees-grow-faster-and-store-more-carbon-as-they-age/ (discussing effect of age and growth on tree's carbon storage capabilities).

sumed, most of the oldest trees in forest around the world actually grow faster, taking up more carbon[;] [a] large tree may put on weight equivalent to an entire small tree in a year."[89] Still, further research is required to determine how this translates into carbon storage.[90]

B. Carbon Release

When forests die prematurely, whether through wildfires or agriculture practices, they release carbon into the atmosphere that would otherwise be stored.[91] The U.N.'s Intergovernmental Panel on Climate Change estimates deforestation contributes to about seventeen percent of all greenhouse gas emissions.[92] This percentage amounts to more than that of the global transportation sector, and only second to that of the global energy sectors.[93] Consequently, unsustainable forestry practices have a substantial effect on global warming.[94] According to *National Geographic*, "[Having] [f]ewer forests means [having] larger amounts of greenhouse gases entering the atmosphere- and increased speed and severity of global warming."[95] Further, when forests are cleared for farming, the soils, depending on management, can be large sources of carbon emissions.[96] The release of carbon from forest fires also is a relatively large source of carbon, especially those seen in Indonesia in 2015.[97] As of October 2015, the forest fires of Indonesia have

89. *Id.* (describing Smithsonian Tropical Research Institute findings). To explain tropical tree growth, Nate Stephenson, lead author and forest ecologist with the U.S. Geological Survey, states, "If human growth would accelerate at the same rate, we would weigh half a ton by middle age and well over a ton at retirement." *Id.*

90. *Id.* (noting limitations of eco-studies). Though the Smithsonian specifically mentions how this research will affect aid programs like the United Nation's REDD+. *Id.*

91. *See* Lindsey, *supra* note 71 (outlining consequence of deforestation).

92. *See About REDD+*, UN-REDD PROGRAMME, http://www.unredd.net/about/what-is-redd-plus.html (last visited Feb. 4, 2016) (detailing effects of deforestation).

93. *See id.* (noting effects of deforestation).

94. *See* Lindsey, *supra* note 71 (explaining deforestation's effect on climate change).

95. *Deforestation, Here's what you need to know about the warming planet, how it's affecting us, and what's at stake*, NATIONAL GEOGRAPHIC, http://environment.nationalgeographic.com/environment/global-warming/deforestation-overview/ (last visited Feb. 25, 2016) (detailing ramifications of deforestation).

96. *See* Lindsey, *supra* note 71 (explaining climate impacts of different deforestation practices).

97. Brittany Patterson, *Hellish Fires in Indonesia Spread Health, Climate Problems*, SCIENTIFIC AMERICAN (Oct. 22, 2015), http://www.scientificamerican.com/article/hellish-fires-in-indonesia-spread-health-climate-problems/ (detailing Indonesia's

emitted an estimated one billion tons of carbon dioxide, totaling about three percent of global fossil fuel emissions.[98] Between September and October 2015, on twenty-six occasions, daily emissions of carbon from the fires exceeded daily emissions of carbon from the entire United States economy.[99] This intersection between carbon storage and carbon release emphasizes the need for managing healthy forests.[100] The benefits of creating and maintaining healthy forests are twofold: preventing the unnecessary release of more carbon into the atmosphere and sequestering already released carbon.[101]

C. Interrupted Water Cycle

Deforestation further contributes to climate change by interrupting the water cycle and altering global precipitation patterns.[102] Tree transpiration is the process by which trees absorb moisture through their roots, and then transpire it into the atmosphere through the pores located on the trees' leaves.[103] A fully-grown tree releases one thousand liters of water vapor per day into the atmosphere.[104] The entire Amazon rainforest transpires twenty billion tons of water vapor per day.[105] This water vapor condenses to form clouds.[106] Additionally, trees emit gases, such as terpenes and isoprene, which, when added to the clouds, help form rain.[107] According to Jim Robbins, a reporter for the *New York Times*, "These water-rich banks of clouds travel long, wind-driven distances, a con-

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forest fires). "Every year, Indonesia is plagued by peat fires, which are deliberately set in what is known as 'slash-and-burn' in order to clear forests for agricultural use. Large plantations of palm oil and rubber are two of the biggest commodities." *Id.*

98. *See id.* (describing amount of CO2 released from forest fires).

99. *See id.* (describing magnitude of daily emissions from fires).

100. For a discussion of the need for sustainable forest management practices, see *supra* notes 69-119 and accompanying text.

101. For a discussion of sustainable forest management practices, see *supra* notes 69-119 and accompanying text.

102. Barbara Fraser, *Report: Forests May Play Bigger Role in Rainfall than Estimated*, FOREST NEWS (Apr. 10, 2014), http://blog.cifor.org/22060/report-forests-may-play-bigger-role-in-rainfall-than-estimated?fnl=en (explaining deforestation's impact on rainfall in tropical forests). "Precipitation is formed when the atmosphere draws moisture from oceans as water vapor, which condenses and falls as rain, hail or snow. Globally, about two-thirds of this precipitation returns to the atmosphere as water vapor, and the majority of that falls again on land." *Id.*

103. *See id.* (explaining transpiration process).

104. *See* Robbins, *supra* note 4 (discovering ways trees transpire water).

105. *See id.* (detailing amount of water transpired in Amazon).

106. *See id.* (illustrating cloud production from transpiration).

107. *See id.* (explaining process of rain production).

veyor belt for the delivery of precipitation that scientists call flying rivers."[108] These 'flying rivers' are a crucial part of the water cycle.[109]

When large areas of forests are destroyed and no longer contribute to these 'flying rivers', rainfall patterns across the globe alter.[110] Specifically, deforestation in the Amazon region of South America influences rainfall from Mexico to Texas.[111] Deforestation in Central Africa changes precipitation rates in the upper and lower Midwest region of the United States.[112] Deforestation in Southeast Asia affects rainfall in China and the Balkan Peninsula.[113] This altered pattern generally causes rainfall to increase in one region and decrease in another, causing flooding and drought, respectively.[114]

The current research on carbon storage and tree transpiration demonstrates the credibility of President Roosevelt's declaration that forests are the 'lungs of our land.'[115] Deforestation stifles the land's ability to breathe, diminishing its capacity to regulate temperature and moisture rates.[116] *New York Times* reporter Jim Robbins stated, "[F]orests represent a kind of ecological infrastructure that helps maintain comfortable living conditions on the planet, whether by taking up and holding carbon dioxide, cleaning water through their roots, preventing floods by stabilizing soil — or . . . by regulating climate."[117] When the ecological infrastructure is destroyed, forests first emit carbon rather than storing it, and second, forests cannot effectively supply precipitation rates to maintain comfortable living conditions on the planet.[118] These two negative effects directly exacerbate climate change.[119]

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108. *Id.* (explaining water cycle).

109. *See* Robbins, *supra* note 4 (explaining importance of water cycle).

110. *See* Mike Bettwy, *Tropical Deforestation Affects Rainfall in the U.S. and Around the Globe*, GODDARD SPACE FLIGHT CENTER (Sept. 13, 2005), http://www.nasa.gov/centers/goddard/news/topstory/2005/deforest_rainfall.html (reporting on long-term impacts of deforestation in tropical regions on climate).

111. *See id.* (specifying region affected by tropical deforestation, like Mexico).

112. *See id.* (illustrating changes tropical deforestation cause).

113. *See id.* (detailing areas whose weather will be affected).

114. *See id.* (describing how changes will be displayed in rain patterns).

115. For a discussion of the research currently conducted on carbon storage and the water cycle, see *supra* notes 69-119 and accompanying text.

116. For a discussion of the consequences of deforestation rates, see *supra* notes 91-119 and accompanying text.

117. Robbins, *supra* note 4 (describing complexity of forests in climate infrastructure).

118. For a discussion of the dangers of deforestation, see *supra* notes 91-119 and accompanying text.

119. For a discussion of forest sequestration and water transpiration, see *supra* notes 102-119 and accompanying text.

IV. CLIMATE CHANGE EXACERBATED DEFORESTATION

"We are at risk of being grilled, fried, and toasted."

—Christine Lagarde, previous Managing Director of the International Monetary Fund[120]

Although forests perish of natural causes, human-caused climate change exacerbates forests' destruction.[121] This section will address how climate change produces increased global temperatures and changing rain patterns.[122] Next, it will focus specifically on present effects of climate change on the American Southwest.[123] Finally, this section will conclude by addressing the interconnected causal links between climate change, changing water patterns, and forest fires.[124]

Climate change adversely impacts global temperature and changing rain patterns in a variety of ways.[125] First, droughts interrupt the water cycle, and consequently, the sky-borne rivers run dry.[126] Second, when temperatures rise two degrees above pre-industrial levels, trees will suffer 'carbon starvation'.[127] Carbon starvation occurs during dry conditions when tree leaves or needles close their stomata to keep water in, which effectively blocks the transmission of carbon.[128] Without sufficient carbon, trees suffer from reduced or fully halted photosynthesis, which causes severe damage.[129] The World Meteorological Organization (WMO) drew upon several analyses from the world's major meteorological agen-

120. *See* David Gelles, *Leaders in Davos Urge Quick Action to Alter the Effects of Climate Change,* THE NEW YORK TIMES (Jan. 23, 2015), http://dealbook.nytimes.com/2015/01/23/leaders-in-davos-urge-quick-action-to-alter-the-effects-of-climate-change/?_r=0 (reporting world leader's reactions to climate change).

121. *See* Chris Mooney, *Scientists say climate change could cause a 'massive' tree die-off in the U.S. Southwest*, THE WASHINGTON POST (Dec. 21, 2015), https://www.washingtonpost.com/news/energy-environment/wp/2015/12/21/scientists-say-climate-change-could-cause-a-massive-tree-die-off-in-the-southwest/ (reporting on tree mortality in Southwest).

122. For a discussion of changing rain patterns, see *infra* notes 102-119 and accompanying text.

123. For a discussion of forest management in the American Southwest, see *infra* notes 135-140 and accompanying text.

124. For a discussion on the connection between deforestation, rain patterns, drought, and climate change, *see infra* notes 141-147 and accompanying text.

125. For a discussion of climate change's adverse effects, see *infra* notes 121-147 and accompanying text.

126. For a more detailed discussion of the water cycle, see *supra* notes 102-119 and accompanying text.

127. *See* Mooney, *supra* note 121 (describing carbon starvation).

128. *See id.* (explaining how carbon starvation occurs).

129. *See id.* (detailing effects of carbon starvation).

cies to confirm that the global average surface temperature in 2015 "broke all previous records by a wide margin."[130] Additionally, the WMO discovered that temperatures for the year 2015, for the first time on record, were one degree Celsius above the pre-industrial era.[131] As a result of this increased temperature, more trees will suffer carbon starvation.[132] According to *Nature*, a international weekly journal of science,

> Forest mortality has been widely documented in recent years and has accelerated in concert with rising CO2 and temperature. The terrestrial carbon sink could be severely diminished over the next century if this acceleration of tree mortality continues with warming and increased extreme drought events, causing a positive feedback on global warming.[133] As a consequence, human-caused climate change aggravates deforestation rates.[134]

An example of the drastic effects of climate change can be seen in the United States' Southwest region.[135] Researchers from *Nature* found that a warming climate could cause "massive" coniferous tree mortality in the United States Southwest region by 2100.[136] Specifically, models predict seventy-two percent of the United States Southwest region's needle leaf evergreen forests will die by 2050, increasing to nearly one hundred percent mortality rates by 2100.[137] The study further found this widespread tree death could emit ten gigatons of carbon, which equals about one year's worth of the globe's current fossil fuel emissions.[138] The lead researcher for *Nature*, Nate McDowell, however, highlighted the uncertainties of such predictions; he stated, "[W]hile the models might overesti-

130. *Scientists Warn Against Economic Disruption from Climate Change; Impacts Will Be With Us for Many Decades Says WMO Head*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (Jan. 25, 2016), http://newsroom.unfccc.int/nature-s-role/scientists-warn-against-economic-disruption-from-climate-change/ (warning of rising temperatures).

131. *See id.* (providing World Meteorological Organization's findings).

132. *See id.* (discussing forest mortality).

133. *See* Douglas Perry, *Massive die-off of Southwest U.S. trees coming within a few decades, researchers conclude*, THE OREGONIAN (Dec. 23, 2015), http://www.oregonlive.com/today/index.ssf/2015/12/massive_die-off_of_southwest_u.html (citing scientists, N.D. McDowell, A.P Williams, C. Xu, and E.T. Pockman, in multi-scale predictions of massive conifer mortality due to chronic temperature rise).

134. *See id.* (illustrating consequences of climate change).

135. *See* Mooney, *supra* note 121 (reporting on tree mortality in Southwest).

136. *See id.* (describing extent of tree mortality in Southwest).

137. *See id.* (predicting tree mortality by 2100).

138. *See id.* (describing study's findings of carbon release).

mate tree death, they could also underestimate it . . . wildfires are not even included in the models in question – and that's a major factor that could compound tree loss over the course of the century, especially when combined with drought."[139] Nonetheless, research predicting tree death exhibits the destructive effect of climate change.[140]

The intersection of climate change, drought, and forest fires is highlighted in California.[141] In 2010, California submitted an assessment of its forests and rangelands to the United States' Forest Service.[142] The assessment explained that climate patterns significantly influence the "size, severity, duration and frequency" of wildfires."[143] This influence manifests in warmer spring and summer temperatures.[144] The assessment specifically found that "[a]lthough fires are a natural part of the California landscape, the fire season in California and elsewhere seems to be starting sooner and lasting longer, with climate change being suspected as a key mechanism in this trend."[145] Additionally, the assessment estimated that the wildfire area burned in Northern California might increase by at least one hundred percent.[146] California, therefore, presents a case study of how climate change exacerbates deforestation rates in a variety of complex ways.[147]

V. POSSIBLE REMEDIES

> "Every time I hear about a government program that is going to spend billions of dollars on some carbon capture and storage program, I just laugh and think, what is wrong

139. *See id.* (concluding predictions of tree mortality inherently difficult).

140. *See* Mooney, *supra* note 121 (showing effects of climate change).

141. *See Climate Change: Threats and Opportunities*, CALIFORNIA'S FORESTS AND RANGELANDS: 2010 ASSESSMENT, *available at* http://frap.fire.ca.gov/data/assessment2010/pdfs/3.7climate_change.pdf (last visited Feb. 4, 2016) (showing effect of climate change on forests).

142. *See id.* (describing assessment).

143. *See id.* (finding climate change's influence on wildfires).

144. *See id.* (detailing manifestation of climate change).

145. *See id.* (reporting on forest fires in California).

146. *See Climate Change*, *supra* note 141 (describing state of California's forests).

147. For a discussion of California's deforestation rates and their consequences, see *supra* notes 141-146 and accompanying text.

> with a tree? All you have to do is look out the window, and the answer is there."
>
> —Nigel Sizer, Director of Forest Programs at the World Resources Institute, a think tank in Washington[148]

According to *Nature*, 'aggressive' forest management over the next ten years could counteract about half of the current global carbon emissions.[149] Aggressive forest management practices require policy makers to focus not on the needs of today, but on the needs of tomorrow.[150] This section shows how a paradigm shift is occurring at the state, national, and global levels, with the recognition of sustainable resources within ecosystems.[151] Ecosystem services are benefits that arise from nature and flow to society, and include trees providing complex climate regulation.[152] If private or public parties are adequately compensated for providing these services by maintaining a healthy forest, then they are incentivized to continue or increase their investment in ecosystems.[153]

A. National Level

1. Federal

The federal government, through its executive, legislative, and judiciary branches, is combating deforestation and climate change issues.[154] The executive branch, for example, issued an instructional memorandum addressing the need for eco-services to be recognized by the executive agencies in any calculated cost-benefit

148. Justin Gillis, *Restored Forests Breathe Life Into Efforts Against Climate Change*, THE NEW YORK TIMES (Dec. 23, 2014), http://www.nytimes.com/2014/12/24/science/earth/restored-forests-are-making-inroads-against-climate-change-.html?%20_r=0 (affirming potential of trees).

149. *See* Jeff Tollefson, *Forests in spotlight at Paris climate talks*, NATURE.COM (Dec. 1, 2015), http://www.nature.com/news/forests-in-spotlight-at-paris-climate-talks-1.18934 (describing Paris climate talks and expectations).

150. *See* Justin Gillis, *supra* note 148 (proposing potential of forest management practices).

151. For a discussion of programs that reflect an appreciation for eco-services, see *infra* notes 154-233 and accompanying text.

152. *See* Kelli Barret, *The Value of Nature to Be Recognized in Every US Federal Agency Under New Guidance,* ECOSYSTEM MARKETPLACE (Oct. 9, 2015), http://www.ecosystemmarketplace.com/articles/value-of-nature-in-federal-agencies/ (defining ecosystem services).

153. *See id.* (proposing effect of incentivizing sustainable forest management practices).

154. For information regarding federal programs, see *infra* notes 154-185 and accompanying text.

analysis.[155] The legislative branch is enacting statutes to promote forestry studies throughout the states and the international community.[156] Finally, the judiciary branch is interpreting existing laws, and often finds for environmental groups attempting to ensure compliance with environmental laws.[157]

On October 7, 2015, the Obama Administration issued an instructional memorandum to all executive departments and agencies.[158] The memorandum addressed the advances in science and technology, specifically declaring "that healthy and intact [ ] habitats . . . [promote] resilience of communities . . . , including reducing vulnerability to climate-change impacts."[159] The directive states, "Agencies shall develop policies to promote consideration of ecosystem-services assessments within existing agency planning and decision frameworks, where appropriate and practicable, in accordance with their statutory authorities and consistent with their specific missions."[160] To explain the scope of the directive, the memorandum states, "For example, should an agency's analysis require consideration of costs, the agency should consider ecosystem-services assessment methods, where appropriate and feasible."[161] The memorandum encourages contemplation of the potential influence federal actions have on ecosystems, particularly those unlikely to be recognized by private actors due to the altruistic nature of the services.[162]

The federal government also encourages a paradigm shift in acknowledging the worth of forests through the Department of Agriculture's Conservation Reserve Program (CRP).[163] "[P]rivate

155. For an example of executive branch combating deforestation, see *infra* notes 158-171 and accompanying text.

156. For an example of the legislative branch combating deforestation, see *infra* notes 172-178 and accompanying text.

157. For an example of judicial branch combating deforestation, see *infra* notes 179-185 and accompanying text.

158. *See* Shaun Donovan, Christina Goldfuss, & John Holdren, *MEMORANDUM FOR EXECUTIVE DEPARTMENTS AND AGENCIES, Incorporating Ecosystem Services into Federal Decision Making*, WHITEHOUSE.GOV (Oct. 7, 2015), *available at* https://www.whitehouse.gov/sites/default/files/omb/memoranda/2016/m-16-01.pdf (directing executive agencies to consider ecosystem services in making decisions).

159. *Id.* (addressing ecosystem services' contribution).

160. *Id.* (pointing out what practices should adopt).

161. *Id.* (explaining how to apply ecosystem services).

162. *See id.* (emphasizing benefits of healthy and intact services).

163. *See Conservation Programs*, U.S. DEP'T OF AGRIC. – FARM SERV. AGENCY, https://www.fsa.usda.gov/programs-and-services/conservation-programs/index (last visited Apr. 17, 2017) (describing federal government's involvement in conservation programs).

owners and families[ ]" care for "[fifty-six] percent of the [United States'] forests[.]"[164] Under the program, "[landowners] . . . agree to [halt] . . . agricultural production" on their land for a period of ten to fifteen years "[i]n exchange for a yearly rental payment[.]"[165] Former United States President Ronald Reagan "[s]igned [the CRP] into law . . . in 1985[.]"[166] Examples of CRP initiatives include the "Highly Erodible Land Initiative[,] [the] Honeybee Habitat Initiative[,] [and the] Longleaf Pine Initiative[.]"[167] The Longleaf Pine Initiative is a reaction to the dramatic mortality of Longleaf Pines over the last one hundred years and highlight mortality rates resulting in the "[ninety] million acres [of Longleaf Pines reducing] to [ ] [only four] million [ ]."[168] In explaining the benefits of renting their land to landowners, the agency specifically referenced "[the] [p]romot[ion] [of] carbon sequestration [and the] [r]educ[tion] [of the] risk of catastrophic loss . . . [from] fire[s][.]"[169] The Bottomland Hardwood Trees Initiative similarly emphasizes forests' ability to "store large amounts of carbon in trees and the[ir] soils[.]"[170] The "voluntary participation [of] . . . land[ ]owners[ ]" makes the "CRP [ ] the largest private[ ] conservation program in the United States."[171]

Additionally, Congress is creating and adapting a federal law to assist in global reforestation efforts.[172] Pursuant to Title 16, Section 4501 of the United States Code, Congress directed the Secretary of

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164. *State Policy Recommendations*, AM. FOREST FOUND., https://www.forestfoundation.org/state-policy-recommendations-forest-carbon (last visited Feb. 4, 2016) (detailing United States' government involvement in deforestation).

165. *Conservation Reserve Program*, U.S. DEP'T OF AGRIC. – FARM SERV. AGENCY, https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index (last visited Feb. 25, 2016) (describing conservation reserve program).

166. *Id.* (detailing history of CRP).

167. *Id.* (listing CRP initiatives).

168. *Conservation Reserve Program - LONGLEAF PINE INITIATIVE*, U.S. DEP'T OF AGRIC. – FARM SERV. AGENCY, https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2015/CRPProgramsandInitiatives/Longleaf_Pine_Initiative.pdf (last visited Feb. 25, 2016) (explaining need for Longleaf Pine Initiative's benefits).

169. *Id.* (noting benefits of Longleaf Pine Initiative).

170. *Conservation Reserve Program - BOTTOMLAND HARDWOOD TREES INITIATIVE*, U.S. DEP'T OF AGRIC. – FARM SERV. AGENCY, https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2015/CRPProgramsandInitiatives/Bottomland_Hardwood_Trees_Initiative.pdf (last visited Feb. 25, 2016) (detailing Bottomland Hardwood Trees Initiative).

171. *Conservation Reserve Program*, *supra* note 165 (last visited Feb. 25, 2016) (describing success of conservation reserve program).

172. For more information on congressional efforts to promote sustainable forest management, see *infra* notes 172-178 and accompanying text.

Agriculture to support international forestry activities to promote conservation and sustainable management of forestland.[173] Congress further directed the Secretary of Agriculture to focus on activity that "could have a substantial impact on emissions of greenhouse gases related to global warming."[174] The statute emphasizes sharing technical, administrative, and managerial skills relating to natural resources, as well as scientific research done by foreign governments and institutions.[175] On September 29, 2015, the Secretary of Agriculture supplemented this statute, which Congress originally enacted in the 1940s, with federal regulation, as codified in Title 7 Section 2.20 of the Code of Federal Regulations.[176] Under this extensive new regulation, the Secretary of Agriculture authorized the Under Secretary for Natural Resources and Environment to implement several programs.[177] These programs include "forest insect, disease, [ ]other pest management programs[,] [and] . . . [c]ritical [l]and[ ] [r]esources [c]onservation [p]rogram[s][.]"[178]

The judiciary branch further combats deforestation through its interpretation of federal law.[179] Congress enacted the broad National Environmental Policy Act (NEPA) in 1970.[180] "The pur-

173. *See* 16 U.S.C. § 4501 (1990) (setting forth Tropical Forest Action Plan). The statute addresses procedures for the Tropical Forestry Action Plan:

> In support of the Tropical Forestry Action Plan and to specifically address tropical deforestation and degradation, the Secretary may[ ] (1) support and actively participate in global and regional meetings that seek to reform such Plan; (2) together with the United States Agency for International Development, and other Federal agencies, provide technical assistance to tropical countries for the formulation of national forestry sector development strategies; and (3) cooperate with tropical countries on research, training, and technical programs aimed at implementing national forestry sector development strategies.

See § 4502.

174. *See* § 4501 (describing congressional intent).

175. *See id.* (describing congressional intent).

176. *See* 7 C.F.R. § 2.20 (2015) (setting forth responsibilities of Under Secretary for Natural Resources and Environment). The Secretary of Agriculture delegated to the Under Secretary for Natural Resources and Environment the authority to "[f]ocus[ ] on countries that could have a substantial impact on global warming[.]" *Id.* at § 2.20(a)(2)(2015).

177. *See id.* (detailing efforts of Under Secretary for Natural Resources and Environment).

178. *See id.* at § 2.20(a)(2)(xxi), § 2.20(a)(3)(v) (noting Under Secretary for Natural Resources and Environment must aid States and other governments in forest resource planning).

179. For a discussion of judicial action to combat deforestation, see *supra* notes 180-185 and accompanying text.

180. *See* 42 U.S.C. § 4321 (1970) (establishing National Environmental Policy Act). The Congressional declaration of purpose reads in full:

pose[ ] of this [statute] [is][ ] . . . [to] encourage productive and enjoyable harmony between man and his environment[ ] [and] to promote efforts which will prevent or eliminate damage to the environment and biosphere[.]"[181] Through NEPA, efforts to combat deforestation are encouraged via citizen suits against federal agencies.[182] For example, in 2014, the League of Wilderness Defenders and the Blue Mountains Biodiversity Project brought suit against the United States Forest Service.[183] The Ninth Circuit found for the environmental organizations, and held the "[financial] interests of logging companies and local governments did not outweigh [the] environmental harms[.]"[184] This displays the federal government's respect for eco-services, and efforts to combat deforestation.[185]

2. State

State programs designed to enhance and protect forests are as unique as the landowners who use the programs.[186] The following paragraphs provide examples of Oregon's and California's state programs that are designed to protect state forests.[187]

Oregon's "forests [encompass] over [thirty] million acres . . . , [covering] almost half of the state."[188] Oregon's Department of Forestry (Department) has over one hundred years of experience

> The purposes of this chapter are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

Id.

181. *Id.*

182. *See* League of Wilderness Defenders/Blue Mountains Biodiversity Project v. Connaughton, 752 F.3d 755, 758 (9th Cir. 2014) (describing United States Forest Service action causing plaintiffs to bring suit). The Hells Canyon Preservation Council also joined as plaintiff. *Id.*

183. *See id.* at 765-66 (filing suit to allege violation of NEPA and ESA).

184. *See id.* at 756 (holding under Administrative Procedure Act, plaintiffs would not succeed on merits of claims because insect infestation and prevention of forest fires warrants no preliminary injunction).

185. *See supra* notes 158-184 and accompanying text for a discussion of the federal government's efforts to combat deforestation.

186. *See generally State Policy Recommendations*, AM. FOREST FOUND., https://www.forestfoundation.org/state-policy-recommendations-forest-carbon (last visited Feb. 4, 2016) (detailing potential state involvement).

187. For a description of state programs designed to prevent deforestation, see *infra* notes 186-212 and accompanying text.

188. *State of Oregon: Forest Benefits - About Oregon's Forests*, OREGON.GOV, http://www.oregon.gov/ODF/ForestBenefits/Pages/AboutForests.aspx (last visited Feb. 25, 2016) (describing Oregon's forests).

preserving forested ecosystems.[189] The Department recognizes the major problem of climate change and views forested ecosystem as a fundamental component of the solution.[190] Specifically, the Department appreciates the ecological function of trees.[191]

> Huge amounts of carbon are stored in forests because trees pull carbon dioxide from the atmosphere through photosynthesis and use it to grow trunks, branches, and leaves. In the process[,] large amounts of oxygen and water vapor are released into the atmosphere—a fully[-]grown tree in one day can release hundreds of liters of water. Wildfires, droughts, and other destructive forces can greatly diminish these functions that help maintain conditions on the planet we enjoy and depend on.[192]

In recognition of forests' functions, the Department initiated several programs designed around the research and development of eco-services.[193] This includes the 1999 Forest Establishment Program.[194] "[The] Forest Establishment Program receive[d] [one and a half] million [dollars] in carbon dioxide emission offset funding from the Klamath Co-Generation Project[.]"[195] The program also rehabilitates forests on non-industrial private lands.[196] Oregon also made two "greenhouse gas reduction goals[:] [ ][to reach] [ten percent] below 1990 levels [in 2020] . . . [and to reach] [ ]at least [seventy five percent] below 1990 levels [in 2050][.]"[197] In 2010, the Oregon Global Warming Commission created a roadmap to reach those levels, including the creation of "ecosystem

189. *See id.* (detailing Oregon's Department of Forestry's history).

190. *See Annotated History of Climate Change- Related Policy in Oregon And the Board of Forestry*, OREGON.GOV, *available at* http://www.oregon.gov/ODF/Documents/ForestBenefits/BOFATTCH201503040701HistoryClimateChange.pdf (last visited Feb, 25, 2016) (describing Oregon's understanding of climate change).

191. *See id.* (illustrating Oregon's need for sustainable forest management).

192. *See State of Oregon: Forest Benefits - Climate Change*, OREGON.GOV, http://www.oregon.gov/ODF/ForestBenefits/Pages/ClimateChange.aspx (last visited Apr. 17, 2016) (detailing effects of deforestation and climate change).

193. *See Annotated History of Climate Change- Related Policy in Oregon And the Board of Forestry*, *supra* note 190 (describing Oregon's understanding of climate change).

194. *See id.* (describing Oregon programs).

195. *Id.* (exploring aspects of Oregon programs).

196. See *State of Oregon: Forest Benefits - Climate Change*, *supra* note 192 (describing Oregon's understanding of climate change).

197. *Interim Roadmap to 2020*, THE OR. GLOBAL WARMING COMM'N (Oct. 29, 2010), *available at* http://www.oregon.gov/energy/GBLWRM/docs/Integrated_OGWC_Interim_Roadmap_to_2020.pdf (quotation marks omitted) (laying out roadmap to climate change mitigation).

service[ ] marketplace."[198] The marketplace would include specific indices to place a value on eco-services.[199]

California has chosen a different incentive program, a form of "cap[ ]and[ ]trade program[.]"[200] The system of cap and trade reduces carbon emissions through allowances.[201] Each year, the Air Resources Board (ARB) distributes allowances, and the total allowed is the amount of carbon to be emitted by industries that year.[202] "Factories [or] other [persons] . . . can [then] buy the allowances they need or sell [those] they do[ ] [not] need."[203] Recently, under the California Global Warming Solutions Act, the ARB chose to investigate how "California['s] forests . . . play [a part] in the carbon cycle."[204] In August 2014, "Governor Jerry Brown[ ] . . . assembled [the Forest Climate Action Team (FCAT)][.]"[205] "[The] FCAT is [composed] of [e]xecutive [ ] members . . . of the [s]tate's natural resources agencies," all of whom hope to develop a Forest Carbon Plan by the end of 2016.[206] Currently, FCAT has identified attributes of "[h]ealthy California [f]orests[,]" which include "[f]orest resiliency[.]"[207] Among other things, FCAT measures forest resiliency by determining whether the forest "[s]erves as a net carbon sink over time."[208] On February 9, 2015, FCAT created an outline of how the state planned to enhance carbon storage through forest health.[209] The outline discusses the

198. *See id.* (describing how Oregon will reach state goal for climate change mitigation).

199. *See id.* (detailing process for climate change mitigation).

200. *See State Policy Recommendations*, AM. FOREST FOUND., https://www.forestfoundation.org/state-policy-recommendations-forest-carbon (last visited Feb. 4, 2016) (reporting California's climate change efforts).

201. *See* Michael Hiltzik, *Emissions cap-and-trade program is working well in California*, L.A. TIMES (June 12, 2015, 8:45 PM), http://www.latimes.com/business/hiltzik/la-fi-hiltzik-20150613-column.html (describing system of cap-and-trade).

202. *See id.* (explaining how cap-and-trade works in practice).

203. *See id.* (explaining trade of carbon allowances).

204. *See Climate Change and Forestry in California*, CAL. ENVTL. PROT. AGENCY - AIR RES. BD., http://www.arb.ca.gov/cc/forestry/forestry.htm (last reviewed on Aug. 24, 2015) (describing ARB efforts to call attention to role of California's forests).

205. *See Forest Climate Action Team (FCAT)*, CA.GOV, http://www.fire.ca.gov/fcat/ (last visited Feb. 4, 2016) (noting Governor Jerry Brown's efforts).

206. *See id.* (stating Forest Climate Action Team's history and objective).

207. *See Attributes of Healthy California Forests*, CA.GOV, *available at* http://www.fire.ca.gov/fcat/downloads/HealthyForestAttributes_FINAL_081215_VERSION.pdf (last visited Feb. 25, 2016) (listing attributes of healthy forests).

208. *Id.* (describing what falls under resilient fire).

209. *California Forests and Climate Change: Enhancing Carbon Storage through Forest Health*, CA.GOV (Feb. 9, 2015), *available at* http://www.fire.ca.gov/fcat/downloads/Forest%20Carbon%20Plan%20Outline%20Working%20Draft%202-9-2015.pdf (providing outline of FCAT's efforts to enhance forests' carbon storage).

regulatory framework of FCAT that would work with "[California's] Endangered Species Act[,] . . . NEPA requirements, . . . and national climate goals[.]"[210] The Forest Carbon Plan Vision states, "Our vision of forest protection and enhancement includes: [s]ustainable forests that are net sinks of carbon[;] [h]ealthy forests that are resilient to anticipated climate change effects, including volatile weather and changing precipitation regimes; increased forest insect and disease threats; and higher wildland fire risks."[211] Both the Oregon and California programs display unique proposals to combat deforestation and promote eco-services initiatives.[212]

B. Global

In Paris, on December 12, 2015, the "world's greatest diplomatic success" occurred as 196 countries agreed to reduce their carbon emissions in what is now known as the Paris Agreement.[213] "The [United Nations Framework Convention on Climate Change] [(]UNFCCC[)] . . . [provided a diplomatic] forum [for this success,] where[by] every country . . . [was] represented . . . equal[ly][,]" no matter its economy or population.[214] In this forum, all 196 countries agreed to secure and bolster the existing Reducing Emissions from Deforestation and Forest Degradation Program (REDD+).[215] The Paris Agreement provided REDD+'s first "political endorsement," although the U.N. created the program in 2008.[216] REDD+ incentivizes developing countries to responsibly manage their forests.[217] The U.N. believes placing a 'carbon' value

210. *See id.* (discussing regulatory framework involved in carbon storage programs).

211. *See Forest Carbon Plan Vision*, CA.GOV, *available at* http://www.fire.ca.gov/fcat/downloads/Forest%20Carbon%20Plan%20Vision%20Draft%202-9-2015.pdf (last visited Feb. 25, 2016) (outlining vision of Forest Carbon Plan).

212. For a discussion of state programs designed to combat deforestation, see *supra* notes 186-211 and accompanying text.

213. *See* Fiona Harvey, *Paris climate change agreement: the world's greatest diplomatic success*, THE GUARDIAN (Dec. 14, 2015, 2:51 PM), http://www.theguardian.com/environment/2015/dec/13/paris-climate-deal-cop-diplomacy-developing-united-nations (describing Paris climate agreement).

214. *See id.* (describing process of Paris agreement).

215. *See* Clayton Aldern, *The Paris Agreement has a few ideas about how to curb deforestation*, GRIST.ORG (Dec. 15, 2015), http://grist.org/climate-energy/the-paris-agreement-has-a-few-ideas-about-how-to-curb-deforestation/ (describing success of Paris Agreement); *see also References to Land Use and REDD+ in the adopted Paris Agreement*, EDF.ORG, *available at* http://blogs.edf.org/climatetalks/files/2015/12/Textreferences_adopted_Paris_agreement.pdf (last visited Feb. 4, 2016) (finding references to land use and REDD+ in Paris agreement).

216. Clayton Aldern, *supra* note 215 (emphasis in original removed) (discussing success of Paris Agreement).

217. *See id.* (describing how REDD+ works).

in standing trees can change deforestation trends.[218] "Having a value for carbon can provide incentives for forest resource users to change their use of forest resources if benefits reach them in a timely, appropriate[,] and effective manner that builds confidence in the process."[219] The U.N. recognizes the importance of predictable and enforceable policies and measures so that investors will feel secure to invest.[220] Due to the program's newness, however, the U.N is still defining these policies and measures.[221]

In response to developing countries that want to participate in REDD+, but who lack the resources to do so, the U.N. created "the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation [ ] in developing countries [(UN-REDD Programme)]."[222] The UN-REDD Programme provides support to countries' "in-depth technical needs[,] . . . such as [reporting and verification mechanisms], stakeholder engagement[,] and . . . [governance]."[223] Between 2011 and 2015, the UNN-REDD Programme aimed to support forty countries.[224] When these in-depth technical needs are met, the REDD+ program will feel secure to invite developed countries to invest in the predictable emission reductions countries have to offer.[225]

Brazil is the first country to implement and undergo verification procedures to receive results-based payment from the UNFCCC through the REDD+ program.[226] Under this procedure, the UNFCCC appoints experts to verify Brazil's reports regarding its "eliminate[ion] [of] illegal deforestation[ ] [and] . . . recover[ing] of forest ecosystems[.]"[227] In addition, Indonesia also accepted the UNFCCC invitation to participate in the REDD+ pro-

218. *See id.* (providing details regarding REDD+).

219. *See Frequently Asked Questions and Answers—The UN-REDD Programme and REDD+*, UN-REDD PROGRAMME, *available at* http://www.unep.org/forests/Portals/142/docs/UN-REDD%20FAQs%20%5B11.10%5D.pdf (last visited Feb. 4, 2016) (finding right incentive for reducing carbon outputs).

220. *See id.* (detailing factors of successful program).

221. *See id.* (noting effects of program's newness).

222. *See id.* (outlining how UN-REDD works).

223. *See id.* (emphasis in original removed) (describing UN-REDD).

224. *See Frequently Asked Questions and Answers—The UN-REDD Programme and REDD+*, *supra* note 219 (discussing success of UN-REDD).

225. *See id.* (showing interaction between UN-REDD and REDD+).

226. *See The Implementation of the Warsaw Framework for REDD+ by Brazil*, MINISTRY OF THE ENV'T, BRAZILIAN GOV'T, *available at* http://redd.mma.gov.br/images/publicacoes/wfr-brazil-2015.pdf (last visited Apr. 17, 2017) (detailing Brazil's deforestation policies).

227. *See id.* (detailing Brazil's deforestation policies).

gram.[228] In 2015, Indonesia submitted a proposal for a national "Forest Reference Emission Level[ ] . . . (FREL[)]" for deforestation and forest degradation.[229] This first step will help the UNFCCC deliver results-based payment for REDD+ related activities.[230] Within the proposal, Indonesia provided data of carbon emission levels from "deforestation, forest degradation[,] and peat decomposition [.]"[231] Ideally, after these rates of deforestation are identified, the UNFCCC will reward Indonesia for effective reduction of these emission levels.[232] These programs and countries' participation in them illustrates the international community's willingness to combat deforestation and promote eco-services.[233]

VI. CONCLUSION

> "What an irony it is that these living beings whose shade we sit in, whose fruit we eat, whose limbs we climb, whose roots we water, to whom most of us rarely give a second thought, are so poorly understood. We need to come, as soon as possible, to a profound understanding and appreciation for trees and forests and the vital role they play, for they are among our best allies in the uncertain future that is unfolding."
>
> —Jim Robbins[234]

The circular relationship between deforestation and climate change presents both a challenge and an opportunity for the global community.[235] The challenge relates to the scale and complexity of

228. Arief Dharmawan et al., *Submission by Indonesia - NATIONAL FOREST REFERENCE EMISSIONS LEVEL FOR REDD+ In the Context of Decision 1/CP.16 Paragraph 70 UNFCCC*, DIRECTORATE GEN. OF CLIMATE CHANGE, THE MINISTRY OF ENV'T & FORESTRY, REPUBLIC OF INDON., *available at* http://redd.unfccc.int/files/national_frel_for_redd__in_indonesia_2015.pdf (last visited Feb. 4, 2016) (detailing Indonesia's deforestation rates).

229. *See id.* (proposing solution to Indonesia's problem with deforestation).

230. *See id.* (describing Indonesia's deforestation).

231. *See id.* (detailing Indonesia's deforestation practices).

232. *See Frequently Asked Questions and Answers—The UN-REDD Programme and REDD+*, *supra* note 219 (detailing motivational practices by UN-REDD PROGRAMME to attract more countries).

233. For a discussion of global programs aiming to combat deforestation, see *supra* notes 213-232 and accompanying text.

234. *Overpopulation, overconsumption - in pictures*, THE GUARDIAN (Apr. 1, 2015, 8:29 PM), http://www.theguardian.com/global-development-professionals-network/gallery/2015/apr/01/over-population-over-consumption-in-pictures (showing effects of overpopulation).

235. For a discussion of the challenges of deforestation and climate change, see *supra* notes 50-147 and accompanying text; additionally, for a discussion of the

the relationship.[236] Deforestation and its effects are a global issue.[237] Further, the science behind eco-climatology is incredibly complex, and requires years of detailed studies.[238] The opportunity arises because society already knows how to mitigate the destructive relationship of climate change and deforestation.[239] David Foster, a research ecologist at the Smithsonian Conservation Biology Institute, commented on this opportunity.[240] He asserted,

> The good news is that forests are resilient[,] and history is not necessarily destiny. Our research makes a compelling case for expanding support for forestland protection and for efforts of private landowners to keep their land forested. It reminds us that forests provide important infrastructure that we should invest in[.][241]

Perhaps the cycle of destruction will finally be broken when we understand and respect the value of forests by halting deforestation and rehabilitating forests.[242]

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opportunities of forest management, see *supra* notes 154-233 and accompanying text.

236. For a discussion of the scale of deforestation, see *supra* notes 38-59 and accompanying text.

237. For a discussion of the global nature of deforestation, see *supra* notes 50-119 and accompanying text.

238. For a discussion of the science behind eco-climatology, see *supra* notes 69-119 and accompanying text.

239. For a discussion of how to mitigate deforestation see *supra* notes 154-233 and accompanying text.

240. *Development will reduce carbon stored in forests, Smithsonian & Harvard scientists predict*, SMITHSONIAN INSIDER (Apr. 16, 2012), http://insider.si.edu/2012/04/development-will-reduce-carbon-stored-in-forests-smithsonian-harvard-scientists-predict/ (commenting on opportunity of forest management).

241. *Id.* (quotation marks omitted) (quoting David Foster) (describing forest's resiliency).

242. For a discussion of efforts to prevent deforestation, see *supra* notes 154-233 and accompanying text.

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