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All I Want for Christmas Is a Carbon Sink

TORI TIMMONS[†]

Anthropogenic climate change is among the gravest problems humanity faces. Nonetheless, global greenhouse gas emissions are not slowing, and the complete elimination of greenhouse gas emissions is not currently foreseeable. American culture and industries rely on activities and technologies that overuse greenhouse-gas-emitting fuel. Despite ever-increasing awareness and concern, many Americans feel apathetic and discouraged regarding behavioral changes for the benefit of the environment, even those who acknowledge the existence and exigency of climate change. In order to make a real impact, and nullify any barriers to action, climate change-focused laws must encompass everyday behaviors. Enter the American Christmas tree market. Dangerously high levels of atmospheric greenhouse gases can be tackled by reducing emissions and increasing absorption and storage of carbon, which can offset continued pollution. Carbon offset projects absorb more carbon than they emit. These projects can be funded by greenhouse-gas-emitting entities that are offsetting their over-pollution. If Christmas tree farms implement practices that are eligible as carbon offset projects, players in the American Christmas tree industry will be subsidized for adjusting their practices in favor of sustainable methods that increase the carbon sequestration of their Christmas tree crops and farmland. Through the implementation of laws that target the reduction of greenhouse gas emissions and the optimization of greenhouse gas sinks on Christmas tree farms, the American Christmas tree industry can become a net-positive climate activity and meet the requirements set by carbon offset programs. This Note will focus primarily on the legal tools that can encourage and require changes in the production of natural Christmas trees in the United States and whether such changes meet common eligibility criteria for carbon offset credits.

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TABLE OF CONTENTS

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) estimates that we have only until 2030 to limit global warming to a maximum of 1.5 degrees Celsius above pre-industrial temperatures in order to avoid climate catastrophe.[1] Anthropogenic—human-caused—greenhouse gas emissions have created unprecedented concentrations of atmospheric carbon dioxide, methane, nitrous oxide, and other greenhouse gases.[2] Complete elimination of greenhouse gas emissions is not immediately feasible,[3] and Americans have deep-seated habits of overusing resources and over-polluting.[4] However, Americans interact with a huge variety of industries and sectors which hold opportunities for mitigation and adaptation.[5] Changing fundamental lifestyle behaviors will be essential to effectively mitigate climate change.[6]

The Christmas tree industry is one example of the abundant opportunities to address climate change through changes in ordinary behaviors. Americans

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1. Jonathan Watts, *We Have 12 Years to Limit Climate Change Catastrophe, Warns UN*, GUARDIAN (Oct. 8, 2018, 2:23 AM), https://www.theguardian.com/environment/2018/oct/08/global-warming-must-not-exceed-15c-warns-landmark-un-report; *Carbon Offsets Are Not Our Get-Out-of-Jail Free Card*, U.N. ENV'T PROGRAMME (June 10, 2019), https://www.unenvironment.org/news-and-stories/story/carbon-offsets-are-not-our-get-out-jail-free-card; *see also* IPCC, GLOBAL WARMING OF 1.5°C (2019), https://www.ipcc.ch/sr15/ [hereinafter IPCC REPORT ON GLOBAL WARMING OF 1.5°C]; *Goal 13: Take Urgent Action to Combat Climate Change and Its Impacts*, UNITED NATIONS, https://www.un.org/sustainabledevelopment/climate-change/ (last visited Apr. 19, 2021).

2. IPCC, CLIMATE CHANGE 2014 SYNTHESIS REPORT 4 (2015), https://www.ipcc.ch/report/ar5/syr/ [hereinafter IPCC FIFTH ASSESSMENT REPORT]. Anthropogenic climate change is caused primarily by the emission of greenhouse gases into the atmosphere. *Id.* at 48. A greenhouse gas is a gas that traps heat in the atmosphere, causing global warming and, ultimately, climate change. *Overview of Greenhouse Gases*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/ghgemissions/overview-greenhouse-gases (last visited Apr. 19, 2021); *Glossary of Climate Change Acronyms and Terms*, U.N. CLIMATE CHANGE, https://unfccc.int/process-and-meetings/the-convention/glossary-of-climate-change-acronyms-and-terms (last visited Apr. 19, 2021). The main greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). *Id.*

3. *See* Kelly Levin, *New Global CO2 Emissions Numbers Are In. They're Not Good.*, WORLD RES. INST. (Dec. 5, 2018), https://www.wri.org/blog/2018/12/new-global-co2-emissions-numbers-are-they-re-not-good; Chris Mooney & Brady Dennis, *Global Greenhouse Gas Emissions Will Hit Yet Another Record High This Year, Experts Project*, WASH. POST (Dec. 3, 2019, 7:01 PM), https://www.washingtonpost.com/climate-environment/2019/12/03/global-greenhouse-gas-emissions-will-hit-yet-another-record-high-this-year-experts-project/; U.S. ENV'T PROT. AGENCY, DRAFT INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2018, at 2-1 (2020), https://www.epa.gov/sites/production/files/2020-02/documents/us-ghg-inventory-2020-main-text.pdf; Alistair Scrutton, *Global Carbon Budget Estimates Global CO2 Emissions Still Rising in 2019*, FUTURE EARTH (Dec. 3, 2019), https://futureearth.org/2019/12/03/globalcarbonbudget2019/.

4. *See, e.g.*, Laura Sydell, *America's Car Culture Clashes with Climate Change*, NPR (Sept. 3, 2007, 4:00 PM), https://www.npr.org/templates/story/story.php?storyId=14142358; Terry Nguyen, *Amazon's 1-Day Shipping Is Convenient—and Terrible for the Environment*, VOX (Oct. 16, 2019, 1:40 PM), https://www.vox.com/the-goods/2019/10/16/20917467/amazon-one-day-shipping-bad-for-environment; RENÉE JOHNSON, CONG. RSCH. SERV., GREENHOUSE GAS EMISSIONS AND SINKS IN U.S. AGRICULTURE 1 (2018), https://crsreports.congress.gov/product/pdf/IF/IF10979/2.

5. *See* S. Pacala & R. Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 SCI. 968, 970 tbl.1 (2004).

6. *See generally* Karine Lacroix & Robert Gifford, *Psychological Barriers to Energy Conservation Behavior: The Role of Worldviews and Climate Change Risk Perception*, 50 ENV'T & BEHAV. 1, 2 (2017) (analyzing cognitive barriers to climate change and their relationships to energy conservation behavior).

purchased over twenty-six million natural Christmas trees in 2019.[7] Presently, despite the potential for farms and the crops they produce to sequester and store greenhouse gases, Christmas tree farms are instead estimated to be net producers of greenhouse gases.[8] Although some governments encourage sustainable farming methods, little to no legislation exists requiring the implementation of sustainable farming methods; any legislation that does exist is composed of mere suggestions.[9]

In the absence of legislation governing sustainable farming methods, Christmas tree farms represent an opportunity to create legislation on foundational aspects of Christmas tree production that will have a sizable impact on emissions reduction. The increasing climate consciousness in the agricultural community,[10] increasing consumer demand for sustainable products,[11] and growing awareness and concern about climate change[12] will likely reduce resistance to such regulation. New legislation is needed because existing legal frameworks are insufficient. Land-use regulation is focused on either agriculture or forestry;[13] however, Christmas tree farms are typically classified as

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7. *The Real Story About the Supply and Price of Christmas Trees in 2019*, NAT'L CHRISTMAS TREE ASS'N, https://realchristmastrees.org/2020/04/06/the-real-story-about-the-price-of-christmas-trees-in-2019/ (last visited Apr. 19, 2021).

8. SYLVAIN COUILLARD, GONTRAN BAGE & JEAN-SÉBASTIEN TRUDEL, COMPARATIVE LIFE CYCLE ASSESSMENT (LCA) OF ARTIFICIAL VS NATURAL CHRISTMAS TREE 24 (2009).

9. *See Sustainable Agriculture*, NAT'L AGRIC. L. CTR., https://nationalaglawcenter.org/research-by-topic/sustainable-agriculture/ (last visited Apr. 19, 2021) (listing the limited statutes, regulations, and case law on sustainable farming, which do not *require* sustainable farming practices); *see, e.g.*, 16 U.S.C. § 3839aa-21(3) (2018) (defining a "conservation stewardship plan" as a plan that, in pertinent part, describes conservation activities and provides for the planning, installation, and management of such activities without requiring conservation activities to be adopted); *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/ (last visited Apr. 19, 2021) (crediting the conservation successes of the program to "voluntary participation by farmers and landowners").

10. *See* Helena Bottemiller Evich, *How a Closed-Door Meeting Shows Farmers Are Waking Up on Climate Change*, POLITICO (Dec. 9, 2019, 5:04 AM), https://www.politico.com/news/2019/12/09/farmers-climate-change-074024; Jeff Berardelli, *"Everything Is Changing": Farmers Seek Solutions, Not Slogans, on Climate Change*, CBS NEWS (July 29, 2019, 12:07 PM), https://www.cbsnews.com/news/climate-change-language-partisan-divide-cbsn-originals/.

11. RANDI KRONTHAL-SACCO & TENSIE WHELAN, SUSTAINABLE SHARE INDEX: RESEARCH ON IRI PURCHASING DATA (2013–2018), at 3 (2019), https://www.stern.nyu.edu/sites/default/files/assets/documents/NYU%20Stern%20CSB%20Sustainable%20Share%20Index%E2%84%A2%202019.pdf; CGS, *CGS Survey Reveals Sustainability Is Driving Demand and Customer Loyalty*, GLOBENEWSWIRE (Jan. 10, 2019, 8:30 AM), https://www.globenewswire.com/news-release/2019/01/10/1686144/0/en/CGS-Survey-Reveals-Sustainability-Is-Driving-Demand-and-Customer-Loyalty.html.

12. Drew Kann, *Poll: Americans Are More Concerned Now About Climate Change*, MERCURY NEWS (Jan. 17, 2020, 2:18 PM), https://www.mercurynews.com/2020/01/17/poll-americans-are-more-concerned-now-about-climate-change/.

13. *See, e.g.*, DEP'T OF REVENUE, WASH. STATE, PROPERTY TAX ADVISORY: CLASSIFICATION OF LAND USED FOR CHRISTMAS TREE PRODUCTION 1 (2014), https://dor.wa.gov/sites/default/files/legacy/Docs/Pubs/Prop_Tax/PTA12_3_2014.pdf (clarifying the statutory guidelines for designation as a Christmas tree farm—distinguishing such farms from agriculture and forest land—and listing criteria for eligibility).

agroforestry.[14] Systems within the agroforestry land-use category have unique greenhouse gas sequestration potential,[15] so regulations should be tailored to agroforestry and related land-management practices. The untapped potential carbon savings, widespread impact, and global urgency of climate change create a unique opportunity for cogent law. Given this alignment, the federal Environmental Protection Agency (EPA), and other similar entities, should draft rules that are tailored to agroforestry-specific circumstances and fill the existing gaps in greenhouse-gas-emission regulation.

Part I will provide background about the American Christmas tree industry, the lifecycle of the common species, and the greenhouse gas emissions of Christmas tree production. Part II will discuss opportunities for reducing greenhouse gas emissions, maximizing greenhouse gas sequestration, and storing greenhouse gases throughout Christmas tree production. Part II will also introduce the carbon offset market and discuss the criteria that projects must meet to be eligible for registration. Finally, Part III will propose a legal framework and analyze the eligibility of the components of that framework for registration as carbon offset projects. This Note focuses primarily on the problems and opportunities surrounding the greenhouse gas emissions and sequestration in natural Christmas tree production. This Note will not address artificial Christmas trees,[16] the disposal of natural Christmas trees,[17] whether the establishment of new Christmas tree farms may be eligible for registration as a carbon offset project, or the ideal carbon offset system within which Christmas tree farms may fit.[18]

14. *See* Andrea De Stefano & Michael G. Jacobson, *Soil Carbon Sequestration in Agroforestry Systems: A Meta-Analysis*, 92 AGROFORESTRY SYS. 285, 289 tbl.1 (2017) (describing types of agroforestry, which encompasses systems that include multispecies tree gardens and trees on pastures).

15. Samantha K. Chapman, Reena U. Palanivel & J. Adam Langley, *Soil Carbon Stability Responds to Land-Use and Groundcover Management in Southern Appalachian Agroecosystems*, 76 SOIL SCI. SOC'Y AM. J. 2221, 2222 (2012).

16. Taxing imported artificial trees has the potential to encourage consumers to purchase local, natural trees and capitalize on the carbon uptake natural trees are capable of.

17. A significant portion of a natural Christmas tree's carbon footprint comes from customers disposing their used Christmas trees in a landfill or by burning. *Is It More Environmentally Friendly to Buy a Fake Christmas Tree, or a Real One?*, SCI. FOCUS, https://www.sciencefocus.com/planet-earth/is-it-more-environmentally-friendly-to-buy-a-fake-christmas-tree-or-a-real-one/ (last visited Apr. 19, 2021). Local tree mulching and composting programs through sanitation departments, or more creative options such as donating used Christmas trees to the local zoo as a toy or treat for the animals, have great potential to mitigate this source of greenhouse gases from Christmas trees' lifecycles. *See, e.g.*, *Mulchfest: Say Fir-Well to Your Holiday Tree at NYC Parks!*, NYC PARKS, https://www.nycgovparks.org/highlights/festivals/mulchfest (last visited Apr. 19, 2021); Julia Banim, *Many Zoos Accept Donated Christmas Trees to Feed Animals With*, UNILAD (Oct. 26, 2017, 11:32 AM), https://www.unilad.co.uk/animals/many-zoos-accept-donated-christmas-trees-to-feed-animals-with.

18. *See* ANJA KOLLMUSS, HELGE ZINK & CLIFFORD POLYCARP, MAKING SENSE OF THE VOLUNTARY CARBON MARKET: A COMPARISON OF CARBON OFFSET STANDARDS 15 (2008), https://mediamanager.sei.org/documents/Publications/SEI-Report-WWF-ComparisonCarbonOffset-08.pdf. This Note will assess whether new efforts on existing Christmas tree farms may be eligible for registration as carbon offset projects. *See infra* Part III.E.

I. THE AMERICAN CHRISTMAS TREE

The potential impact of changes in Christmas tree production is primarily due to the size of the Christmas tree industry and the way in which trees are typically produced. In 2019, Americans purchased approximately 26.2 million natural Christmas trees at a median price of $76.87, spending over $2 billion.[19] It was estimated that nearly ninety-six million American households would purchase a Christmas tree for their home that year, though only about nineteen percent of those households would purchase a natural tree.[20] Because of the size of the natural Christmas tree industry alone, in terms of money and customers, changes in the American Christmas tree market related to greenhouse gas emissions and sequestration have the potential to make a sizable impact on atmospheric greenhouse gases and bring greater public awareness to climate change mitigation.

To support the holiday tradition, approximately 350,000 acres in the United States are used to grow nearly 350 million Christmas trees.[21] Over seventy-seven million trees are produced each year at Christmas tree farms across all fifty states.[22] The number of years between planting on the Christmas tree farm and the harvest of those trees is called a rotation.[23] As the young trees are cultivated, farmers prune, shear, and care for them.[24] A tree's rotation varies depending on its species, the soil, the climate, and other factors.[25] Some trees have a rotation as short as four years; others are as long as fifteen years.[26] The average rotation of the common Christmas tree species is about seven years.[27] By this time, the tree has grown to be between seven and eight feet tall, the most common height range for saleable trees.[28]

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19. *See The Real Story About the Supply and Price of Christmas Trees in 2019*, *supra* note 7.

20. *Ninety-Six Million U.S. Households Will Celebrate the Christmas Holiday with a Christmas Tree in 2019*, MKTS. INSIDER (Dec. 10, 2019, 5:00 PM), https://markets.businessinsider.com/news/stocks/ninety-six-million-u-s-households-will-celebrate-the-christmas-holiday-with-a-christmas-tree-in-2019-1028752619.

21. *Quick Tree Facts*, NAT'L CHRISTMAS TREE ASS'N, https://realchristmastrees.org/dnn/Education/Quick-Tree-Facts (last visited Apr. 19, 2021).

22. *History of Christmas Trees*, HISTORY, https://www.history.com/topics/christmas/history-of-christmas-trees (Dec. 2, 2020).

23. ROBERT D. WRAY, CHRISTMAS TREES FOR PLEASURE AND PROFIT 60 (4th ed. 2008). Novice Christmas tree farmers are encouraged to start their farms with saplings that are at least a couple years old. *Id.* at 28–29; Jack Hope, *Starting a Christmas Tree Business*, MOTHER EARTH NEWS, https://www.motherearthnews.com/homesteading-and-livestock/christmas-tree-business-zmaz90ndzshe (last visited Apr. 19, 2021). Therefore, seeds are often planted and cultivated at nurseries and, later, saplings are purchased by farmers and transplanted into the fields on their Christmas tree farms. WAP SUSTAINABILITY CONSULTING, LIFE CYCLE ASSESSMENT: COMPARATIVE LCA OF THE ENVIRONMENTAL IMPACTS OF REAL CHRISTMAS AND ARTIFICIAL CHRISTMAS TREES 16 (2018), https://8nht63gnxqz2c2hp22a6qjv6-wpengine.netdna-ssl.com/wp-content/uploads/2018/11/ACTA_2018_LCA_Study.pdf [hereinafter ACTA 2018 LIFE CYCLE ASSESSMENT].

24. ACTA 2018 LIFE CYCLE ASSESSMENT, *supra* note 23, at 16–17; WRAY, *supra* note 23, at 60–61, 105–12.

25. WRAY, *supra* note 23, at 17–27, 61.

26. *Quick Tree Facts*, *supra* note 21.

27. *Id.*

28. WRAY, *supra* note 23, at 61.

Trees are then cut down and tied up for transport or, if it is a "choose and cut" Christmas tree farm, customers can visit the farm to pick their still-live tree and cut it down that same day.[29] Farmers typically plant in sections, called blocks, so that farmers have steady income from annual harvests; the trees on one block are harvested while the trees on other blocks continue to mature.[30] After a block has been harvested, farmers clear the fields by removing stumps to prevent rotting and the spread of disease to healthy trees; then farmers wait until the spring to replant.[31] Because not every tree that is planted will be saleable, whether due to death, disease, slower growth, or undesirable shape, farmers typically plant several transplants for every tree they harvest.[32] In each stage of Christmas tree production, there are greenhouse gas emissions; many of the emissions are caused by farming practices such as tilling soil, using pesticides and fertilizers, machine use, and unsustainable harvest methods.[33] The emissions from these practices are explained in more detail below.

A. Christmas Tree Production and Its Environmental Implications

Throughout the production of a Christmas tree, there are natural and anthropogenic sources of greenhouse gas emissions.[34] Greenhouse gas emissions to the atmosphere are part of the natural lifecycle of trees and other plants.[35] Needles, flowers, fruit, branches, and bark may fall off the tree, decompose, and release greenhouse gases, some of which are stored in the soil and some of which are released to the atmosphere.[36] However, the significant sources of greenhouse gas emissions in the production of Christmas trees are anthropogenic, that is human-caused, usually emitted through cultivation and

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29. ACTA 2018 Life Cycle Assessment, *supra* note 23, at 16; *see* Wray, *supra* note 23, at 149, 153–56, 163; *Selection Tips*: *What to Look for When Buying a Tree*, Nat'l Christmas Tree Ass'n, https://realchristmastrees.org/All-About-Trees/Selection-Tips (last visited Apr. 19, 2021). Approximately twenty-two percent of natural Christmas trees sold in the United States are chosen and cut by the customers that visit farms; the remainder are pre-cut. Lisa Munniksma, *About Christmas Tree Farms*, Hobby Farms (Sept. 28, 2015), https://www.hobbyfarms.com/about-christmas-tree-farms-3/.

30. Wray, *supra* note 23, at 48–49, 63–67.

31. *Christmas Tree Farming Throughout the Year*, Collopy Fam. Farm, https://collopyfamilyfarm.com/your-christmas-tree/christmas-tree-farming-throughout-the-year/ (last visited Apr. 19, 2021); *Christmas Tree Farming Throughout the Year*, Wadsworth Christmas Tree Farm, http://www.wadsworthchristmastrees.com/Christmas-Tree-Farming-Throughout-the-Year.html (last visited Apr. 19, 2021) [hereinafter Wadsworth Christmas Tree Farm]; Wray, *supra* note 23, at 147–49.

32. *See* Wray, *supra* note 23, at 35–36, 47, 138–39; *Christmas Tree Facts*, Univ. of Ill. Extension: Christmas Trees & More, https://web.extension.illinois.edu/trees/facts.cfm (last visited Apr. 19, 2021); *Quick Tree Facts*, *supra* note 21.

33. ACTA 2018 Life Cycle Assessment, *supra* note 23, at 16–22.

34. *Id.*; *see also* Wray, *supra* note 23, at 93–104 (discussing human-powered and machine-powered tools to keep plantations clean during tree rotation).

35. *The Carbon Cycle*, Univ. Corp. for Atmospheric Rsch., https://scied.ucar.edu/carbon-cycle (last visited Apr. 19, 2021).

36. *Id.*; Rattan Lal, *Digging Deeper: A Holistic Perspective of Factors Affecting Soil Organic Carbon Sequestration in Agroecosystems*, 24 Glob. Change Biology 3285, 3287 fig.2 (2018).

related land-use and land-management practices.[37] Typical farming activities, including manipulating soil by tilling, applying fertilizers and pesticides, using fossil-fueled machinery, and harvesting unsustainably, cause greenhouse gases to be released into the atmosphere and disrupt the natural greenhouse-gas uptake and storage of trees and soil.[38] This Subpart will explore these activities and their emissions impact in more detail.

1. Tilling

Historically, soil cultivation has constituted the largest fraction of agricultural emissions.[39] Tilling is intended to "incorporate or remove crop residues, kill weeds, and prepare land for irrigation."[40] For Christmas tree farms in particular, tilling is recommended as a technique to loosen up heavy sod before planting because young trees are happiest when their roots are surrounded by loose soil.[41] Tilling heavy sod also makes it easier to plant trees and disrupts the competing vegetation, potentially reducing mortality and improving the form and growth rate of the Christmas trees.[42] Because tilling requires digging, overturning, and stirring the soil, it releases significant amounts of the greenhouse gases stored in the topsoil into the atmosphere.[43] The practice is recommended as a last-resort alternative to applying pesticides.[44]

2. Pesticides

Pesticides cause significant disruption in the soil and its microorganisms, producing significant greenhouse gas emissions.[45] Using pesticides is recommended to help farmers manage the vegetation, insects, and fungi on the

37. *See* ACTA 2018 LIFE CYCLE ASSESSMENT, *supra* note 23, at 38; *Overview*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#ca (last visited Apr. 19, 2021).

38. *Land Use, Land-Use Change, and Forestry Sector Emissions and Sequestration*, *Sources of Greenhouse Gas Emissions*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#land-use-and-forestry (last visited Apr. 19, 2021); KENDRA KLEIN, FRIENDS OF THE EARTH, PESTICIDES AND SOIL HEALTH 3–4 (2019), http://foe.org/wp-content/uploads/2019/08/PecticidesSoilHealth_Final-1.pdf.

39. William J. Parton, Myron P. Gutmann, Emily R. Merchant, Melannie D. Hartman, Paul R. Adler, Frederick M. McNeal & Susan M. Lutz, *Measuring and Mitigating Agricultural Greenhouse Gas Production in the US Great Plains, 1870–2000*, 112 PNAS, Aug. 25, 2015, at E4681, E4681.

40. *Methods of Regenerative Agriculture #2: Zero or Low Tillage & Mulching*, GREEN AM. (Feb. 20, 2018), https://greenamerica.org/blog/methods-regenerative-agriculture-2?_ga=2.52027881.1541346820.1583088855-1561391934.1580856154.

41. *See* WRAY, *supra* note 23, at 43, 94–95.

42. *Id.* at 15, 44–45, 94–95.

43. *Land Use, Land-Use Change, and Forestry Sector Emissions and Sequestration*, *Sources of Greenhouse Gas Emissions*, *supra* note 38; *Methods of Regenerative Agriculture #2: Zero or Low Tillage & Mulching*, *supra* note 40; Humberto Blanco-Canqui & R. Lal, *No-Tillage and Soil-Profile Carbon Sequestration: An On-Farm Assessment*, 72 SOIL SCI. SOC'Y AM. J. 693, 693 (2008). However, a study comparing soil organic carbon levels between no-tilling farming systems and plow-tilling farming systems showed that no-tilling systems increased soil organic carbon levels in less than half of the studied plots, and the change was isolated to the top four inches of soil. *Id.*

44. WRAY, *supra* note 23, at 44–45.

45. KLEIN, *supra* note 38, at 3–4.

plantation during tree growth.[46] Pesticides are a supplement that can kill weeds while leaving enough vegetation to protect against erosion and reduce the need for mowing.[47] In some cases, farmers must use pesticides to ensure that they can export trees to states or countries with strictly enforced bans against imported pests.[48] However, pesticides cause significant carbon loss primarily by disrupting soil microorganism networks.[49] By changing the diversity and composition of the soil, pesticides alter the manner and effectiveness of soil carbon sequestration.[50] The insects, fungi, and vegetation that are targeted by the pesticides release carbon back into the atmosphere as they die and decompose.[51] Worse still, untargeted insects, fungi, and vegetation make up the majority of organisms harmed by pesticide applications.[52]

3. Fertilizers

The use of synthetic fertilizers is an even larger portion of the greenhouse gas emissions caused by agriculture.[53] Using petroleum-based fertilizers is one recommended method for improving crop growth during the trees' rotation.[54] The problem lies in the impact of these chemicals on the environment, particularly the air.[55] Both the use and the manufacturing of synthetic fertilizers are sources of greenhouse gas emissions.[56] The production of synthetic fertilizers requires the use of large quantities of fossil fuels,[57] and, although the use of fertilizers can stimulate plant growth, fertilizers offer little benefit to soil health which has far greater potential to sequester carbon than vegetation.[58]

4. Machinery

Moreover, the increased use of fueled machinery has further exacerbated the emissions produced from farm operations.[59] Significant greenhouse gas

46. *See* WRAY, *supra* note 23, at 43–44, 139.

47. *Id.* at 43, 96–97.

48. Hannah Wallace, *Seasons Greening: How Christmas Tree Farmers Are Cutting Down on Pesticides*, CIV. EATS (Dec. 11, 2014), https://civileats.com/2014/12/11/seasons-greening-how-christmas-tree-farmers-are-cutting-down-on-pesticides/.

49. KLEIN, *supra* note 38, at 3–4.

50. *See id.* at 4.

51. *Id.*; *The Carbon Cycle*, *supra* note 35.

52. KLEIN, *supra* note 38, at 4.

53. *Climate Change and Agriculture Fact Sheet*, PESTICIDE ACTION NETWORK EUR., https://www.pan-europe.info/old/Resources/Factsheets/Climate_change.pdf.

54. WRAY, *supra* note 23, at 43–44.

55. *How Our Food System Affects Climate Change*, FOODPRINT, https://foodprint.org/issues/how-our-food-system-affects-climate-change/ (last visited Apr. 19, 2021).

56. Brian Barth, *Pro & Cons of Petrochemical Fertilizers*, S.F. GATE, https://homeguides.sfgate.com/pro-cons-petrochemical-fertilizers-86254.html (last visited Apr. 19, 2021).

57. *Id.*

58. *Id.*; *see infra* Part II.B.

59. Alla Katsnelson, *Stump-Grown Christmas Trees Are the Gift That Keeps on Giving*, SMITHSONIAN MAG. (Dec. 20, 2018), https://www.smithsonianmag.com/science-nature/coppice-farming-grows-christmas-trees-keep-giving-180971068/; WRAY, *supra* note 23, at 89–92.

emissions on Christmas tree farms come from the use of machines to prepare the land, manage vegetation, harvest trees, and prepare trees for transport and sale.[60] Commonly used machines include mowers, tractors with a bush hog, roller crimpers, spraying machines for fertilizers and pesticides, helicopters or small planes to spray chemicals or to air lift trees out of tight plantations, power augers to drill holes for planting trees, mechanical shearing tools, chainsaws, mechanical shakers, balers, and color applicators for greening or needle retention spray.[61] In large part, these machines have motors and use fossil fuels to operate,[62] but manual alternatives exist for many of these tools.[63] Even if farmers choose to eliminate fossil-fueled tools such as chainsaws, or use an electric equivalent, they can still cause significant emissions by harvesting the Christmas trees unsustainably.[64]

5. *Harvest*

Finally, harvest practices are also a source of greenhouse gas emissions from Christmas tree farms.[65] When trees are harvested, they lose their ability to absorb greenhouse gases and begin to release it back into the atmosphere as they decay.[66] When non-saleable trees are later disposed of by burning or being left in a landfill, the combustion and decomposition of the biomass that respectively result release significant volumes of greenhouse gases to the atmosphere.[67] Because significant amounts of greenhouse gases are released from the combustion of organic matter, any burning should be limited to pyrolysis for the creation of biochar.[68] Alternatives exist for disposing of and repurposing the damaged trees, including mulching and composting.[69]

In spite of all these sources of greenhouse gas emissions from Christmas tree production, Christmas tree farms can also sequester and store greenhouse

60. *See* ACTA 2018 LIFE CYCLE ASSESSMENT, *supra* note 23, at 4; *Which Christmas Tree Is Better for the Environment—Real or Artificial?*, PURDUE UNIV. EXTENSION: FORESTRY & NAT. RES. (Nov. 27, 2015), https://www.purdue.edu/fnr/extension/which-christmas-tree-is-better-for-the-environment-real-or-artificial-2/.

61. WADSWORTH CHRISTMAS TREE FARM, *supra* note 31; WRAY, *supra* note 23, at 95–97, 149, 153–56; Munniksma, *supra* note 29; *Organic No-Till*, RODALE INST., https://rodaleinstitute.org/why-organic/organic-farming-practices/organic-no-till/ (last visited Apr. 19, 2021); Wallace, *supra* note 48. Larger plantations typically use larger machines, such as "a double mower pulled by a tractor," mechanical planters, and tractor-mounted herbicide sprayers. WRAY, *supra* note 23, at 46, 95–97, 101.

62. *See, e.g.*, FRASER KNOLL, FALL 2020 PRODUCT GUIDE 18, 44, 46, 62 (2020), http://fraserknoll.com/catalog2020.pdf.

63. *See, e.g.*, *id.* at 18, 20, 64; WRAY, *supra* note 23, at 75, 97, 101, 109–10.

64. NICHOLAS INST. FOR ENV'T POL'Y SOLS., HARNESSING FARMS AND FORESTS IN THE LOW-CARBON ECONOMY 24–25 (Zach Willey & Bill Chameides eds., 2007).

65. *Id.*

66. *Id.*

67. *Id.* at 24.

68. *Is It More Environmentally Friendly to Buy a Fake Christmas Tree, or a Real One?*, *supra* note 17; *see infra* Part II.B.5.

69. *See Can You—SHOULD You—Compost Diseased Tree Leaves*, GARDENS ALIVE, https://www.gardensalive.com/product/ybyg-can-you-should-you-compost-deseased-tree-leaves (last visited Apr. 19, 2021).

gases.[70] These carbon uptake and storage methods are underutilized and, consequently, American Christmas tree production is a net-producer of greenhouse gases.[71] Through minimizing each of these common Christmas-tree-farming activities and maximizing carbon uptake and storage, farmers have an opportunity to ensure that American Christmas tree production is a sustainable, net-neutral, or net-negative carbon industry.

II. OPPORTUNITIES FOR SUSTAINABLE CHRISTMAS TREE PRODUCTION

Christmas tree production has the potential to mitigate atmospheric greenhouse gases. There are three main categories of mitigation techniques applicable to Christmas tree cultivation. First, there are direct techniques and activities that reduce greenhouse gas emissions from the sources noted above.[72] Second, Christmas tree farmers can employ techniques to optimize the sequestration of Christmas tree production. Finally, there are exogenous incentives to reduce greenhouse gas emissions, specifically via the carbon offset market.

A. REDUCING EMISSIONS

Farmers can reduce greenhouse gas emissions from their Christmas tree production by minimizing or eliminating activities that cause emissions on the farm. By altering their tilling practices, pesticide use, fertilizer use, machinery, and harvest methods, farmers can significantly decrease the volume of greenhouse gas emissions from their operations.

1. Tilling

Farmers can engage in low-tilling or no-tilling to reduce the risks of greenhouse gas emissions from the soil.[73] While many scientists maintain that no-till systems mitigate greenhouse gas emissions and dramatically improve soil carbon stocks,[74] thereby improving the overall quality of soil, other studies have yielded inconclusive or contrary evidence.[75] Consequently, no-till practices

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70. COUILLARD ET AL., *supra* note 8, at 18, 24.

71. *Id.*

72. *See supra* Part I.

73. Stefanie Spears, *What Is No-Till Farming?*, REGENERATION INT'L (June 24, 2018), https://regenerationinternational.org/2018/06/24/no-till-farming/.

74. Carbon stocks are a measure of the mass of carbon that is stored in a carbon pool at a moment in time. Alain Karsenty, Cécile Blanco & Thomas Dufour, *Forests and Climate Change: Instruments Related to the United Nations Framework Convention on Climate Change and Their Potential for Sustainable Forest Management in Africa* (Food & Agric. Org. Forestry Prods. Div., Working Paper No. 1, 2002), http://www.fao.org/3/ac836e/AC836E03.htm. Carbon pools are ecological reservoirs of carbon, such as the Earth's soil or surface-level ocean, that have the potential to amass or emit carbon. *Id.*

75. *See* RODALE INST., COVER CROPS AND NO-TILL MANAGEMENT FOR ORGANIC SYSTEMS 1 (2011), https://western.sare.org/wp-content/uploads/Cover-Crops-And-No-Till-Management-for-Organic-Systems.pdf; Keith Paustian, Johannes Lehmann, Stephen Ogle, David Reay, G. Philip Robertson & Pete Smith, *Climate-Smart Soils*, 532 NATURE 49, 50 (2016); Stephen M. Ogle, Cody Alsaker, Jeff Baldock, Martial Bernoux, F. Jay Breidt, Brian McConkey, Kristiina Regina & Gabriel G. Vasquez-Amabile, *Climate and Soil Characteristics*

remain controversial.[76] Even if there are no direct reductions of greenhouse gas emissions by these practices, no-till systems reduce, and can even eliminate, the use of pesticides and may change or reduce fossil-fueled machine use, and cause an indirect reduction in greenhouse gas emissions.[77] Adding an incentive for farmers to practice no-tilling can only help, even if by less than other efforts; therefore, it is worthwhile to incorporate in the regulatory scheme proposed in this Note.

2. Pesticides

Pesticide regulation should be modified or expanded to create stringent standards around pesticide use and alternatives to pesticides should be promoted in order to reduce farmers' reliance on the chemicals. Existing federal and state laws include some regulation of pesticides.[78] The EPA has regulated the use and handling of pesticides, including herbicides, fungicides, and insecticides.[79] Under federal laws, including the Federal Insecticide, Fungicide, and Rodenticide Act, pesticides must be registered by the EPA.[80] Entities must apply for registration if they wish to produce a new pesticide, add a new active ingredient to a pesticide, produce a new product for an existing pesticide, or add a new use case for an existing pesticide.[81] The EPA evaluates applications and creates risk assessments for a pesticide's potential "harm to humans, wildlife, fish, and plants, including endangered species and non-target organisms."[82] Many states have their own similar laws regulating pesticides.[83] Normatively, these should all be stricter in order to phase out the use of pesticides. Despite the integral role pesticides play in modern agriculture, the emissions created from the production and use of the chemicals on all farms are significant enough to warrant stricter regulation.[84] This is especially true when there are viable alternatives, such as "integrated pest management."[85]

Oregon programs have been introducing Christmas tree farmers to "integrated pest management" techniques in order to reduce the use of chemicals.[86] One of the programs, Socially and Environmentally Responsible Farm (SERF), requires farms to create a sustainability plan and commit to "a

Determine Where No-Till Management Can Store Carbon in Soils and Mitigate Greenhouse Gas Emissions, 9 SCI. REPS., Aug. 12, 2019, at 1, 4.

76. Ogle et al., *supra* note 75, at 4.

77. RODALE INST., *supra* note 75, at 3, 7–10.

78. WRAY, *supra* note 23, at 98.

79. *Id.*

80. *About Pesticide Registration*, U.S. ENV'T. PROT. AGENCY, https://www.epa.gov/pesticide-registration/about-pesticide-registration (last visited Apr. 19, 2021).

81. *Id.*

82. *Id.*

83. WRAY, *supra* note 23, at 98.

84. *Id.*

85. *Id.* at 103–04; Wallace, *supra* note 48.

86. Wallace, *supra* note 48.

balanced economic, social and environmentally sustainable Christmas tree operation."[87] SERF certified Christmas tree farms promote biodiversity, employ integrated pest management, protect soil, and pass regular inspections of each of these efforts.[88] Because pesticides harm vegetation,[89] reduce soil health by destroying soil microbes,[90] may harm animals,[91] and may indirectly increase soil erosion by eliminating too much ground cover,[92] they are used minimally on SERF certified farms.[93]

Examples of practices that have been adopted as alternatives to pesticide use include the strategic use and management of cover crops[94] and the introduction of lacewings and ladybugs that prey on common Christmas tree-harming insects.[95] These methods have significantly reduced the use of pesticides.[96] Pesticides are used sparingly and on smaller areas of the farm; farmers administer the pesticides on foot instead of by helicopter.[97] Reducing pesticide use, in combination with other practices, has the potential to double the concentration of carbon in soil.[98] Farmers should be encouraged or required to reduce their pesticide use because their efforts would greatly reduce carbon loss on Christmas tree farms.[99]

3. *Fertilizers*

Fertilizers should be regulated with the goal of decreasing use without eliminating fertilizers altogether because they help to improve trees' lush, green appearance.[100] Moreover, fertilizers shorten tree rotation, consequently increasing the productivity of the farm.[101] Fertilizer emissions can vary greatly

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87. *About SERF*, PAC. NW. CHRISTMAS TREE ASS'N, http://www.pnwcta.org/serf/about.html (last visited Apr. 19, 2021).

88. PAC. NW. CHRISTMAS TREE ASS'N, DEVELOPING A SUSTAINABILITY PLAN FOR YOUR CHRISTMAS TREE FARM: GROWER CERTIFICATION GUIDELINE FOR SERF 3–5 (2012). SERF-certified farms are not the same as certified organic farms. Organic farms, contrary to popular belief, may still use pesticides so long as the pesticides are derived from natural materials. Munniksma, *supra* note 29; Christie Wilcox, *Mythbusting 101: Organic Farming > Conventional Agriculture*, SCI. AM. (July 18, 2011), https://blogs.scientificamerican.com/science-sushi/httpblogsscientificamericancomscience-sushi20110718mythbusting-101-organic-farming-conventional-agriculture/.

89. WRAY, *supra* note 23, at 98.

90. SIERRA CLUB: IOWA CHAPTER, AGRICULTURAL PRACTICES PRODUCING AND REDUCING GREENHOUSE GAS EMISSIONS 2, https://www.sierraclub.org/sites/www.sierraclub.org/files/sce/iowa-chapter/Ag-CAFOs/AgAndGHG.pdf (last visited Apr. 19, 2021).

91. Wallace, *supra* note 48.

92. *See* WRAY, *supra* note 23, at 43, 96–97.

93. PAC. NW. CHRISTMAS TREE ASS'N, *supra* note 88, at 14–15.

94. WRAY, *supra* note 23, at 103–04.

95. Wallace, *supra* note 48.

96. *Id.*

97. *Id.*

98. Sydney Brownstone, *Don't Feel Bad About Getting a Christmas Tree*, MOTHER JONES (Dec. 12, 2012), https://www.motherjones.com/politics/2012/12/christmas-trees-seeking-carbon-markets/.

99. *See id.*

100. Wallace, *supra* note 48.

101. WRAY, *supra* note 23, at 96–97.

with changes in precipitation, sun exposure, and soil content.[102] Scientists of University of California, Berkeley hope that research on the adverse effects of fertilizers "will contribute to changes in fertilizer use and agricultural practices that will help to mitigate the release of nitrous oxide into the atmosphere."[103] The scientists' 2012 study revealed that nitrogen content in fertilizers was causing an increase in atmospheric N_2O[104] and recommended timing "fertilizer application to avoid rain, because wet and happy soil microbes can produce sudden bursts of nitrous oxide."[105]

Federal and state regulations of fertilizers typically require that a fertilizer is registered with the state's department of agriculture and most states have nutrient management planning laws that require a written plan of "the amount, source, placement and timing of plant nutrients and soil amendments."[106] However, fewer than half the states have regulations that actually limit the physical application of fertilizers to farmland.[107] Thus, states should increase regulation around the use and application methods of fertilizers, particularly on crops that will end up in consumers' homes. Stricter regulation of fertilizers may have an especially large effect on the reduction of atmospheric greenhouse gases because there are alternatives to fertilizers that simultaneously improve crop growth and soil health, decreasing carbon loss from the vegetation and the soil respectively.[108] One alternative that has gained popularity is the use of cover crops such as soybeans because they naturally provide nitrogen to the soil.[109] Another common alternative is the use of beneficial fungi and bacteria from local sources that help to improve soil fertility and health.[110]

4. Machinery

Regulation of mechanical farm equipment can discourage farmers from using fossil-fueled tools to further reduce greenhouse gas emissions from Christmas tree farms. Instead, farmers should use electric equipment or non-mechanical equipment. Though electric equipment has room for improvement,

102. COUILLARD ET AL., *supra* note 8, at 51.

103. Robert Sanders, *Fertilizer Use Responsible for Increase in Nitrous Oxide in Atmosphere*, BERKELEY NEWS (Apr. 2, 2012), https://news.berkeley.edu/2012/04/02/fertilizer-use-responsible-for-increase-in-nitrous-oxide-in-atmosphere/.

104. *Id.*

105. *Id.*

106. PEGGY KIRK HALL & ELLEN ESSMAN, STATE LEGAL APPROACHES TO REDUCING WATER QUALITY IMPACTS FROM THE USE OF AGRICULTURAL NUTRIENTS ON FARMLAND 4, 5 fig.2 (2019), https://farmoffice.osu.edu/sites/aglaw/files/site-library/State_Legal_Approaches_to_Agricultural_Nutrients.pdf.

107. *Id.* at 5 fig.2.

108. *See* Gosia Wozniacka, *With Regenerative Agriculture Booming, the Question of Pesticide Use Looms Large*, CIV. EATS (Sept. 5, 2019), https://civileats.com/2019/09/05/with-regenerative-agriculture-booming-the-question-of-pesticide-use-looms-large/.

109. WRAY, *supra* note 23, at 42.

110. Jesse Frost, *An Introduction to Korean Natural Farming*, GROWING FOR MKT. (Jan. 12, 2020), https://www.growingformarket.com/articles/an-introduction-to-Korean-Natural-Farming.

the agriculture industry is moving toward more sustainable options.[111] Major farm and construction equipment producers such as John Deere and Caterpillar are adding electric models of popular equipment to their product lines.[112] Costs of electric tractors are comparable, and capability is approaching that of gas and diesel powered machines.[113] As a result, regulation discouraging fossil-fueled machinery in favor of their electric counterparts is feasible and attractive for farmers and environmentalists alike.

5. Harvest

Changes in harvesting methods hold potential to further reduce greenhouse gas emissions.[114] One unique harvesting method used by some Christmas tree farmers is coppicing.[115] Coppicing is the practice of cutting down trees by leaving a couple layers of bottom branches, allowing regrowth from the stump.[116] With appropriate management, a single stump has the potential to support more than one tree, which increases a farm's productivity.[117]

Farm owners can save money on seedlings and reduce tree rotation by up to three years because coppicing reserves the already-established root system.[118] The sunlight reaching the understory of the plantation increases the diversity of plants, insects, and reptiles.[119] Carbon is retained in the stump, because it has not died, and in the soil because it has not been disturbed.[120] Coppicing is a sustainable alternative to clear-cut harvesting and can help trees in areas that are more susceptible to drought because the roots can expand and grow deeper instead of being dug out every six to ten years.[121] The increased biodiversity and health of the soil makes a coppiced grove a rich ecosystem and, as a result, high-

111. Julia Bayly, *Are Eco-Friendly Electric Tractors the Machines of Farming Future?*, HELLO HOMESTEAD, https://hellohomestead.com/are-eco-friendly-electric-tractors-the-machines-of-farming-future/ (Jan. 25, 2019); Todd Janzen, *All Electric Excavator Is a Sign of Farm Equipment to Come*, JANZEN AG L.: TECH BLOG (Feb. 5, 2019), https://www.aglaw.us/janzenaglaw/2019/2/2/all-electric-excavator-is-a-preview-of-farm-equipment-to-come.

112. René Koerhuis & Bas van Hattum, *John Deere: 'We Believe in Electric Tractors. 100%'*, FUTURE FARMING (Mar. 12, 2020), https://www.futurefarming.com/Machinery/Articles/2020/3/John-Deere-We-believe-in-electric-tractors-100-552869E/; Fred Lambert, *Caterpillar Unveils an All-Electric 26-Ton Excavator with a Giant 300 kWh Battery Pack*, ELECTREK (Jan. 29, 2019, 6:00 AM), https://electrek.co/2019/01/29/caterpillar-electric-excavator-giant-battery-pack/.

113. Bayly, *supra* note 111.

114. *See* Katsnelson, *supra* note 59.

115. *See id.*

116. *Id.*

117. *Id.*

118. *Stump Culture: Coppice for Conifers*, MAST TREE NETWORK (Nov. 13, 2010), http://www.mast-producing-trees.org/2010/11/stump-culture-coppice-for-conifers/. The Pieropan Christmas Tree Farm in Ashfield, Massachusetts, is one of very few farms that use this regenerative method. Katsnelson, *supra* note 59; EMMET VAN DRIESCHE, CARVING OUT A LIVING ON THE LAND: LESSONS IN RESOURCEFULNESS AND CRAFT FROM AN UNUSUAL CHRISTMAS TREE FARM 35–36 (2019).

119. Katsnelson, *supra* note 59.

120. *How Green Is Your Christmas Tree?*, GREEN AM. (Dec. 3, 2017), https://www.greenamerica.org/blog/how-green-your-christmas-tree.

121. Katsnelson, *supra* note 59; *see Quick Tree Facts*, *supra* note 21; WRAY, supra note 23, at 61, 147–49.

quality Christmas trees grow without the use of chemicals, heavy machinery, or much labor other than light pruning and scything weeds.[122] Encouraging farmers to change their harvesting practices to coppicing has the potential to eliminate a significant amount of greenhouse gases and waste, optimize greenhouse gas sequestration and storage, and promote sustainable, yet profitable, agroforestry.

B. OPTIMIZING SEQUESTRATION

Christmas tree farmers can also employ new practices to optimize greenhouse gas sequestration on their farms. Trees absorb CO_2 and other greenhouse gases as they grow.[123] The process of transferring atmospheric greenhouse gases into biomass and soil storage is called sequestration.[124] Plants remove greenhouse gases from the atmosphere through photosynthesis.[125] As a result, carbon is stored in tree trunks, branches, leaves, and roots.[126] As measured in CO_2-eq,[127] it is estimated that a Christmas tree farm sequesters approximately 0.809 metric tons of greenhouse gases per acre per year during the trees' rotation.[128] This value can vary with respect to climate, tree species, tree age and weight, and density of the acres.[129]

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122. *Id.*; Max Paschall, *Christmas Tree Farms and Climate Change: A Permaculture Perspective*, SHELTERWOOD FOREST FARM (May 23, 2019), https://www.shelterwoodforestfarm.com/blog/2019/5/22/christmas-tree-farms-and-climate-change-a-permaculture-perspective.

123. *Land Use, Land-Use Change, and Forestry Sector Emissions and Sequestration*, *Sources of Greenhouse Gas Emissions*, *supra* note 38.

124. Lal, *supra* note 36, at 3285.

125. *How Forests Sequester Carbon*, FOREST ECOLOGY NETWORK, http://www.forestecologynetwork.org/climate_change/forest_sequestration.html (last visited Apr. 19, 2021). In this process, chlorophyll, the green pigment in plant leaves, absorbs sunlight and that energy is combined with water and carbon dioxide in a reaction that produces sugars and oxygen. *Id.*; Bill Robertson, *Q: How Does Photosynthesis Work?*, SCI. & CHILDREN, Apr./May 2007, at 60, 62–63. The plant then uses the sugars to produce carbon-based cellulose, which helps to form the structure of the cell wall in plant cells. *How Forests Sequester Carbon*, *supra*.

126. *How Forests Sequester Carbon*, *supra* note 125; *Carbon Sequestration*, U.S. DEP'T OF AGRIC. FOREST SERV., https://www.fs.fed.us/ecosystemservices/carbon.shtml (Oct. 7, 2016).

127. Because greenhouse gases differ in their warming influence, emissions are typically measured in metric tons of carbon dioxide equivalent (CO_2-eq). IPCC, CLIMATE CHANGE 2007 SYNTHESIS REPORT 36 (2008), https://www.ipcc.ch/site/assets/uploads/2018/02/ar4_syr_full_report.pdf [hereinafter IPCC FOURTH ASSESSMENT REPORT]; *Understanding Global Warming Potentials*, U.S. ENV'T. PROT. AGENCY, https://www.epa.gov/ghgemissions/understanding-global-warming-potentials (last visited Apr. 19, 2021). CO_2-eq is the amount of CO_2 emissions that has the same warming effect as another greenhouse gas. *CO_2e*, U.S. ENV'T PROT. AGENCY, https://www3.epa.gov/carbon-footprint-calculator/tool/definitions/co2e.html (last visited Apr. 19, 2021); IPCC FOURTH ASSESSMENT REPORT, *supra*, at 36.

128. This value was calculated by converting the estimate of two metric tons of CO_2-eq per hectare per year into a per-acre-per-year measurement by multiplying by the hectare-to-acre conversion rate of 0.4046856119. *See* COUILLARD ET AL., *supra* note 8, at 8–9; *Hectares to Acres*, METRIC CONVERSIONS, https://www.metric-conversions.org/area/hectares-to-acres.htm (July 22, 2018).

129. *See* COUILLARD ET AL., *supra* note 8, at 8–9; NICHOLAS INST. FOR ENV'T POL'Y SOLS., *supra* note 64, at 52. As time goes on, the rate of tree growth and sequestration slow, but mature trees store a significant amount of greenhouse gases. *Id.* The American Christmas Tree Association (ACTA) commissioned a study of the environmental impacts of natural and artificial Christmas trees, which estimated that, subject to a number of assumptions, a tree weighing thirty-three pounds has absorbed approximately twenty-four pounds of CO_2 during its cultivation, nearly seventy-three percent of the tree's mass. ACTA 2018 LIFE CYCLE ASSESSMENT, *supra* note 23, at 19.

In addition to being stored in biomass, greenhouse gases can be captured and stored in soil organic matter, which is composed of the waste product and remains of plants and animals.[130] Soil organic carbon is the measure of CO_2 stored in soil organic matter[131] and it is typically 1.5 to 3 times the levels stored in vegetation.[132] Farmers have numerous opportunities to optimize Christmas tree farms to capture carbon and reduce atmospheric greenhouse gases through crop species selection, soil properties, land use, ground cover, and use of biochar.

1. Species Selection

Certain species of trees should be promoted by and among farmers because those species have greater sequestration potential due to their longer rotations.[133] It is estimated that increasing the amount of time between the establishment of a block of trees and the harvest of those trees can sequester several metric tons of CO_2-eq per acre each year.[134] It is unlikely that the optimal saleable size of American Christmas trees can be increased because the current seven-to-eight-foot optimal tree height is based on average ceiling heights of eight to ten feet in most American homes.[135] The other way to allow trees to grow for longer is to choose species that take longer to reach the desired saleable size.

For example, spruce trees take longer to grow on average, so they sequester more carbon because they take longer to reach seven to eight feet tall.[136] Moreover, spruces, and firs to some extent, grow more uniformly and have a natural conical shape.[137] Therefore, spruces and firs require less shearing over their lifetime, which can mean a reduction in machine use.[138] Thus, promoting the planting of spruce trees through subsidies may encourage farmers to grow more of them, which would result in reduced emissions and greater carbon sequestration by any Christmas tree farm.

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130. ECOLOGICAL SOC'Y OF AM., CARBON SEQUESTRATION IN SOILS 1 (2000), https://www.esa.org/esa/wp-content/uploads/2012/12/carbonsequestrationinsoils.pdf; SOIL SCI. SOC'Y OF AM., SOILS OVERVIEW 1, https://www.soils.org/files/about-soils/soils-overview.pdf (last visited Apr. 19, 2021).

131. Wayne Pluske, Dan Murphy & Jessica Sheppard, *Total Organic Carbon*, SOIL QUALITY, https://s3.amazonaws.com/soilquality-production/fact_sheets/15/original/Biol_-_Total_Organic_Carbon_V2_web.pdf (last visited Apr. 19, 2021).

132. De Stefano & Jacobson, *supra* note 14, at 286.

133. NICHOLAS INST. FOR ENV'T POLICY SOLS., *supra* note 64, at 23.

134. *Id.*

135. *See* Patricia Palermo, *What Size Christmas Tree Do I Need?*, BALLARD DESIGNS: HOW TO DECORATE, https://www.ballarddesigns.com/howtodecorate/2014/10/what-size-christmas-tree-do-i-need/ (last visited Apr. 19, 2021); Fred A. Bernstein, *Developers and Architects Face a Tall Order from Buyers*, N.Y. TIMES (Jan. 22, 2006), https://www.nytimes.com/2006/01/22/realestate/developers-and-architects-face-a-tall-order-from-buyers.html.

136. WRAY, *supra* note 23, at 21; U.S. DEP'T OF ENERGY, METHOD FOR CALCULATING CARBON SEQUESTRATION BY TREES IN URBAN AND SUBURBAN SETTINGS 7 tbl.1, 8 tbl.2 (1998), https://www3.epa.gov/climatechange/Downloads/method-calculating-carbon-sequestration-trees-urban-and-suburban-settings.pdf.

137. WRAY, *supra* note 23, at 110.

138. *Id.*

2. Soil Properties

It is imperative for farmers to improve the sequestration of the soil on their farms because soil has the ability to sequester and store even more greenhouse gases than vegetation.[139] The potential for soil to sequester and store carbon depends in part on the properties of the soil; therefore, farmers could use and maintain particular types of soils to capitalize on this potential.[140] Most Christmas tree species thrive in soil that can retain water fairly well while still allowing enough space for air to get to the roots.[141]

Clay is soil with smaller particles whereas sand is soil with larger particles.[142] The spacing and water retention of soil will depend upon its particular blend of particles.[143] Generally, the best soil texture for growing Christmas trees is loam, which is somewhere between clay and sand, though it varies from species to species.[144] Studies have shown that increased levels of soil organic carbon are generally correlated with higher concentrations of clay, but a change in the clay concentration of the soil does not alone significantly impact the soil's ability to sequester carbon.[145] Levels of soil organic carbon and clay concentration both increase "with higher precipitation levels," which "suggests that shifts in climactic conditions may regulate the relationship between [soil organic carbon] stocks and clay content."[146]

In systems that have had a decrease in soil organic carbon due to agricultural depletion, it is especially true that soil texture is less important than density and drainage for soil organic carbon content.[147] It appears that the best soil for carbon sequestration and storage is high-density soil with poor drainage.[148] Unfortunately, trees are happiest when their roots are surrounded by loose soil that is well-drained.[149] As a result, legislation requiring farms to change their soil properties will be unpopular and will harm Christmas tree farms' productivity. Some species, such as the balsam fir, the Canaan fir, and the black spruce, can tolerate wetter soils.[150] Farmers can be given economic incentives to plant more of these species of trees and use denser soils to sequester more carbon.

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139. *See* De Stefano & Jacobson, *supra* note 14, at 286.

140. *See id.* at 286–87; WRAY, *supra* note 23, at 15.

141. WRAY, *supra* note 23, at 15.

142. *Id.*; SOIL SCI. SOC'Y OF AM., *supra* note 130, at 2.

143. WRAY, *supra* note 23, at 15.

144. *Id.*

145. Kendra K. McLauchlan, *Effects of Soil Texture on Soil Carbon and Nitrogen Dynamics After Cessation of Agriculture*, 136 GEODERMA 289, 297 (2006); Zekun Zhong, Zhengxing Chen, Yadong Xu, Chengjie Ren, Gaihe Yang, Xinhui Han, Guangxin Ren & Yongzhong Feng, *Relationship Between Soil Organic Carbon Stocks and Clay Content Under Different Climatic Conditions in Central China*, 9 FORESTS 598, 605 tbl.4 (2018).

146. Zhong et al., *supra* note 145, at 606.

147. McLauchlan, *supra* note 145, at 297.

148. Eric C. Brevik, *Soils and Climate Change: Gas Fluxes and Soil Processes*, 53 SOIL HORIZONS, July 2012, at 12, 14–15, 17.

149. *See* WRAY, *supra* note 23, at 8–9, 94.

150. *Id.* at 8–9, 18–19.

3. Land Use

On Christmas tree farms that are classified as particular land use systems, farmers can modify their land use practices to improve greenhouse gas sequestration.[151] Approximately one-third of anthropogenic carbon emissions between 1850 and 1990 were due to changes in land use, particularly clearing forests for agriculture.[152] Studies show that Christmas tree farms and other agroforestry systems have lower concentrations of soil carbon than forests.[153] However, researchers speculate that this is due to the initial disturbance of the soil when the land was converted from forest to agriculture, and not due to the Christmas tree farming itself because Christmas tree farming does not yield greater losses of soil carbon over time.[154] Further, soil carbon has been shown to remain relatively steady with respect to the duration of tree farming.[155]

Determining the type of land use of a Christmas tree farm can aid in the tailoring of laws that change farmer behavior around land use, land use change, and soil preparation. Though Christmas tree farms vary,[156] many Christmas tree farms can be classified as either a silvopastoral system or an agrisilvicultural system depending on individual farming practices.[157]

Christmas tree farms fall within the agroforestry land-use category.[158] Agroforestry comprises woody perennials that are "used on the same land-management units as agricultural crops and/or animals."[159] The main agroforestry systems are agrisilvicultural systems, silvopastoral systems, and agrosilvopastoral systems.[160] Agrisilviculture is a system of trees combined with crops.[161] Silvopastoral systems involve trees combined with pastures or

151. *See generally Silvopasture*, U.S. DEP'T OF AGRIC., https://www.fs.usda.gov/nac/practices/silvopasture.php (last visited Apr. 19, 2021) (describing that well-managed silvopastures differ from woodlands or plantations in that silvopastures often have pasture grasses, legume crops, and grazing livestock); De Stefano & Jacobson, *supra* note 14, at 296–97 (explaining that carbon stored in the soil significantly increased due to sowing legumes).

152. *See* R.A. Houghton, *The Annual Net Flux of Carbon to the Atmosphere from Changes in Land Use 1850–1990*, 51 TELLUS B: CHEM. & PHYSICAL METEOROLOGY 298, 298–99 (1999); *see also* De Stefano & Jacobson, *supra* note 14, at 287.

153. *See, e.g.*, Chapman et al., *supra* note 15, at 2225–26.

154. *Id.* at 2228.

155. *Id.* at 2225.

156. WRAY, *supra* note 23, at 16–17.

157. *See* De Stefano & Jacobson, *supra* note 14, at 289 tbl.1.

158. *See Agroforestry*, FOOD & AGRIC. ORG. OF THE U.N., http://www.fao.org/forestry/agroforestry/80338/en/ (Oct. 23, 2015). Agricultural land includes arable land, permanent crops, and permanent pastures. *Agriculture*, FOOD & AGRIC. ORG. OF THE U.N., http://www.fao.org/ag/agn/nutrition/Indicatorsfiles/Agriculture.pdf (last visited Apr. 19, 2021). This definition explicitly "excludes land under trees grown for wood or timber," therefore Christmas tree farms are not considered agricultural lands. *Id.* Christmas tree farms are not considered to be forest plantations because the Christmas trees rarely, if ever, reach the minimum height of five meters for trees on forest plantations. *See* FOOD & AGRIC. ORG. OF THE U.N., GLOBAL FOREST RESOURCES ASSESSMENT 2000 ch. 3 (2001), http://www.fao.org/3/y1997e/y1997e08.htm.

159. *Agroforestry*, *supra* note 158.

160. *Id.*; De Stefano & Jacobson, *supra* note 14, at 288.

161. *Agroforestry*, *supra* note 158; De Stefano & Jacobson, *supra* note 14, at 288.

animals.[162] Agrosilvopastoral systems combine animals, crops, and trees.[163] If a Christmas tree farm has rows of trees planted in a tilled field or among crops, it is likely to be an agrisilvicultural system.[164] If a Christmas tree farm more closely resembles a forest or has other vegetation around the trees, it is likely to be a silvopastoral system.[165]

A meta-analysis of the impact of agroforestry systems on soil carbon stocks revealed that agricultural lands had the lowest stocks, followed by forest plantations, and then agroforestry.[166] Forest systems had the highest levels of soil carbon stocks.[167] The results of the analysis show that on average, out of the three aforementioned agroforestry systems, agrisilvicultural systems had the lowest soil carbon stock, agrosilvopastoral systems had slightly higher stocks, and silvopastoral systems had much higher stocks.[168] For Christmas tree farms that more closely resemble an agrisilvicultural system, adding cover and forage crops or introducing livestock grazing can transition the farms to a silvopastoral system and increase the farms' carbon sequestration.[169] Thus, the proposed legal framework of this Note includes an opportunity and incentive for farmers of agrisilvicultural systems to improve the carbon stocks through land use.

4. *Ground Cover*

Additionally, Christmas tree farmers can facilitate greater greenhouse gas sequestration and storage in soil by increasing ground coverage between trees.[170] Non-competitive vegetation, particularly some combination of grain and grass, can stabilize the soil without threatening young trees.[171] Following the annual harvest, the fields are sometimes bare until farmers can replant in the spring or the following fall.[172] Ground cover during this time, either temporarily or alongside the Christmas tree crops, can minimize erosion and maintain the soil's health and ability to retain water.[173] "[G]rowing a crop of grain, grass, clover, soy beans or a mixture of these" can also help control weeds, reducing the need for herbicides.[174]

162. *Agroforestry*, *supra* note 158; De Stefano & Jacobson, *supra* note 14, at 288.

163. *Agroforestry*, *supra* note 158; De Stefano & Jacobson, *supra* note 14, at 288.

164. *See* De Stefano & Jacobson, *supra* note 14, at 289 tbl.1.

165. *See id.*

166. *Id.* at 285, 295–97.

167. *Id.*

168. *Id.* at 285, 290–95.

169. *See Silvopasture*, *supra* note 151.

170. Chapman et al., *supra* note 15, at 2227.

171. WRAY, *supra* note 23, at 43, 66.

172. *Id.* at 48–49.

173. *See Methods of Regenerative Agriculture: #3 Cover Cropping & Crop Rotation*, GREEN AM. (Feb. 27, 2018), https://greenamerica.org/blog/methods-regenerative-agriculture-3?_ga=2.210955861.1541346820.1583088855-1561391934.1580856154.

174. WRAY, *supra* note 23, at 103–04. Options that thrive in shade and prefer dense trees above them include salal, bear-grass, falsebox, sword fern, deer fern, and evergreen huckleberry. Open or sunny areas can be filled

Moreover, recalcitrant carbon levels in the soil are directly correlated with the amount of interspace ground cover.[175] Recalcitrant carbon is carbon that is resistant to microbial decomposition, meaning it resides in the soil for longer instead of being released into the atmosphere.[176] The vegetation reduces erosion and offers shade that lowers the soil temperature.[177] Low soil temperature also increases recalcitrant carbon.[178] Any soil disturbance from erosion or high temperatures would cause greater soil respiration and, consequently, greater loss of greenhouse gases to the atmosphere.[179] Similarly, low- or no-tillage farms will have healthier soil that has not been disturbed and is able to store greenhouse gases better.[180] One drawback that may make farmers wary of increasing ground cover is that ground cover is favored by mice and rabbits that will eat the bark of younger trees as part of their winter diet.[181] In order to avoid this, farmers have to manage the cover crops and ensure they are not overgrown.[182]

5. Biochar

Finally, Christmas tree farms can mitigate biomass waste while improving soil health and sequestration through the use of biochar.[183] Biochar is a charcoal-like substance made from the controlled burning of woody organic material through pyrolysis.[184] Pyrolysis is the heating of biomass in the absence of oxygen.[185] Without oxygen, the process avoids combustion and produces bio-oil, syngas, and biochar.[186] Pyrolysis kilns can be purchased for as little as $500.[187] After the pyrolysis creates raw biochar, it is recommended that the charcoal-like pieces be crushed to more closely resemble soil particles.[188] Then, the biochar should be inoculated with microbes and organic nutrients and allowed time to mature, similar to the thermophilic process used in

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with Scotch broom or Oregon grape. Richard D. Hallman, Christmas Trees: Plantations to Agroforestry Systems (1998) (unpublished manuscript at 104), https://nfs.unl.edu/documents/SpecialtyForest/Hallman.pdf.

175. Todd A. Ontl & Lisa A. Schulte, *Soil Carbon Storage*, NATURE EDUC. KNOWLEDGE (2012), https://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790/.

176. *Id.*

177. Chapman et al., *supra* note 15, at 2227.

178. *Id.*

179. *Id.*

180. *See supra* Part II.A.1.

181. *See* WADSWORTH CHRISTMAS TREE FARM, *supra* note 31.

182. *Id.*

183. Stefanie Spears, *What Is Biochar?*, REGENERATION INT'L (May 16, 2018), https://regenerationinternational.org/2018/05/16/what-is-biochar/.

184. *Id.*

185. *What Is Pyrolysis?*, U.S. DEP'T OF AGRIC.: AGRIC. RSCH. SERV., https://www.ars.usda.gov/northeast-area/wyndmoor-pa/eastern-regional-research-center/docs/biomass-pyrolysis-research-1/what-is-pyrolysis/ (Apr. 14, 2017).

186. *Id.*

187. *See, e.g.*, *Charcoal Kilns*, FOUR SEASONS FUEL LTD., https://www.fourseasonsfuel.co.uk/retort-and-wood-kiln-dryer/charcoal-kilns-8-0-P-73/ (last visited Apr. 19, 2021). At the time this was calculated, £1 GBP was worth approximately $1.23 USD.

188. Learn Organic Gardening at GrowingYourGreens, *What Is BioChar? How to Make & Why You Shouldn't Use Raw Biochar*, YOUTUBE (Jan. 27, 2014), https://www.youtube.com/watch?v=7REMpeJlf64.

composting.[189] The use of biochar with soil improves root aeration and increases water retention, both of which stabilize and assist plant growth.[190] Biochar also creates an ideal habitat for microorganisms, improving soil fertility.[191]

Biochar increases soil carbon stocks primarily in two ways.[192] First, biochar improves soil aggregation,[193] which is the structure of soil particles being held together by attraction and soil organic matter.[194] Second, biochar increases levels of recalcitrant organic materials, decreasing the decomposition of soil organic carbon.[195] From a study examining the impacts of cover crops, conservation tillage, and biochar on soil organic carbon levels, biochar was by far the most effective, increasing soil organic carbon levels by thirty-nine percent.[196] Perhaps the most important benefit of biochar is that it has the ability to store carbon for centuries.[197]

The use of biochar is a win-win cultivation method that reduces the need for fertilizer while improving soil health and increasing carbon sequestration and storage.[198] Moreover, this relatively inexpensive process can mitigate or eliminate waste on Christmas tree farms by providing a sustainable solution for the disposal and repurposing of stumps, leaves, branches, and non-saleable trees that must be removed from the fields.[199]

There are many opportunities to capitalize on the sequestration and storage potential of the land and the trees, and even more opportunities to reduce emissions from sources of greenhouse gases throughout Christmas tree production. The legal framework proposed in this Note includes regulations around each of these activities.[200] There are prohibitions and disincentives for activities that cause greenhouse gas emissions and requirements and subsidies for activities that reduce emissions or improve sequestration.[201] Christmas tree farmers can use several of these approaches as projects warranting registration as carbon offset projects, as a way to either fund the sustainable farming methods or to promote and increase awareness of sustainably managed Christmas tree farms.

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189. *Id.*

190. *Biochar*, PYREG, https://www.pyreg.de/terra/?lang=en (last visited Apr. 19, 2021).

191. *Id.*

192. Xiongxiong Bai, Yawen Huang, Wei Ren, Mark Coyne, Pierre-Andre Jacinthe, Bo Tao, Dafeng Hui, Jian Yang & Chris Matocha, *Responses of Soil Carbon Sequestration to Climate-Smart Agriculture Practices: A Meta-Analysis*, 25 GLOB. CHANGE BIOLOGY 2591, 2592 (2019).

193. *Id.*

194. *Aggregation*, N.D. STATE UNIV., https://www.ndsu.edu/soilhealth/?page_id=404 (last visited Apr. 19, 2021).

195. Bai et al., *supra* note 192.

196. *Id.* at 2594.

197. *Biochar*, *supra* note 190.

198. Spears, *supra* note 183.

199. Learn Organic Gardening at GrowingYourGreens, *supra* note 188.

200. *See infra* Part III.

201. *See infra* Part III.

C. Carbon Offset Project Potential

When a person or entity invests in a carbon offset, it helps neutralize their emissions.[202] If they neutralize enough to offset all of their emissions, they become carbon neutral even without reducing any of their own greenhouse gas emissions.[203] In order for carbon offset projects to be effective carbon-reducing investments, they must be carbon *sinks*, meaning that they remove greenhouse gases from the atmosphere by capturing greenhouse gases, sequestering greenhouse gases, or displacing fossil fuels.[204] Examples of carbon offset projects include forest regeneration projects and tree planting projects.[205]

1. The Carbon Market

There are two main markets for carbon offsets: the voluntary market and the compliance market.[206] This Note will focus on the players and requirements of the compliance market in California. In the compliance market, legal systems require emitters to reduce their greenhouse gas emissions to a certain level, and the legal authority issues and distributes a limited number of permits to pollute.[207] The limit of allowable emissions is the "cap" of cap-and-trade programs.[208] The administrator of the cap-and-trade program will give an emitter an allowance of only enough permits to pollute up to its cap.[209] Some emitters will reduce their emissions enough that they have some permits left over.[210] Other emitters will exceed their cap.[211] When an emitter is unable to stay under its cap, it must either buy other emitters' unused permits or pay a penalty.[212] In

202. *Go Carbon Neutral*, DAVID SUZUKI FOUND., https://davidsuzuki.org/what-you-can-do/go-carbon-neutral/ (last visited Apr. 19, 2021).

203. *Id.*

204. *Are Carbon Offsets the Answer to Climate-Altering Flights?*, DAVID SUZUKI FOUND., https://davidsuzuki.org/what-you-can-do/carbon-offsets/ (last visited Apr. 19, 2021).

205. *Offset Your Emissions*, GOLD STANDARD, https://www.goldstandard.org/take-action/offset-your-emissions (last visited Apr. 19, 2021); *Tree Planting*, CARBON FOOTPRINT, https://www.carbonfootprint.com/treeplanting.html (last visited Apr. 19, 2021).

206. *Mandatory and Voluntary Carbon Markets*, FAIR CLIMATE FUND, https://www.fairclimatefund.nl/en/compensation/mandatory-and-voluntary-carbon-markets (last visited Apr. 19, 2021); *Carbon Market: Overview*, ECOSYSTEM MARKETPLACE, https://www.ecosystemmarketplace.com/marketwatch/carbon/ (last visited Apr. 19, 2021).

207. *How Cap and Trade Works*, ENV'T DEF. FUND, https://www.edf.org/climate/how-cap-and-trade-works (last visited Apr. 19, 2021).

208. *Id.*

209. *Id.*

210. *Id.*

211. *Id.*

212. *Id.*; *see, e.g.*, *Compliance Offset Program*, CAL. AIR RES. BD., https://ww3.arb.ca.gov/cc/capandtrade/offsets/offsets.htm (last visited Apr. 19, 2021); *Emission Offsets*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/nsr/emissions-offsets (last visited Apr. 19, 2021); CORSIA ELIGIBLE EMISSIONS UNITS, INT'L CIV. AVIATION ORG. (2020), https://www.icao.int/environmental-protection/CORSIA/Documents/TAB/TAB%202020/ICAO_Doc_CORSIA_Eligible_Emissions_Units_November_2020.pdf; *see also* Press Release, Forest Trends, Demand for Nature-Based Solutions for Climate Drives Voluntary Carbon Markets to a Seven-Year High (Dec. 5, 2019), https://www.forest-trends.org/pressroom/demand-for-nature-based-solutions-for-climate-drives-voluntary-carbon-markets-to-a-seven-year-high/; Jocelyn Timperley, *Corsia: The UN's Plan to*

some programs, emitters of greenhouse gases are permitted to offset their pollution by purchasing carbon offset credits.[213] For example, California's cap-and-trade program allows over-polluting emitters to offset up to eight percent of their emissions if they are unable to purchase enough permits at auctions or unused permits from other emitters.[214]

There are several players in the carbon market.[215] The emitters are the purchasers of offset credits; this includes companies, entities, and people that use products, burn fossil fuels, and cause greenhouse gas emissions.[216] There are brokers that connect the emitters with carbon offset projects.[217] Brokers either have databases of projects on their website that show the variety of offset credits that are available for purchase or offer their services in helping emitters find and purchase carbon offset credits.[218] Registries also have databases that include active, approved, and pending projects.[219] Both brokers and registries subscribe to and comply with standards, created by either nongovernmental organizations or legal authorities.[220] Compliance with these standards is achieved in the measurement and calculation of credits called verified emissions reductions (VERs).[221] Each VER represents a savings of one metric ton of CO_2-eq.[222] Brokers and registries will choose the standard with which their projects must comply based on stringency, allowable project types, and consideration of co-benefits such as social, economic, and environmental improvement.[223] Many

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'Offset' Growth in Aviation Emissions, CARBON BRIEF (Feb. 4, 2019, 3:46 PM), https://www.carbonbrief.org/corsia-un-plan-to-offset-growth-in-aviation-emissions-after-2020.

213. *See, e.g.*, *Compliance Offset Program*, *supra* note 212; *Emission Offsets*, *supra* note 212; CORSIA ELIGIBLE EMISSIONS UNITS, *supra* note 212.

214. CAL. AIR RES. BD., CAP-AND-TRADE REGULATION INSTRUCTIONAL GUIDANCE 12 (2012), https://ww3.arb.ca.gov/cc/capandtrade/guidance/chapter1.pdf.

215. KOLLMUSS ET AL., *supra* note 18, at 2–6, 8 chart 3, 11–12.

216. *See id.* at 8 chart 3.

217. *Are Carbon Offsets the Answer to Climate-Altering Flights?*, *supra* note 204.

218. *See, e.g.*, *Offset Your Life*, CARBONFUND.ORG, https://carbonfund.org/carbon-offsets/ (last visited Apr. 19, 2021); *Project Browser*, NATURAL CAP. PARTNERS, https://www.naturalcapitalpartners.com/projects (last visited Apr. 19, 2021); *Project Overview*, ATMOSFAIR, https://www.atmosfair.de/en/climate-protection-projects/ (last visited Apr. 19, 2021).

219. *See, e.g.*, *Registry*, AM. CARBON REGISTRY, https://acr2.apx.com/mymodule/mypage.asp (last visited Apr. 19, 2021).

220. *See, e.g.*, *Quality Assurance Protocol*, CARBONFUND.ORG, https://carbonfund.org/quality-assurance-protocol/ (last visited Apr. 19, 2021); GOLD STANDARD, PRINCIPLES & REQUIREMENTS 14 (2019), https://globalgoals.goldstandard.org/standards/101_V1.2_PAR_Principles-Requirements.pdf; *Compliance Offset Program*, *supra* note 212.

221. ANJA KOLLMUSS & BENJAMIN BOWELL, TUFTS CLIMATE INITIATIVE, VOLUNTARY OFFSETS FOR AIR-TRAVEL CARBON EMISSIONS 12, 15–17 (2007), https://sustainability.tufts.edu/wp-content/uploads/TCI_Carbon_Offsets_Paper_April-2-07.pdf.

222. *Mandatory and Voluntary Carbon Markets*, FAIR CLIMATE FUND, https://www.fairclimatefund.nl/en/compensation/mandatory-and-voluntary-carbon-markets (last visited Apr. 19, 2021); *Carbon Market: Overview*, ECOSYSTEM MARKETPLACE, https://www.ecosystemmarketplace.com/marketwatch/carbon/ (last visited Apr. 19, 2021). Two popular standards are the Clean Development Mechanism (CDM) and Gold Standard. KOLLMUSS ET AL., *supra* note 18, at vii.

223. *See* KOLLMUSS & BOWELL, *supra* note 221, at 15–17; *see, e.g.*, *Quality Assurance Protocol*, *supra* note 220.

organizations have broadened so that they alone have a sector of their business covering each of these roles in the carbon market.[224]

To enforce compliance, third-party verifiers independently survey projects to determine whether they meet the criteria and standards set by a broker or registry.[225] In the compliance market, there are administrative and legal authorities that create the regulations that form the compliance market.[226] The administrative and legal bodies have the power to determine which standards or project types will be eligible, purchasable credits for offsetting the pollution in excess of the emitter's cap.[227] Alternatively, administrative and legal bodies can create their own standards.[228] Finally, there are the project creators and implementers, who form the idea for the project, put those ideas into action, hire third-party verifiers to ensure compliance with a particular standard, and submit proposals to brokers and registries for consideration.[229]

California's compliance market illustrates how these players all fit together. California has a cap-and-trade program under the California Global Warming Solutions Act of 2006.[230] The California Air Resources Board (CARB), an administrative agency, implements and enforces the cap-and-trade program.[231] The regulatory cap on emissions for covered entities and the existence of an administrative authority make this a compliance carbon market.[232] CARB has a list of approved registries, including American Carbon Registry, and a list of approved third-party verifiers.[233] The registries list all of the projects that have been approved as permitted offsets under California's cap-and-trade program and give details about the progress and characteristics of

224. For example, Verra is a registry that also acts like a broker in helping emitters find and purchase offset project credits and Verra administers the Verified Carbon Standard and the Climate, Community, and Biodiversity Standard. *Projects & Programs*, VERRA, https://verra.org/project/vcs-program/projects-and-jnr-programs/ (last visited Apr. 19, 2021); *Welcome to the Verra Registry*, VERRA, https://www.vcsprojectdatabase.org/#/projects (last visited Apr. 19, 2021); *see also* GOLD STANDARD, *supra* note 220, at 7–9; *Develop a Project*, GOLD STANDARD, https://www.goldstandard.org/project-developers/develop-project (last visited Apr. 19, 2021); *Impact Registry*, GOLD STANDARD, https://registry.goldstandard.org/projects?q=&page=1 (last visited Apr. 19, 2021).

225. *See, e.g.*, *Carbon Offset Verification*, SCS GLOB. SERVS., https://www.scsglobalservices.com/carbon-offset-verification-energy-industry-agriculture (last visited Apr. 19, 2021); *see also Quality Assurance Protocol*, *supra* note 220; GOLD STANDARD, *supra* note 220.

226. KOLLMUSS ET AL., *supra* note 18, at 4–5.

227. *See* CAL. CODE REGS. tit. 17, §§ 96010–96014 (2021).

228. For example, the California Air Resources Board created the Compliance Offset Protocols as the standard for offset projects under its cap-and-trade program. *Compliance Offset Program*, *supra* note 212.

229. *See, e.g.*, *Your Project Proposal*, ATMOSFAIR, https://www.atmosfair.de/en/your_project_proposal/ (last visited Apr. 19, 2021); *How It Works*, CLIMATE ACTION RSRV., http://www.climateactionreserve.org/how/ (last visited Apr. 19, 2021); *Carbon Offset Verification*, *supra* note 225.

230. A.B. 32, 2005–2006 Leg., Reg. Sess. (2006) (enacted); *AB 32 Global Warming Solutions Act of 2006*, CAL. AIR RES. BD. (Sept. 28, 2018), https://ww3.arb.ca.gov/cc/ab32/ab32.htm.

231. *Id.*

232. *Compliance Offset Program*, *supra* note 212.

233. *Offset Project Registries*, CAL. AIR RES. BD., https://ww3.arb.ca.gov/cc/capandtrade/offsets/registries/registries.htm (last visited Apr. 19, 2021); *Offset Verification*, CAL. AIR RES. BD., https://ww3.arb.ca.gov/cc/capandtrade/offsets/verification/verification.htm (last visited Apr. 19, 2021).

those projects.[234] CARB issues offset credits for projects that are qualified pursuant to CARB's Compliance Offset Protocols.[235] Current approved protocols include U.S. Forest Projects, which is the most applicable protocol to Christmas tree farms because the proposed legal framework suggests changes that fit within the Improved Forest Management and Avoided Conversion project types.[236]

2. *Offset Credit Criteria*

Many standards have similar basic eligibility requirements that carbon offset projects must meet.[237] Some standards are stricter; Gold Standard, for example, certifies only the energy efficiency and renewable energy project types because it wants to cause a shift away from reliance on fossil fuels.[238] The common essential criteria include that the greenhouse gas reduction by a project is (1) real, (2) additional, (3) permanent, (4) verifiable, and (5) unlikely to cause negative externalities.[239]

A project is real when it has actual, quantifiable reductions of greenhouse gases.[240] Additionality requires that the greenhouse gases reduced for any given carbon offset project are beyond the reductions from business as usual and beyond any local, state, or federal regulations.[241] Therefore, projects are only eligible as offset credits if their greenhouse gas reductions would not have been eliminated in the absence of the project.[242] If the reductions would have happened anyway, "the project is not additional."[243] Permanence is the length of time the stored greenhouse gases will remain stored.[244] The useful life of a carbon offset project for offsetting purposes ends when the greenhouse gases are released back into the atmosphere because it is as if the reduction never happened.[245] All of these factors and more must be quantifiable and measurable so that the project is verifiable by the third-party verifiers.[246]

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234. *See, e.g.*, *Registry*, *supra* note 219.

235. *Compliance Offset Program*, *supra* note 212; *Compliance Offset Program: About*, CAL. AIR RES. BD., https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/about (last visited Apr. 19, 2021).

236. CAL. AIR RES. BD., U.S. FOREST OFFSET PROJECTS 2–3 (2019), https://ww2.arb.ca.gov/sites/default/files/classic/cc/capandtrade/offsets/overview.pdf.

237. *See* KOLLMUSS ET AL., *supra* note 18, at x.

238. *Id.*; GOLD STANDARD, GHG EMISSIONS REDUCTION & SEQUESTRATION PRODUCT REQUIREMENTS 4–5 (2019), https://globalgoals.goldstandard.org/standards/501_V1.2_PR_GHG-Emissions-Reductions-Sequestration.pdf; *Are Carbon Offsets the Answer to Climate-Altering Flights?*, *supra* note 204.

239. *See, e.g.*, *Quality Assurance Protocol*, *supra* note 220; *Criteria for Protocol Development*, CLIMATE ACTION RSRV., http://www.climateactionreserve.org/how/future-protocol-development/criteria/ (last visited Apr. 19, 2021); GOLD STANDARD, *supra* note 220, at 14–17.

240. *See, e.g.*, *Quality Assurance Protocol*, *supra* note 220; GOLD STANDARD, *supra* note 220, at 14.

241. *Quality Assurance Protocol*, *supra* note 220; KOLLMUSS ET AL., *supra* note 18, at 15.

242. *Quality Assurance Protocol*, *supra* note 220; KOLLMUSS ET AL., *supra* note 18, at 15.

243. KOLLMUSS ET AL., *supra* note 18, at 15.

244. *Quality Assurance Protocol*, *supra* note 220; KOLLMUSS ET AL., *supra* note 18, at 21.

245. *See* KOLLMUSS ET AL., *supra* note 18, at 21.

246. *Quality Assurance Protocol*, *supra* note 220; *Criteria for Protocol Development*, *supra* note 239; KOLLMUSS ET AL., *supra* note 18, at 34–35.

Brokers, registries, and third-party verifiers also look at the project's impact on its surroundings.[247] Leakage, a common negative externality, occurs when a project causes greenhouse gas emissions outside the boundaries of the project.[248] Co-benefits or co-effects are positive externalities, which are sometimes part of the essential criteria for project certification and are sometimes non-essential perks a project can offer for consideration.[249] These include social benefits, such as development of communities, technological advancement, and job creation.[250] Additional environmental benefits are also taken into consideration, such as habitat preservation, biodiversity enhancement, and protection of soil health.[251] Other factors that may determine a project's viability for certification include impacts on the market, project location, and whether the project tells an inspiring story.[252]

3. Pros and Cons of the Carbon Market

The carbon offset market is lauded for offering a cost-effective method for reducing total atmospheric greenhouse gases that provides financial support for emerging green services and practices.[253] The money that is spent by emitters on these projects goes toward implementing the greenhouse gas sequestration methods that should reduce the amount of greenhouse gases in the atmosphere by the time the project is completed.[254] The emissions reductions are typically spread over the life of the project; the reductions do not happen the instant that they are purchased.[255] The qualification of Christmas tree farms as carbon offset projects can be a source of funding for the farmers' regenerative farming practices if farmers are careful about the brokers from which they seek review and certification as a carbon offset project.[256] The allocation of funds from purchases of potential Christmas tree farm offset credits can serve as an

247. *Quality Assurance Protocol*, *supra* note 220; KOLLMUSS ET AL., *supra* note 18, at 20.

248. *Quality Assurance Protocol*, *supra* note 220; *Criteria for Protocol Development*, *supra* note 239; KOLLMUSS ET AL., *supra* note 18, at 20.

249. *Quality Assurance Protocol*, *supra* note 220; *Criteria for Protocol Development*, *supra* note 239; KOLLMUSS ET AL., *supra* note 18, at 28–33.

250. *Quality Assurance Protocol*, *supra* note 220.

251. *Id.*

252. *Id.*; *Are Carbon Offsets the Answer to Climate-Altering Flights?*, *supra* note 204; KOLLMUSS ET AL., *supra* note 18, at 25–26.

253. Eric Niiler, *Do Carbon Offsets Really Work? It Depends on the Details*, WIRED (Jan. 14, 2020, 12:19 PM), https://www.wired.com/story/do-carbon-offsets-really-work-it-depends-on-the-details/.

254. Carolyn Sherwood Call, *The Benefits and Drawbacks of Carbon Offsets*, GREENBIZ (Apr. 1, 2008), https://www.greenbiz.com/news/2008/04/01/benefits-and-drawbacks-carbon-offsets.

255. *Id.* Brokers have previously been investigated and criticized for inefficient allocation of funding. Kirsten Dirksen, *Carbon Offsets II: Where Does the Money Go?*, *FAIRCOMPANIES (May 4, 2007), https://faircompanies.com/articles/carbon-offsets-ii-where-does-the-money-go/. A report published by the Tufts Climate Initiative in 2007 revealed that some brokers spent as little as twenty-five percent of the money from purchased offset credits on carbon offset project implementation. KOLLMUSS & BOWELL, *supra* note 221, at 24–25.

256. *See Develop A Project*, *supra* note 224.

economic relief for farmers who choose to pursue more expensive or time-consuming practices that ultimately result in net reductions of greenhouse gases.

However, carbon offset programs are also criticized for their limitations.[257] In forestry projects, one major challenge is that it is expensive and difficult to accurately monitor and measure carbon sequestration due to the complex carbon emission and absorption cycle of trees.[258] Even more challenging is the quantifying of greenhouse gases that is sequestered by soil, since the amount is quite small relative to the greenhouse gases already stored in the soil[259] and there are many other factors that affect greenhouse gas sequestration.[260] Additionally, offsetting is quite controversial because it does nothing to reduce or eliminate *emissions*.[261] Offsets usually accomplish greenhouse gas removal, not emissions reduction.[262] Consequently, polluters will continue their business as usual and wealthy companies will be able to simply buy the permits and offsets needed to continue polluting at the current unsustainable levels.[263] Although planting trees is one of the world's cheapest and most effective ways to sequester atmospheric greenhouse gases,[264] environmental scientists assert that "[t]here is no way that planting trees, even across a global area the size of the United States, can absorb the enormous amounts of fossil carbon emitted from industrial societies."[265] Despite valid criticisms, the use and increasing popularity of offsetting is a step in the right direction so long as it is one of many mitigation strategies.[266]

The potential qualification of any sustainable farming activities as a carbon offset project depends, in part, on its role in any regulatory framework.[267] The available improvements to Christmas tree production explored above, including ways to reduce emissions and ways to support and improve sequestration, inform the structure and substance of the foregoing legal framework. The variety of available sustainable farming practices offers farmers flexibility; this breadth is reflected using a range of regulations.

III. Proposed Legal Framework

This Note proposes a legal system that combines obligations, choices from several sustainable farming alternatives, and disincentives in order to optimize

257. *Carbon Offsets Are Not Our Get-Out-of-Jail Free Card*, *supra* note 1; Niiler, *supra* note 253.

258. Nicholas Inst. for Env't Pol'y Sols., *supra* note 64, at 52.

259. *Id.* at 64.

260. *See Carbon Sequestration*, *supra* note 126.

261. *See Carbon Offsets Are Not Our Get-Out-of-Jail Free Card*, *supra* note 1.

262. *Id.*

263. *See id.*

264. Damian Carrington, *Tree Planting 'Has Mind-Blowing Potential' to Tackle Climate Crisis*, Guardian (July 4, 2019, 2:00 PM), https://www.theguardian.com/environment/2019/jul/04/planting-billions-trees-best-tackle-climate-crisis-scientists-canopy-emissions.

265. Erle C. Ellis, Mark Maslin & Simon Lewis, *Planting Trees Won't Save the World*, N.Y. Times (Feb. 12, 2020), https://www.nytimes.com/2020/02/12/opinion/trump-climate-change-trees.html.

266. *See Carbon Offsets Are Not Our Get-Out-of-Jail Free Card*, *supra* note 1.

267. *Quality Assurance Protocol*, *supra* note 220; Kollmuss et al., *supra* note 18, at 15.

the environmental and economic potential of Christmas tree farms. Allowing Christmas tree farmers to retain some freedom in the way they choose to manage their tree production is imperative to their acceptance and overall compliance with the regulations.[268] This system is intended to be implemented as a federal regulatory system by the federal EPA. Because the EPA is charged with implementing the Clean Air Act, and has existing expertise on greenhouse gas emissions, it is the appropriate authority to promulgate and enforce this legal framework.[269] Different Christmas tree farms across the nation span different jurisdictions,[270] climates,[271] and consumer preferences,[272] so a relatively flexible system of laws will allow farmers to employ the practices that best suit their particular business and crops, without penalizing them for other factors that are much more difficult to control.

In this framework, a Christmas tree farm does not have any choice in the obligations with which it must comply because those requirements and prohibitions are part and parcel of operating a Christmas tree farm. Similarly, a Christmas tree farmer must employ a sustainable waste management practice, but has the choice between pyrolysis, composting, or mulching. Each farmer must employ a minimum of two out of the possible six sustainable farming alternatives, but more can always be added, and those extra efforts will be subsidized. A Christmas tree farm that is classified as agrisilvicultural has a seventh option to introduce livestock grazing or forage crops to the farm as one of its two minimum sustainable practices. Finally, farmers may employ any of the disincentivized practices, but will be charged fees or taxes in order to do so. Table 1 shows the regulations that are categorized as obligations, alternatives, and disincentives.

268. *See* Susan Weinschenk, *Why Having Choices Makes Us Feel Powerful*, PSYCH. TODAY (Jan. 24, 2013), https://www.psychologytoday.com/us/blog/brain-wise/201301/why-having-choices-makes-us-feel-powerful.

269. *See Air Enforcement*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/enforcement/air-enforcement (last visited Apr. 19, 2021).

270. *History of Christmas Trees*, *supra* note 22.

271. WRAY, *supra* note 23, at 13, 17–27.

272. *Id.* at 16–17. For example, the white fir is popular in western states, and spruces are popular in the northern United States. *Id.* at 20–21.

TABLE 1.

Type of Regulation	Applicability	Regulations
Obligation	All farms must comply.	(A) Prohibiting Clear Cutting
		(B) Prohibiting Disposal of Organic Matter by Combustion
		(C) Requiring Interspace Ground Coverage
		(D) Requiring Monitoring and Reporting of Greenhouse Gas Emissions to the EPA
Obligation with Choice	All farms must choose one waste management practice.	(I) Turning Biomass Waste into Biochar
		(II) Composting Biomass Waste
		(III) Mulching Biomass Waste
Choice of Alternatives	All farms must choose a minimum of two alternatives. Only farms that are classified as agrisilvicultural may choose option (*) as one of their two alternatives.	(*) Introducing Forage Crops or Livestock Grazing to the Farm
		(1) Planting Tree Species that Tolerate Wetter, Denser Soils
		(2) Planting Tree Species that Have a Longer Average Rotation
		(3) Planting Tree Species that Require Less Maintenance
		(4) Coppicing
		(5) Introducing Pest Predators to the Farm
		(6) Using Biochar on the Farm
Disincentive	Any farm may employ any of these practices, but they each have an additional cost.	(a) Tilling
		(b) Using Fossil-Fueled Machines
		(c) Using Fertilizers
		(d) Using Pesticides

A. OBLIGATIONS

By growing and selling Christmas trees, a farm subjects itself to the following obligations. All Christmas tree farms must comply with these regulations. The proceeds from any criminal or civil penalties from violations of these obligations will be pooled and donated to carbon offset projects to mitigate the damage the activities have caused.

The harshest regulations are obligations prohibiting clear cutting and the disposal of organic matter by combustion, because these two practices cause tremendous greenhouse gas emissions and generate unnecessary waste.[273] If a Christmas tree farmer violates these prohibitions, the farmer is subject to a criminal penalty. In Virginia, clear cutting is a Class 1 misdemeanor, subjecting the perpetrator to up to twelve months of incarceration, a fine of up to $2,500, or both.[274] The penalty of the Virginia misdemeanor is borrowed and applied identically in this legal framework. While no analogous law exists on the combustion of biomass, it will also be classified as a misdemeanor with the same penalty because of the extensive emissions from combustion.[275]

Due to the impact ground coverage has on soil carbon stocks, farmers are required to install or improve cover crops between Christmas trees.[276] Each year after trees are harvested, before the next rotation, farmers must ensure adequate ground coverage between trees and replace any that has been damaged.[277] Because this is relatively inexpensive to do,[278] regulation of ground coverage is a command as opposed to an alternative, as explained in following Subparts. Finally, Christmas tree farms are required to monitor their greenhouse gas emissions from machine use, harvest method, or other farm operations and must report such emissions to the EPA. Under this proposed framework, any violation of the requisite installation and maintenance of ground coverage or a failure to monitor and report emissions will result in a civil fine of $250,000 for a willful or reckless violation and $100,000 for a negligent violation.[279]

B. OBLIGATION WITH CHOICE

Additionally, every farmer is required to employ one of the enumerated waste management practices. The farmer will be subsidized for the one chosen, but not for any additional waste management practices beyond the required one. If a Christmas tree farm remains in compliance with any of these three waste management practices, it will have certified white tags to label its trees as "Zero-Waste" trees. Failing to employ one of the waste management practices will

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273. *Clearcutting and Climate Change*, CTR. FOR BIOLOGICAL DIVERSITY, https://www.biologicaldiversity.org/programs/public_lands/forests/clearcutting_and_climate_change/ (last visited Apr. 19, 2021); NICHOLAS INST. FOR ENV'T POL'Y SOLS., *supra* note 64, at 24.

274. VA CODE ANN. § 18.2-11(a) (2021); *see* Wesley Edwards, *Man Accused of Violating Chesapeake Bay Act to Serve Time*, SHORE DAILY NEWS (Dec. 12, 2017), https://shoredailynews.com/headlines/man-accused-of-violating-chesapeake-bay-act-to-serve-time/; Nancy Drury Duncan, *Clear-Cutting 3-Acre Waterfront Wetlands Property Lands Virginia Man in Jail*, DELMARVA NOW (Dec. 12, 2017), https://www.delmarvanow.com/story/news/local/virginia/2017/12/12/clear-cutting-wetlands-property-jail-sentence/943476001/.

275. *See* P'SHIP FOR POL'Y INTEGRITY, CARBON EMISSIONS FROM BURNING BIOMASS FOR ENERGY (2004), https://www.pfpi.net/wp-content/uploads/2011/04/PFPI-biomass-carbon-accounting-overview_April.pdf.

276. *See* Chapman et al., *supra* note 15, at 2226.

277. Permitted ground coverage crops will include grain, grass, clover, soybeans, legumes, salal, bear-grass, falsebox, sword fern, deer fern, evergreen huckleberry, Scotch broom, Oregon grape, or a blend of these.

278. *See* JAMES J. HOORMAN, ECONOMICS OF COVER CROPS (2016), https://mccc.msu.edu/wp-content/uploads/2016/10/OH_2015_Economics-of-cover-crops-presentation.pdf; *see, e.g.*, *Grains & Cover Crops*, BAKER CREEK HEIRLOOM SEEDS, https://www.rareseeds.com/store/vegetables/grains-and-cover-crops (last visited Apr. 19, 2021).

279. These civil penalties are based loosely on the additional civil penalties for violation of California's Fuel Regulations. *See* CAL. HEALTH & SAFETY CODE § 43027 (West 2021).

result in a civil penalty of $500 per acre per year. The proceeds of any civil penalties will go to waste management carbon offset projects.

Christmas tree farms can choose between composting, mulching, or pyrolysis from their agricultural waste. Compost bins can be purchased for as little as $100 or made for much less, particularly if farmers already have materials to build one.[280] Mulching is even cheaper.[281] Composting and mulching will each be subsidized by an annual stipend of $100 per acre, so long as the Christmas tree farm can verifiably show that all waste has been composted or mulched. Pyrolysis is slightly more expensive and has additional sequestration benefits, so farms that choose this method will receive a larger subsidy of $150 per acre per year. What farmers choose to do with the product of their sustainable waste management practice is up to them; they may use the biochar, mulch, or compost on their own farms or sell the product to make additional income.

C. Choice of Alternatives

All Christmas tree farms must choose a minimum of two out of six sustainable farming practices to employ. All of the alternatives are subsidized by the government. A farmer will still receive the subsidy for practices that are employed to meet their minimum obligations. A special seventh option that can be chosen as one of the two required practices is available to Christmas tree farms that are classified as agrisilvicultural by the EPA. If the farmer chooses to employ additional alternatives beyond the required two, the farmer will receive the subsidy from each of those extra efforts as an incentive. While farmers may incur some start-up costs, the implementation of these of additional efforts beyond the required minimum can qualify as a carbon offset project, so the monetary incentive will eventually come from carbon credit purchasers.[282] Moreover, increasing the carbon sequestration on their Christmas tree farms is aligned with farmers' goals for long-term profitability.[283] Due to their thin margins, Christmas tree farmers will likely favor the prospect of long-term profitability combined with short-term monetary incentives.[284]

280. *The Economics of Composting*, O_2 Compost, https://www.o2compost.com/the-economics-of-composting.aspx? (last visited Apr. 19, 2021); *see also* Vanessa Beaty, *35 Cheap And Easy DIY Compost Bins That You Can Build This Weekend*, DIY & Crafts (Jan. 21, 2018), https://www.diyncrafts.com/33618/home/gardening/35-cheap-easy-diy-compost-bins-can-build-weekend; *see, e.g.*, *Greenes 173.92 Gal. Cedar Wood Composter*, Home Depot, https://www.homedepot.com/p/Greenes-173-92-Gal-Cedar-Wood-Composter-RCCOMP36/207148994? (last visited Apr. 19, 2021); *Aeroplus 3-Stage Compost Bin—21 Cubic Feet*, Eartheasy, https://eartheasy.com/aeroplus-3-stage-compost-bin-21-cubic-feet/?sku=AEROPLUS6000&gclid (last visited Apr. 19, 2021).

281. *See* Jennifer Noonan, *How To: Make Mulch from Scratch*, Bob Vila, https://www.bobvila.com/articles/how-to-make-mulch/ (last visited Apr. 19, 2021).

282. *See supra* Part II.2.C.

283. Brownstone, *supra* note 98.

284. *Id.*

Any violation of this scheme of employing a minimum of two alternatives will result in a civil penalty of $800 per acre per year. Agrisilvicultural Christmas tree farms have the unique option of introducing either forage crops or livestock grazing, or both, to satisfy one of the two minimum requirements. A subsidy of $500 per acre per year will be granted for this option; a minimum of one acre of implementation is required.

Other options will also be measured on a per-acre basis, including the options to: (1) plant tree species that tolerate wetter, denser soils; (2) plant species that have a longer rotation; (3) plant species that require less maintenance; or (4) coppice. Farmers will receive a $2,000 subsidy the year the farmer plants balsam firs, Canaan firs, black spruces, or a blend of these.[285] Other than these aforementioned species, spruce trees have a longer rotation and, along with fir trees, require less maintenance, which will help to decrease the use of fossil-fueled machinery, fertilizers, and pesticides. Thus, farmers will receive a $2,500 subsidy for each acre of fir trees planted and a $3,000 subsidy for each acre of spruces trees planted, in the year they are planted. Lastly, for every acre on which a farmer replaces selective cutting with coppicing harvest methods, farmers will receive $5,000 per acre per year for employing this regenerative farming practice.

The subsidies for displacing the use of fertilizers and pesticides will be calculated based on pounds of fertilizers and pesticides forgone as a result of the employed practice. The amount of forgone fertilizers and pesticides will be measured against business as usual, before the employed practices were implemented. Successful implementation of both of these practices will qualify a Christmas tree farm for certified red tags to label their trees as "Chemical Free." Introducing predators of common pests will yield a one-time subsidy of $2 per pound of pesticide forgone or $100 per acre that is pesticide free, whichever is greater.[286] Predators that are permitted under this regulation are lacewings and ladybugs; other pest predators must be approved by the EPA before their introduction to a farm qualifies for this subsidy. The use of biochar to enhance soil nutrients and fertility will yield a one-time subsidy of $130 per pound of fertilizer forgone or $1,500 per acre that is fertilizer-free, whichever is greater.[287]

D. DISINCENTIVES

It is unrealistic to expect farmers to change overnight or to overhaul every method they use to make their farm productive. Thus, there will be no criminal

285. This amount for the stipend is based roughly on the difference in prices between the average eight-foot pine tree and the average eight-foot spruce tree. *See Types, Prices & Care*, MR. TREE FARM, http://www.mrtreefarm.com/MR_TREE_TYPES__TIPS___CARE.html (last visited Apr. 19, 2021).

286. This subsidy was calculated based on the estimation that 56.25 kg/hectare of pesticides are used when trees are in the field. *See* COUILLARD ET AL., *supra* note 8, at 10 tbl.2.1.

287. This subsidy was calculated based on the estimation that 3650 kg/hectare of fertilizers are used when trees are in the field. *See* COUILLARD ET AL., *supra* note 8, at 10 tbl.2.1.

liability for failing to make these changes. Instead, these practices will simply be discouraged by imposing taxes on particular products to make them more expensive and fees for employing certain farming methods. The disincentive will cause most farmers to adapt their methods to sustainable methods over time because the regenerative and sustainable methods will be cheaper.

Tilling will be disincentivized by requiring a fee of $100 per acre that is tilled in the year that it is tilled.[288] Machine use will be disincentivized by charging a fee of $50 per gallon of greenhouse-gas-emitting fuel used.[289]

Purchasing fertilizer and pesticide products will be more expensive as a result of new taxes and tariffs on any of these products. In addition, farmers will be required to pay a fine for the use of fertilizers and pesticides. For every year of use, use of fertilizers will cost $150 per pound of chemicals or $230,000 per acre on which fertilizers are used, whichever is more expensive.[290] Similarly, use of pesticides will cost $8 per pound or $1,000 per acre on which pesticides are used, whichever is more expensive.[291]

A farmer's efforts to comply with the obligations suggested above are not eligible as carbon offset projects because they are required by law and, thus, they are not additional.[292] The same is true for whichever sustainable waste management practice a Christmas tree farmer chooses to employ. However, a farmer's effort with regard to any of the choice alternatives may be eligible as a carbon offset project, assuming that those efforts are beyond the two minimum required sustainable farming practices necessary to comply with the proposed legal framework. A Christmas tree farmer's actions toward eliminating any of the disincentivized activities from their farm may also qualify as a carbon offset project if they do not already employ the practice. The viability of each of the sustainable farming alternatives and disincentivized activities as a carbon offset project is analyzed in light of these limitations.

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288. This disincentive was calculated based on the estimation that farmers can save approximately $20 per acre by using minimal-tilling or no-tilling methods. *See Consider Costs Before Tilling*, FARM PROGRESS (Nov. 2, 2011), https://www.farmprogress.com/tillage/consider-costs-tilling.

289. This disincentive was calculated based on the highest recorded average price for a gallon of diesel fuel. *See Gas Prices*, AAA, https://gasprices.aaa.com/ (last visited Apr. 19, 2021). Machines subject to this regulation include, but are not limited to, mowers, tractors, bush hogs, roller crimpers, spraying machines for fertilizers and pesticides, helicopters or small planes, power augers, shearing tools, chainsaws, shakers, balers, color applicators for greening or needle retention spray, double mowers pulled by a tractor, mechanical planters, and tractor-mounted herbicide sprayers. *See supra* Part I.A.4.

290. This disincentive was calculated based on the estimation that 3650 kg/hectare of fertilizers are used when trees are in the field. *See* COUILLARD ET AL., *supra* note 8, at 10 tbl.2.1.

291. This disincentive was calculated based on the estimation that 56.25 kg/hectare of pesticides are used when trees are in the field. *See id.*

292. *See Quality Assurance Protocol*, *supra* note 220; KOLLMUSS ET AL., *supra* note 18, at 15.

E. ELIGIBILITY OF PROJECTS ON CHRISTMAS TREE FARMS AS CARBON OFFSET PROJECTS

It is beyond the scope of this Note to evaluate or design the ideal carbon offset system into which Christmas tree farms fit. Nevertheless, examining common eligibility requirements can illustrate what it may take for changes in practices on Christmas tree farms to be viable carbon offset projects. A Christmas tree farm continuing its current operations will not be a viable carbon offset project if it already exists because any emissions reductions would not be additional.[293] This may limit the opportunities for Christmas tree farmers who have already implemented sustainable farming practices because their efforts would not be additional to business as usual.[294] Instead, a Christmas tree farm would be eligible as a carbon offset project only if the farmer employed a *new* sustainable farming practice. Using the framework of the California cap-and-trade program as an example, the potentially viable offset projects from Christmas tree farms are either Improved Forest Management or Avoided Conversion project types within the U.S. Forest Project protocol.[295] The potential projects are analyzed in light of this system of protocols.

First, there are several projects that may be eligible as carbon offset projects, including introducing livestock grazing and forage crops, coppicing, introducing pest predators, reducing or eliminating pesticide and fertilizer use, or producing biochar. Introduction of livestock grazing or forage crops to the farm could create real emissions reductions by allowing soil to sequester more carbon.[296] If the Christmas tree farmer can show that these changes to the land use on the farm were not intended or foreseeable before the project, the sequestration will likely be considered additional. Permanence may be difficult to prove, especially because the soil will continue to be disturbed as farm operations (including harvest) continue. Due to soil sampling, change in soil carbon stocks makes this project easily verifiable. The introduction of forage crops is unlikely to cause any leakage. However, if a Christmas tree farmer plans to introduce livestock, there may be a problem with leakage from livestock waste. Although farmers will likely run into concerns with proving permanence, introduction of livestock grazing or forage crops may be eligible as a carbon offset project.

Similarly, coppicing could also qualify as a carbon offset project by reducing degradation of the trees during harvest. There are real emissions reductions from keeping the stumps alive and minimizing soil disturbance.[297] Unless the farmer reverts to old harvest methods or removes the coppiced stumps, the emissions reductions are permanent. It may be difficult to prove

293. *See* De Stefano & Jacobson, *supra* note 14, at 290–95.
294. *See id.*
295. *See* CAL. AIR RES. BD., *supra* note 236, at 3.
296. *See supra* Part II.B.3.
297. *How Green Is Your Christmas Tree?*, *supra* note 120.

additionality,[298] but assuming the farmer has only done traditional selective or clear-cut harvesting in the past, additionality will likely be satisfied. While the emissions reduced are not easily measurable, they can be estimated, and the continuation of the practice is easily verifiable. Coppicing may be a viable carbon offset project.

Further, the introduction of pest predators, decreased use or elimination of pesticides and fertilizers, and producing biochar may all be eligible carbon offset projects. Each of these practices would yield real emissions reductions.[299] Because the chemicals are not being sprayed all over the farm, the reductions here are permanent unless the farmer uses fertilizers or pesticides in the future. The amount of chemicals forgone in any of these practices is easily quantifiable and verifiable. The only trouble may be with the additionality of these practices because reduction of fertilizer and pesticide use in favor of more sustainable methods is arguably gaining popularity in agriculture.[300] Assuming the Christmas tree farmer can show additionality, any of these practices are likely to be eligible carbon offset projects. In a similar vein, it is likely sufficiently additional if a Christmas tree farmer decides to *produce* biochar because it requires some type of pyrolysis system, rather than simply *using* biochar on the farm. Creating biochar from biomass waste reduces emissions from the decomposing waste and permanently stores the carbon in the stable biochar.[301] While emissions reductions may be slightly difficult to measure, these are likely viable carbon offset projects.

Conversely, several of these activities are not likely to be eligible carbon offset projects primarily because the resulting emissions reductions are likely not additional. If a Christmas tree farmer chooses to plant trees that are able to tolerate wetter, denser soils, their efforts are unlikely to qualify as a carbon offset project. Although the practice would result in real sequestration,[302] it would be difficult for farmers to show that it would not have happened in the absence of the project. Because trees get replanted each year, the planting of the newest block that happens to be a different species of tree will probably be viewed as independent from the implementation of the project. Moreover, the sequestration is not permanent because eventually those trees will be harvested. This practice is unlikely to be eligible as a carbon offset project. The eligibility of carbon offset credits for planting trees with longer average rotations or planting trees that require less maintenance both have similar problems. Moreover, because composting and mulching are already quite common in farming, it would be difficult to prove additionality when implementing these efforts. It is unlikely that either practice would be eligible as a carbon offset project.

298. Additionality requires that emissions reductions would not have happened in absence of the project. *Quality Assurance Protocol*, *supra* note 220; KOLLMUSS ET AL., *supra* note 18, at 15.

299. *See supra* Part II.

300. *See* Wozniacka, *supra* note 108.

301. *See supra* Part II.B.5.

302. *See supra* Part II.B.1.

Finally, it is unlikely that minimizing tilling or machine use will surpass the high bar for additionality. Similar to limiting pesticide and fertilizer use, the agriculture industry is already shifting toward these sustainable farming methods.[303] Further, while the emissions reductions are real, they may not be permanent, particularly in the case of possible future soil disturbance. These two practices are unlikely to qualify as carbon offset projects.

CONCLUSION

The reality is that human behavior must change in order to avoid irreversible climate catastrophe.[304] This will require major shifts in the activities and transactions in which the typical person engages.[305] For many Americans, one of those transactions is the annual purchase of a Christmas tree.[306] The number of Christmas trees that are produced across the United States in order to meet this demand presents a major opportunity for reducing greenhouse gas emissions and improving greenhouse gas sequestration.

Further, American lawmakers have underutilized the opportunity to capitalize on the distinctive sequestration potential in agroforestry systems. Moreover, the increased consumer awareness through the use of special labels and certifications gives Americans a stake in the effort to reduce atmospheric greenhouse gases and a fun way to accomplish that goal.[307] The carbon offset market, while imperfect, facilitates profitability and atmospheric greenhouse gas reductions; even if emissions are not reduced, carbon offsets still yield an environmental benefit. Christmas tree farmers have the opportunity to engage in sustainable practices for the cultivation and harvest of their trees and earn incentives and national, or global, attention for doing so.

Although it is cliché, there is something magical about Christmas and its concomitant possibilities of peace, love, and forgiveness.[308] During the holiday season, people are often kinder to each other.[309] Media is filled with joyful messages that make people feel more generous and nostalgic.[310] The practical result of this is that consumers may be willing to spend a little more for a sustainable Christmas tree, allowing farmers some flexibility in their profit

303. Wozniacka, *supra* note 108.

304. IPCC REPORT ON GLOBAL WARMING OF 1.5ºC, *supra* note 1, at 18–19.

305. *Id.*

306. *See Ninety-Six Million U.S. Households Will Celebrate the Christmas Holiday with a Christmas Tree in 2019*, *supra* note 20.

307. Dinara Bekmagambetova, *Two-Thirds of North Americans Prefer Eco-Friendly Brands, Study Finds*, BARRON'S (Jan. 10, 2020, 8:08 AM), https://www.barrons.com/articles/two-thirds-of-north-americans-prefer-eco-friendly-brands-study-finds-51578661728.

308. *See* Janelle de Weerd, *The Psychology of Christmas*, CROBOX (Dec. 3, 2020), https://blog.crobox.com/article/the-psychology-of-christmas.

309. *Are People Actually Nicer During the Holidays?*, BRAINY BUSINESS (Nov. 8, 2018), https://thebrainybusiness.com/2018/11/08/are-people-actually-nicer-during-the-holidays/.

310. *Id.*

margins.[311] The sentimental warmth people feel from doing good for the planet is also notable.[312] Because humans act based on tradition and habit, adapting American traditions to be more sustainable will result in purposeful, consistent action.[313] That action can ultimately power the changes needed to mitigate climate change.

311. *See* de Weerd, *supra* note 308.

312. *See* Laura M. Holson, *What if Holidays Could Save the Planet?*, N.Y. TIMES (Nov. 17, 2018), https://www.nytimes.com/2018/11/17/business/eco-friendly-holiday.html.

313. *See* de Weerd, *supra* note 308.